PUBLIC AGENDA
SASKATOON ENVIRONMENTAL ADVISORY COMMITTEE

Thursday, November 12, 2015, 11:30 a.m.
Committee Room A, Second Floor, City Hall
Committee Members:

Dr. M. Hill, Chair
Ms. K. Aikens, Vice-Chair
Councillor M. Loewen
Ms. A. Bugg
Dr. D. McGrane
Mr. B. Latimer
Mr. S. Homenick
Ms. A. Garg
Ms. N. Kochar
Dr. S. Moshiri
Mr. B. Sawatzky

Pages

1. CALL TO ORDER

2. CONFIRMATION OF AGENDA

Recommendation

That the agenda be confirmed as presented.

3. ADOPTION OF MINUTES

Recommendation

1. That the minutes of Regular Meeting of the Saskatoon Environmental Advisory Committee held on September 10, 2015 be adopted as amended; and
2. That the minutes of Regular Meeting of the Saskatoon Environmental Advisory Committee held on October 8, 2015 be adopted.

4. UNFINISHED BUSINESS

5. REPORT OF THE CHAIR

Verbal Update - M. Hill

Recommendation

That the information be received.

6. COMMUNICATIONS

6.1 Integrated Waste Management Annual Report 2014 (File CK. 430-78) 4 - 34

Attached is a report of the General Manager, Corporate Performance Department, dated October 13, 2015, which was considered at the Standing Policy Committee on Environment, Utilities & Corporate Services held October 13, 2015; it was resolved that the report be forwarded to SEAC for its information.

Recommendation

That the information be received.

6.2 2015 Update to Our Environment: The City of Saskatoon's Environmental Leadership Report (File CK. 7550-1) 35 - 50

Attached is a report of the General Manager, Corporate Performance Department, dated October 13, 2015, which was considered at the Standing Policy Committee on Environment, Utilities & Corporate Services held October 13, 2015; it was resolved that the report be forwarded to SEAC for its information.

Recommendation

That the information be received.

7. REPORTS FROM ADMINISTRATION

7.1 Natural Areas and Wetlands Policy (File CK. 4110-38 x 1700-1)

Verbal Update - Allan Wallace, Director of Planning & Development will be in attendance to update the Committee on the predevelopment protocols for environmental protection.

Recommendation

That the information be received.

7.2 Environmental and Corporate Initiatives (File CK. 7550-1)

Verbal Update - B. Wallace

Recommendation

That the information be received.

7.3 Stormwater Management (File CK. 8355-1) 51 - 104

Twyla Yobb, Watershed Protection Manager will be in attendance for a discussion on stormwater management. The discussion will focus on current best practices for stormwater management and what it might take to shift our community from treating stormwater as a waste to managing rain as a resource. SEAC members will be asked to consider the following:

1. Further to the work commissioned by SEAC on stormwater in 2012 (see attached), does the committee have additional ideas or information they feel needs to be considered?
2. What critical elements does the committee feel are most effective for integrating community-based stormwater initiatives (e.g. green roof, rainwater harvesting, etc.)?
3. As stormwater planning will be part of the Natural Area Master Plan, what opportunities and risks might arise as a result?

Recommendation

That the direction of Committee issue.

8. STATEMENT OF EXPENDITURES 105 - 105

Attached is a current Statement of Expenditures.

Recommendation

That the information be received.

9. ADJOURNMENT

Integrated Waste Management Annual Report 2014

Recommendation
That the report of the General Manager, Corporate Performance Department dated October 13, 3015, be forwarded to City Council for information.

Topic and Purpose
The performance of civic waste handling and reduction programs are reported in the Integrated Waste Management Annual Report for 2014.

Report Highlights
1. Saskatonians continue to dispose less waste than the national average, but at a rate higher than most Canadian cities at 249 kilograms per person.
2. A Waste Diversion Rate of 70% by 2023 has been established as a Performance Target. The 2014 rate is 22.5%, below the national average (2012) of 33.7%.
3. The compost program contributes 13% toward the waste diversion rate of 22.5%. The next biggest contributor to waste diversion is the curbside recycling program at 7% followed by recycling depots at 2%.
4. A new education blitz at the landfill reminded 600 customers about covering or tarping loads; residents were provided information about alternative disposal options for compostable materials, paint, tires and household hazardous waste.
5. More than 86,000 vehicles delivered loads to the landfill. Total material deposited in 2014 was 125,238 tonnes.
6. 2.8 million garbage carts are emptied each year with a reliability rate of 99.9%. In 2014, City staff responded to 2,400 calls about missed garbage collections.
7. 1.1 million blue recycling carts were tipped in 2014 with 1,110 occurrences of incorrectly placed or overfilled carts (for a non-compliance rate of 0.1%).

Strategic Goal
The information in this report supports the four-year priorities to promote and facilitate city-wide composting and recycling and implement energy-efficient practices in City operations, along with the long-term strategy to eliminate the need for a new landfill under the Strategic Goal of Environmental Leadership.

Background
City Council received an Integrated Waste Management Annual Report for 2013, prepared by Environmental and Corporate Initiatives Division in 2014.

Report
Attachment 1 is the *Integrated Waste Management Annual Report* for 2014. The report provides a description of the waste handling, waste reduction, and waste diversion programs and services provided by the City of Saskatoon (City). These include curbside garbage and recycling collections for all single-family households; a regional

landfill; optional leaves and grass curbside collections; 2 compost depots; 4 recycling depots; household hazardous waste drop-off events; garbage collection for many multi-unit and commercial customers (other buildings and businesses contract to private haulers), and multi-unit recycling collection. Other waste diversion programs include home composting education, curbside swap, and integrated waste education.

The report highlights changes measurable outcomes achieved, and describes the responsibilities of Environmental & Corporate Initiatives and Public Works. Highlights from the report are outlined above. Now that the City has adopted a Waste Diversion target of 70% by 2023, this report and future Integrated Waste Management Annual Reports will serve as a progress report toward this ambitious target.

Communication Plan

The 2014 *Integrated Waste Management Annual Report* will be available for viewing on the City's website. A Public Service Announcement and social media posts will be distributed.

Environmental Implications

Greenhouse gas (GHG) emissions implications and other environmental protection measures are included in the annual report.

Other Considerations/Implications

There are no public and/or stakeholder involvement, policy, financial, privacy or CPTED implications or considerations.

Due Date for Follow-up and/or Project Completion

An Integrated Waste Management Annual Report will continue to be produced each year. The next report will be prepared for the 2015 year, submitted to the Standing Policy Committee on Environment, Utilities and Corporate Services in April 2016.

Public Notice

Public Notice pursuant to Section 3 of Policy No. C01-021, Public Notice Policy, is not required.

Attachment

1. Integrated Waste Management Annual Report 2014

Report Approval

Written by: Amber Jones, Education and Environmental Performance Manager
Reviewed by: Brenda Wallace, Director of Environmental and Corporate Initiatives
Michelle Jelinski, Environmental Operations Manager
Pat Hyde, Director of Public Works
Approved by: Catherine Gryba, General Manager, Corporate Performance Department

2014 Integrated Waste Management Annual Report

Introduction – What is Integrated Waste Management

Integrated Waste Management is a systems approach to waste handling that focuses on reducing waste where possible, re-using whatever can be given a new purpose, recycling and recovering resources to minimize demand for raw materials, and conscientiously managing what remains to ensure the safety of people and the environment.

The City's core services include:

- curbside garbage and recycling collections for all single-family households;
- a regional landfill;
- optional leaves and grass curbside collections;
- 2 compost depots;
- 4 recycling depots;
- household hazardous waste drop-off events;
- garbage collection for many multi-unit and commercial customers (other buildings and businesses contract to private haulers); and
- multi-unit recycling collection

Other waste diversion programs include home composting education, curbside swap, and integrated waste education.

Reducing Waste – Targets

The City of Saskatoon has adopted a 10-year target to divert 70% of waste from the Saskatoon landfill with a longer term vision of achieving Zero Waste. This ambitious target shows a commitment by the City of Saskatoon (City) to establish new options for waste reduction in recycling, reusing, and composting as well as continuously improving our existing programs. Joining the National Zero Waste Council (NZWC) in 2014 sets a clear visionary direction for reducing waste to the highest degree possible. This global movement towards eliminating waste includes not only recycling, reusing, and composting of produced waste but also requires a philosophical shift towards reducing the waste in the first place through design and planning decisions.

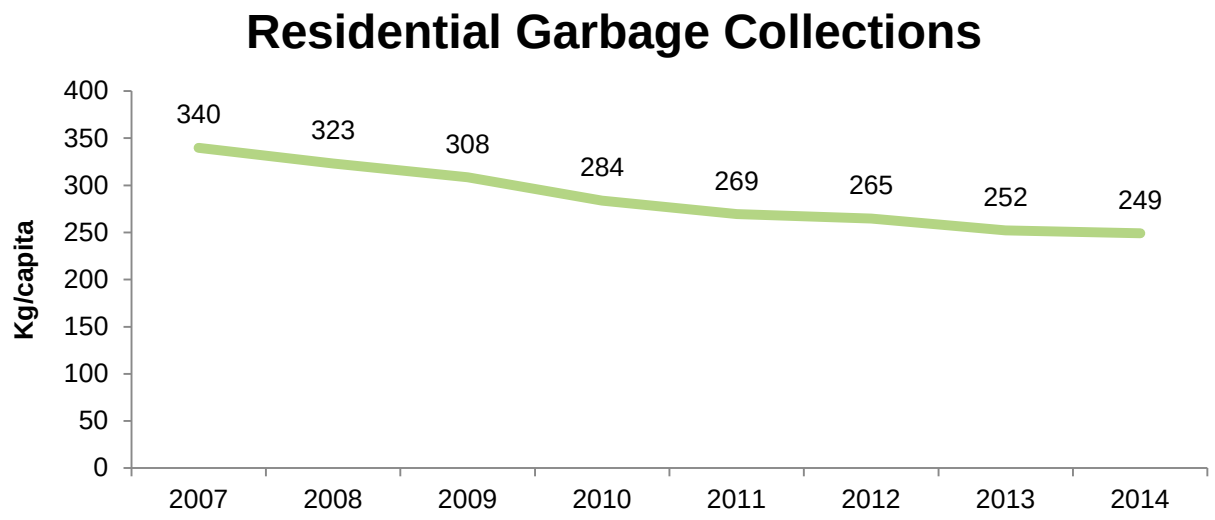
The City's Waste Diversion Rate, at 22.5%, has been relatively stable over the last two years. For this reason the progress toward the target of 70% has been identified as needing improvement.

Saskatoon's Waste Disposal

The amount of garbage collected is reducing every year. In 2014:

- 125,238 tonnes of garbage was disposed of at the City landfill from all sources
- Residential collections by the City accounted for 64,091 tonnes (53,000 tonnes from black carts, the rest from multi-units)
- 249 kg of garbage was disposed per person.

As shown in the figure below, the rate of garbage disposal per person has been declining over time.



Saskatoon's disposal was compared to the national and provincial averages as shown in the table below and compares favorably to both the national and provincial averages.

Region	Year	Total Waste Disposed (tonnes)	Total Waste Rate (kg/capita)	Residential Component (tonnes)	Residential Rate (kg/capita)
Saskatoon	2012	117,660	486	64,363	265
Saskatoon	2014	125,238	484	64,091	249
Saskatchewan	2012	957,669	881	315,987	290
Canada	2012	25,013,204	720	9,586,511	276

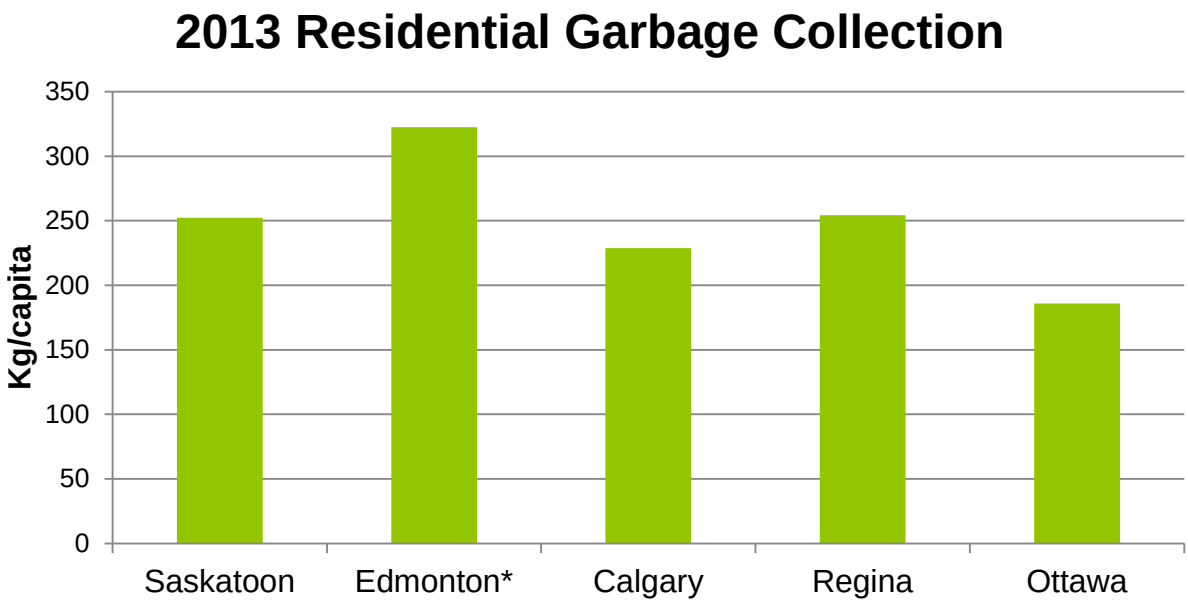
Source: Stats Canada

Saskatoon's Residential Waste Disposal Rate was also compared to other cities in Canada using data from the National Solid Waste Benchmarking Initiative[1] (NSWBI).

As shown in the table below, residents in Saskatoon dispose of a similar amount of waste to residents in Regina, but more waste than three other comparable cities in

[1] National Solid Waste Benchmarking Initiative collects data on waste management in select cities, in 2013 twelve (12) cities participated

2013. NSWBI also reported that on average 0.60 tonnes of waste is collected per single family household, while Saskatoon's average is approximately 0.79 tonnes per household.

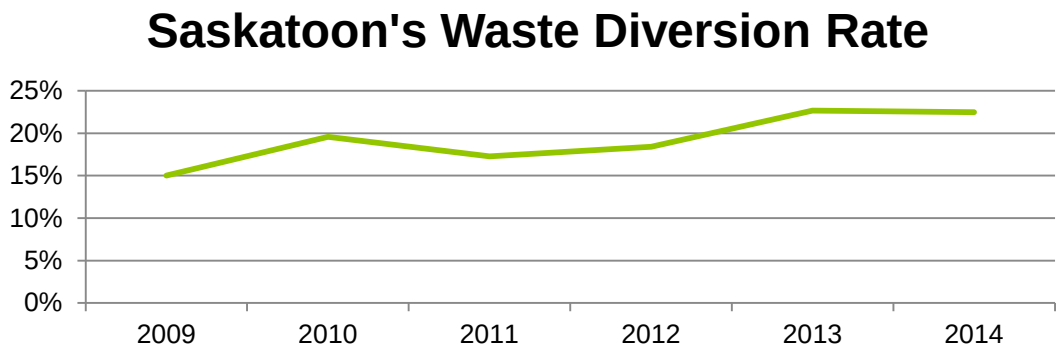


Source: National Solid Waste Benchmarking Initiative 2014

* Edmonton collects organics and garbage in a single-stream. An estimated 37% of the organics is diverted from the collected waste.

Saskatoon's Waste Diversion

Saskatoon's Waste Diversion rate remained stable since last year and is below the national average. On average in 2012 (Stats Canada), Canadians diverted 243 tonnes of waste per capita resulting in an overall diversion rate of 33.7% (almost 8.5 million tonnes) while in Saskatchewan, approximately 143 tonnes per capita was diverted resulting in a diversion rate of 16.3%. Saskatoon's diversion rate in 2012 was well below the national average at 18.4%, it increased to 22.7% in 2013, and remained relatively stable at 22.5% in 2014.



Saskatoon's 2014 diversion rate was also benchmarked against other Canadian Cities, as shown in the table below. Saskatoon's diversion rate is second last amongst compared Cities.

City	2014 Diversion Rate
Halifax	61%
Toronto	53%
Ottawa	52%
Edmonton	51%
Calgary	34%
Saskatoon	23%
Regina	19%

City of Saskatoon Waste Service Delivery

Integrated Waste Management falls within the **Environmental Health** Business Line which is jointly managed by Public Works (Waste Handling Service Line) and Environmental & Corporate Initiatives (Waste Reduction & Resource Recovery Service Line). The goal of the Waste Handling Service Line is to provide efficient, effective, and customer-oriented waste management services. Waste Handling includes:

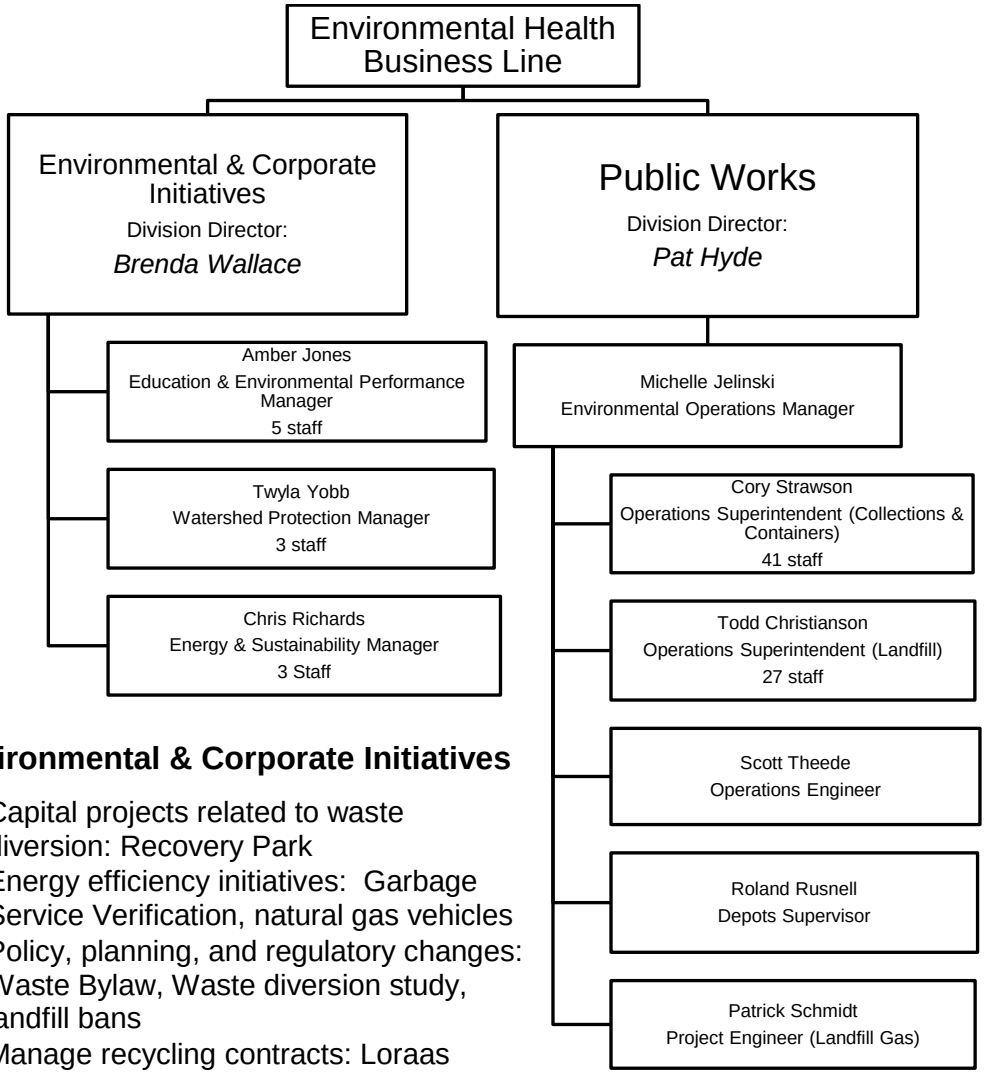
- solid waste collections;
- the management of City-owned garbage carts; and
- operating the landfill to optimize available space and comply with environmental requirements.

The goal of Waste Reduction is to provide a focus on reducing, reusing, recycling, and recapturing resources while seeking operational efficiencies. Initiatives under this program include:

- recycling contracts for curbside and multi-unit dwellings;
- support for recycling depots located across the community;
- composting of yard waste at drop-off depots; and
- residential subscription yard waste collection initiative.

Role of Public Works and Environmental & Corporate Initiatives

Integrated Waste Management is delivered by Public Works and Environmental & Corporate Initiatives under the **Environmental Health** Business Line.



Environmental & Corporate Initiatives

- Capital projects related to waste diversion: Recovery Park
- Energy efficiency initiatives: Garbage Service Verification, natural gas vehicles
- Policy, planning, and regulatory changes: Waste Bylaw, Waste diversion study, landfill bans
- Manage recycling contracts: Loraas Recycle, Cosmopolitan Industries Ltd.
- Coordinate Household Hazardous Waste Days
- Waste diversion programs and initiatives: Saskatoon Curbside Swap, public space recycling, festival and event sustainability, civic recycling
- Education, outreach and communications pertaining to waste reduction and diversion programs and future diversion initiatives

Public Works

- Garbage containers and garbage collection services
- Manage the Saskatoon Regional Waste Management Facility (Landfill)
- Operate compost and recycling depots
- Leaves & Grass collections including providing green carts
- Deliver recyclable materials from depots to Cosmo
- Communications pertaining specifically to waste management operations

Garbage Handling Service – Keeping Saskatoon Safe and Clean

Containers

Providing waste carts to new homes and repairing carts when they are damaged.

Containers Provided to Residential (Curbside) Properties

The City of Saskatoon owns and maintains the black roll-out carts provided to street-oriented residential properties. In 2014:

- 1,300 new carts were delivered to new homes
- 6,100 carts were repaired or replaced (430 of these were stolen and could not be recovered)
- Current cart failure rate has been reduced to 0.55% due to improvements in purchasing specifications made in late 2012. In neighbourhoods with carts purchased under old specifications, failure rates can be as high as 15% (i.e. Caswell Hill, College Park, Confederation Park)

Carts are replaced because they reached the end of their useful life or because they were not performing in the field.

Multi-Unit Residential Containers

The City of Saskatoon does not provide garbage containers for multi-unit dwellings and instead offers a Multi-Unit Dwelling Waste Bin Grant to offset the cost borne by condominium associations and property managers for the purchase and maintenance of metal waste bins.

The grant provides $8 per year per residential unit. $265,764 was paid to 740 buildings as part of this program in 2014.

Resources

The containers crew is comprised of 3 permanent staff plus 1 additional seasonal staff in the summer. These employees deliver new garbage containers to new homes, as well as repair or replace damaged containers in the field. They also deliver and retrieve the larger 300 gallon garbage containers for Taste of Saskatchewan, the Fringe Festival, Rib Fest, and other special events.

The containers crew, rear loader crew and a customer service representative are overseen by the Utility Customer Service Supervisor (Debbie Donahue).

Garbage Collections

Collecting garbage from black carts and steel bins across the city.

Garbage Collection from Residential (Curbside) Properties

Garbage collection services are provided to 67,000 single-family homes by a fleet of 21 garbage trucks.

In Saskatoon, the average weight of the contents of each cart on collection day ('tip') is 18 kilograms (40 lbs). The national average was 14 kilograms (31 lbs) according to national benchmarking.

Scheduled garbage collections occur from Monday to Friday, including Stat holidays, except for Christmas Day and New Year's Day. In 2014, weekly collections were conducted from April to October inclusive, with the remainder of the year on a bi-weekly collection schedule. Additional garbage collections were also provided during the Christmas holiday season.

Garbage Collection from Multi-Unit Residential Properties

The City of Saskatoon provides one collection per week for each multi-unit residential property as part of the regular service supported by property taxes. Additional levels of

service may be contracted with the City or through a private waste management company.

The City operates 2 fork-lift trucks in the provision of metal bin garbage collection services to multi-unit residential properties and commercial contracts. Approximately 64% of multi-unit residential properties use the services provided by the City of Saskatoon. The remaining 36% of property managers and condominium associations choose to contract services through private options.

Resources

The Collections group in Public Works is comprised of 17 permanent Utility Collections Operators plus an additional 6 seasonal Utility Collections Operators during weekly collections in the summer.

Operators drive specialty equipment called sideloaders for residential collections and commercial collections of 300 gallon poly containers. Fork truck operators drive large waste trucks outfitted with fork-lift arms to collect waste from metal bins located at multi-unit dwellings and from the commercial sector. They also operate the fork trucks to collect recycling materials from the City-owned recycling depots and deliver this material to Cosmopolitan Industries.

A rear loader crew, consisting of two operators and two labourers, conduct special garbage collection services for elderly or disabled residents. These 4 employees also service the recycling depots by collecting illegally dumped and overflowing materials from in and around the bins. The rear loader crews provide some back lane collection of

illegally dumped materials in the public right of way if the identity of the individual or property from which the material originated cannot be identified.

The Collections crew is overseen by a Supervisor VI (Jose Juarez) and a Supervisor II (Debbie Kautzman).

Commercial Collections

618 commercial customers used the services of the City of Saskatoon in 2014. Rates were last set in 2011 and have remained unchanged. The number of commercial customers has remained relatively stable.

Efficient Waste System

Improving the waste collection system to save fuel, operator time, and improve overall service for residents.

Installation of the Efficient Waste System began in 2014 with the application of barcode tags to carts throughout the city. This initiative was part of a larger project that utilized an internally-provided $1.2 million productivity improvement loan.

The project components include outfitting trucks with GPS, wireless communications, on-board computers, cameras, and barcode readers and a new software tool to achieve the following benefits:

- Efficient routing for Garbage and Green Cart collections services
- Real-time information about the status of collections activities for improved customer service
- More accurate billing for contracted collections services
- Improved drive logs that include photos of collection issues encountered in the field
- Improved tracking of garbage, recycling, and green carts
- An effective and reliable database that merges cart, collection and customer service requests
- Support tools for Environmental Protection Officers
- Enhanced analysis and reporting capabilities to ensure efficient and effective management of waste services

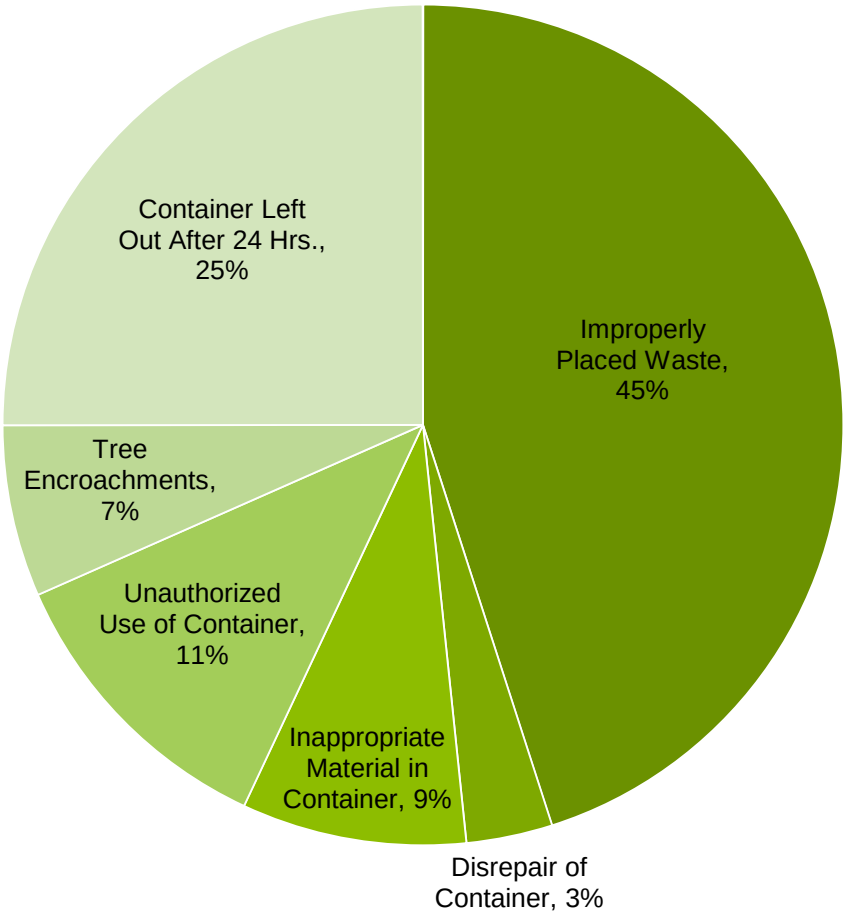
The project also includes improvements to the '306-975-2486' customer service line people call for waste-related matters. System commissioning will be complete in 2015 and new, efficient collection routes will be launched in January 2016.

Waste Bylaw Enforcement

Providing education and enforcement to ensure garbage and recycling are managed by the community in a way that is safe for people and the environment.

Two Environmental Protection Officers (EPO's) focus on issues in the community related to the Waste Bylaw 2004 (Bylaw No. 9071). In addition to enforcing the Waste Bylaw, EPOs are primarily responsible for responding to hydraulic spills, illegal dumping and waste & recycling cart complaints as well as conducting bylaw related education initiatives for the general public.

In 2014, the EPO's addressed more than 486 individual complaints. A breakdown of the types of complaints received is identified below.



New in 2014, the EPOs and landfill staff conducted load inspection blitzes at the landfill during three different summer weekends. These blitzes were intended to educate residential customers on the Waste Bylaw requirements for covering/tarping loads as well as to clarify what materials are accepted or not accepted at the landfill. Nearly 600 individual loads were inspected and customers were provided information on:

- appropriate disposal options for compostable materials;
- paint;
- tires; and
- household hazardous waste.

No tickets were issued during these blitzes as they were conducted as an educational public outreach initiative.

Also new in 2014, was the implementation of neighbourhood blitzes for cart placement requirements under the Waste Bylaw. This education campaign was developed in response to numerous complaints about:

- unsightliness;
- congestion;
- scavenging; and
- theft and damage to waste and recycling carts left in back lanes after collection day.

Back lane inspections were carried out by the EPOs in the Buena Vista, North Park and Caswell Hill neighbourhoods since these neighbourhoods generated the most complaints and operational challenges for back lane garbage and recycling collection.

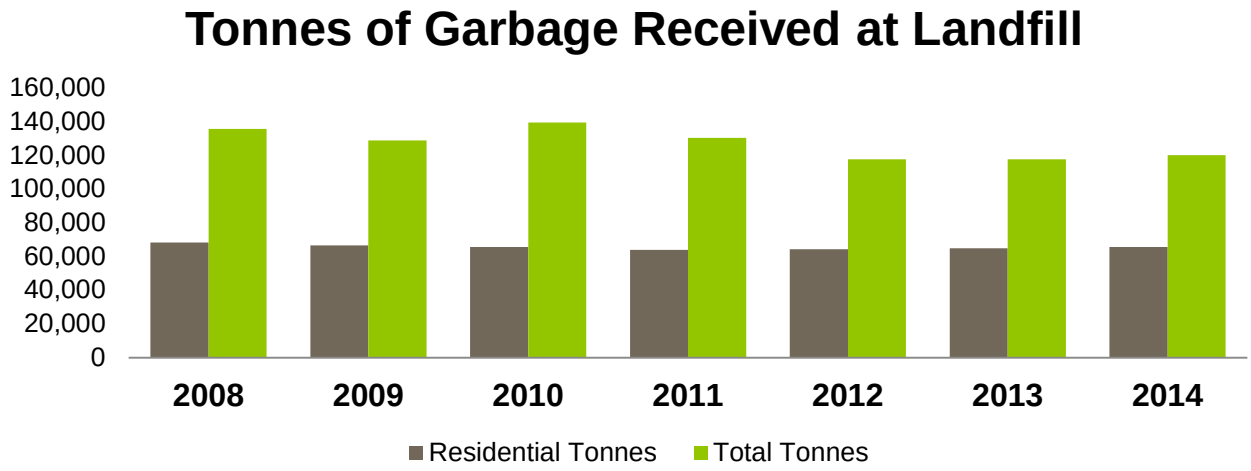
The EPOs delivered education letters to residents whose black or blue carts were left out for more than 24 hours (contravention of the Waste Bylaw) followed by a warning letter and ultimately a notice of violation ($100 ticket) if subsequent inspections showed that compliance was not achieved. Initial inspections showed that up to 35% of homes in certain areas were in non-compliance resulting in more than 1,400 education and warning letters being issued to residents. Following the distribution of education and warning letters to these homes, only 7% of homes were still found to be in non-compliance and a total of 68 tickets were issued in 2014. Cart placement education blitzes have continued in different neighbourhoods in 2015.

Saskatoon Regional Waste Management Centre (Landfill)

A sophisticated facility that is designed and operated to maximize available space and ensure solid waste is managed in a safe and environmentally sound manner.

The Saskatoon Regional Waste Management Centre (landfill) has been in operation since 1955. The Saskatchewan Ministry of Environment currently regulates the operations of the Facility under a Permit to Operate a Waste Disposal Ground.

In 2014, approximately 168,300 tonnes of material was accepted at the landfill, 125,238 tonnes of garbage requiring burial and 43,400 tonnes of clean earth fill used for construction purposes or landfill cover. Over 800 tonnes of metals, white goods, propane tanks, batteries and 49,000 litres of used oil were removed from the site for recycling or disposal as hazardous waste.



The landfill is open to the public every day of the year except for Christmas Day and New Year's Day. The site is a secure compound with fencing and security checks after-hours. Six transfer bins are located on site for public waste disposal. In addition, several public drop-off areas are provided for metals, white goods, batteries, propane tanks, used oil, oil containers, filters and used antifreeze.

Resources

Costs incurred at the Landfill for each tonne of material disposed has increased significantly over the past 10 years, due in large part to significant investment in capital improvements during this period, and increased operating costs to meet regulatory requirements and service levels. Also of significance is the fact that annual tonnages are trending downward, resulting in fixed costs being spread over fewer tonnes. A Continuous Improvement initiative is now underway and cost mitigation strategies are being implemented, including reducing overtime, reducing fleet downtime impacts, and general operating improvements.

The landfill experiences a lot of equipment downtime due to the age of equipment (older than industry averages) and the number of pieces of equipment (fewer than industry averages). A significant proportion of the cost escalation is also attributable to the capital improvement program required to ensure the landfill achieves its full lifespan and complies with current environmental regulations. 41% of 2014 expenditures at the landfill were put toward capital projects.

Landfill attendants carry out various duties including:

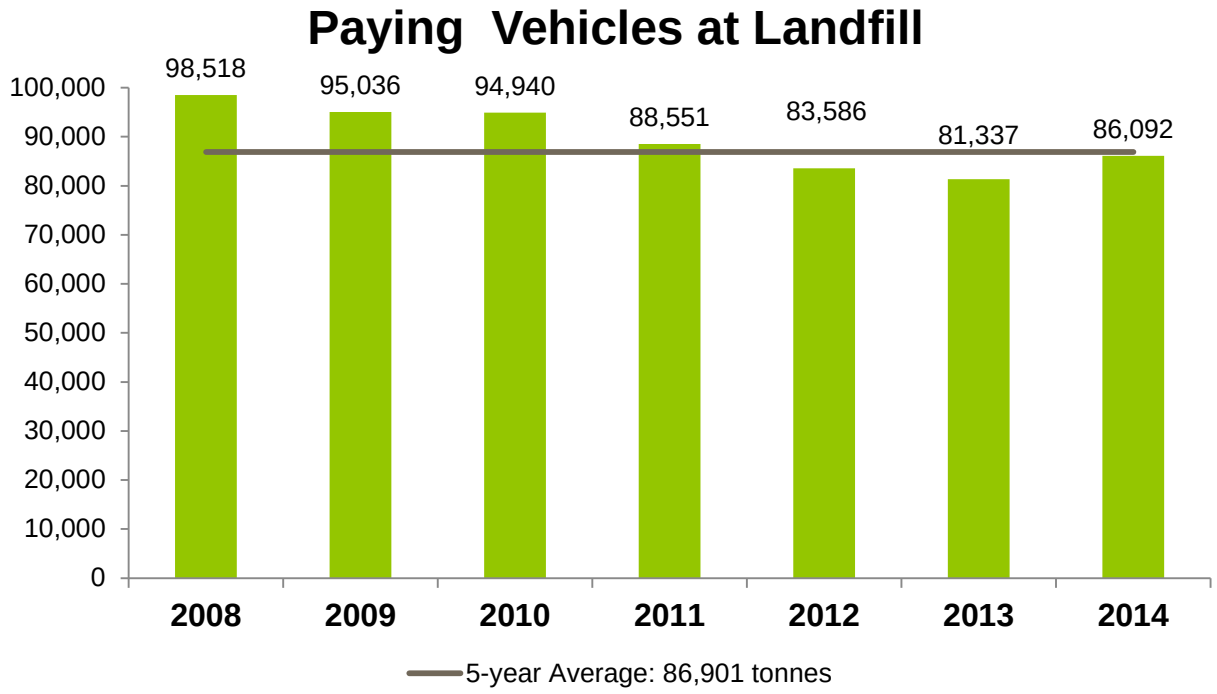
- operation of the landfill scales
- traffic control and load inspection duties at the blue transfer bins and at the active face
- operation of roll-off trucks to haul waste from the public transfer station to the active face
- operation of water trucks for dust control and fire suppression
- operation of equipment for snow removal, sanding
- grading and road maintenance or repairs
- safe operation of the used oil facility and other recycling areas on site

Labourers are primarily responsible for litter management and other site maintenance requirements. Equipment operators ensure that all waste delivered to the active face is compacted and buried in a safe and environmentally acceptable manner.

The landfill employs 5 heavy equipment operators, 12 permanent landfill attendants, 4 seasonal landfill attendants, and labourers. Landfill operations are overseen by two Supervisor VI's and two Supervisor II's who report to the Landfill Superintendent, Todd Christianson.

Landfill Customers

Paying customers at the landfill increased slightly in 2014 over 2013 with a total of 86,092 visitors. While more customers used the landfill in 2014 than 2013, the number of commercial haulers has decreased while residential and other subsidized haulers have increased. Some of the decline in commercial visitors may be a result of competition from the Northern Landfill operated by Loraas Disposal and more recently, competition from Green Prairie Environmental, the new owner and operator of the former South Corman Park Landfill.



Saskatoon has one of the highest rates of residential garbage self-hauled to the Landfill in Canada. The average size of chargeable loads delivered to the Facility has been shrinking and was approximately 0.6 tonnes in 2014. A review of rates and subsidies in 2012 led to changes to the schedule of fees. As of January 1, 2013, all subsidies previously available to customers at the Landfill were removed with the exception of a 75% subsidy which is applied to very small loads weighing less than 250 kilograms. The rationale for this subsidy is to offer options to residents in the absence of a curbside service for the handling of bulky items that may not fit in City-provided roll-out garbage carts. This subsidy, however, is contributing to the shrinking sizes of average loads at the landfill. This, in turn, increases demands for traffic management and can increase wait-times for customers.

According to nation-wide benchmarking for 2014, the range of fees for tipping waste among 31 municipal landfills across Canada is $36.15 to $140 per tonne. Saskatoon's fees, at $95 in 2014, fall in the middle of this range.

Environmental Protection

A number of environmental protection measures are part of the regular operations of the landfill.

Surface water management ensures that any storm water that may have come in contact with garbage does not flow off-site. Storm water management infrastructure also helps minimize the creation of leachate ('garbage juice') and protects roadways and other customer-serving assets of the site. Improvements to storm water infrastructure are integrated into the capital improvement plan for the site.

Ground water monitoring results are reviewed by an independent party each year to ensure the landfill is not impacting the environment beyond its site. In 2014, there were 43 monitoring locations analyzed. Additional leachate collection system development is planned on the basis of monitoring results. 27 hectares of the waste footprint at the Landfill Facility is unlined and leachate interception is therefore an important environmental protection measure.

Fire prevention and suppression is critical. Materials within the mound have the potential to burn for prolonged periods and to release toxins into the atmosphere. Landfill staff are trained in fire prevention and suppression and operate a water truck on-site to respond to incidents in a timely manner. A strong relationship with Saskatoon Fire and Protective Services has also been developed as landfill fires pose a unique challenge.

Landfill gas management began in 2012 with the completion of the clay cap on the north mound of the site. Since then, 29 vertical gas collection wells have been drilled into the waste, the Landfill Gas Collection and Power Generation Facilities were completed and the system was fully commissioned in late 2013. In 2014, the landfill gas system collected and combusted over 190,000,000 cubic feet of landfill gas, reducing the greenhouse gas emissions from the landfill by more than 49,000 tonnes of CO2e or the equivalent of removing 10,200 vehicles off Saskatoon roads.

Greenhouse gas emissions reduction efforts occur at two levels at the landfill. The destruction of landfill gases (which have greenhouse gas concentrations up to 21 times stronger than carbon dioxide) is addressed through landfill gas management. As equipment is replaced, Tier IV emissions-compliant equipment is being selected to significantly reduce this impact.

Customer Service for Garbage Handling Services

Over 10,000 phone calls and voicemail messages are received on an annual basis regarding containers, missed collections, and other inquiries. In addition, the garbage@saskatoon.ca webmail address received more than 2,600 emails which were all responded to in a timely manner.

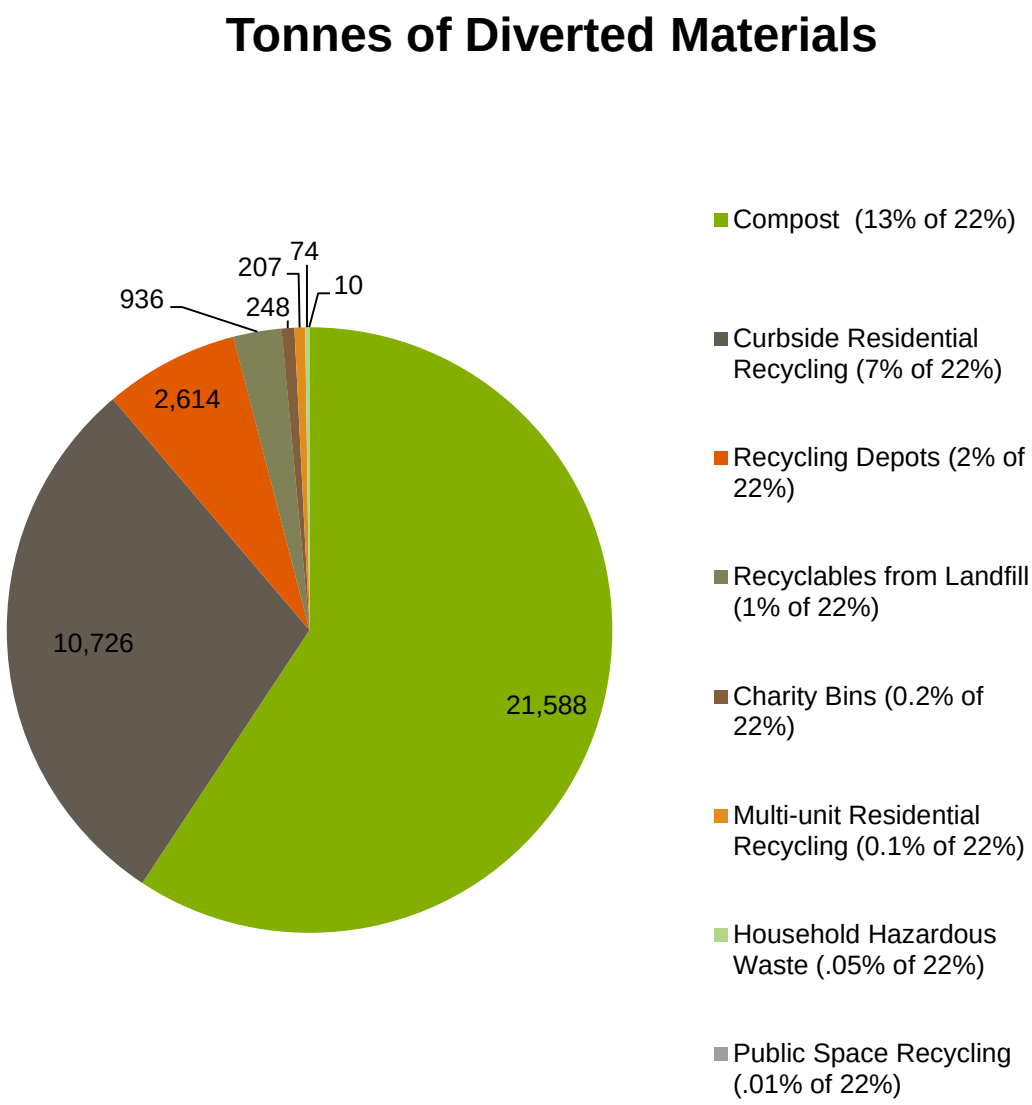
In 2014, collections staff responded to over 2,400 calls about missed garbage collections. With over 2.8 million cart collections conducted on an annual basis, this equates to a 99.9% garbage collection reliability. Approximately 75% of the recorded missed collection calls originated from collections operators themselves when they were unable to collect carts for various reasons such as carts placed too close to fences/power poles/parked vehicles, carts on wrong side of the lane, overfilled carts, inappropriate materials identified in carts (i.e. propane tanks), or other issues.

One customer service representative responds to phone calls received at the 306-975-2486 Waste Stream Management Customer Service Line.

Towards a Waste Diversion Target of 70%

Waste Diversion

Waste is diverted from going to the landfill through a variety of programs and initiatives including recycling, composting, and hazardous waste collection. Additional outreach and education programs include the Saskatoon Curbside Swap, charity bin program, and home composting education that contribute to waste reduction and raise awareness. The figure below shows the tonnes of recyclables diverted from each program (total of 36,338 tonnes), and how each contributed to the diversion rate of 22.5% in 2014.



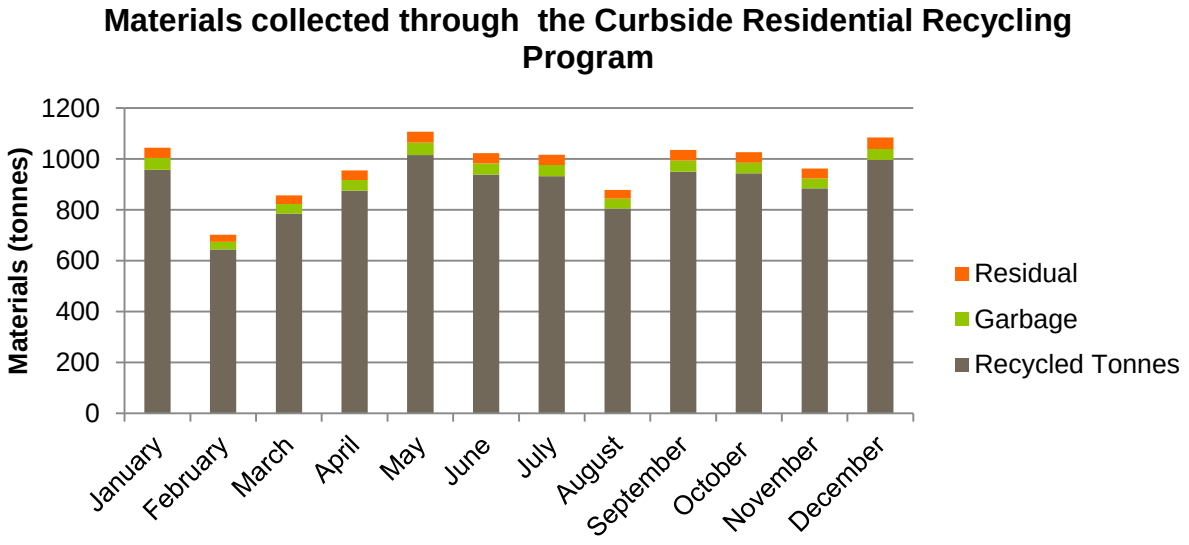
Recycling

Providing convenient programs for all residents to recycle their paper and packaging.

Collections Provided to Residential (Curbside) Properties

Loraas Recycle has been providing curbside recycling service to single family households in Saskatoon since 2013. Each of the 66,793 households participating in the City's curbside program is provided with a blue cart that is collected from their curb every second week based on a published schedule.

- 10,724 tonnes of recyclable materials were recycled, contributing 7% toward the City's waste diversion rate
- 11,104 tonnes of material were collected
- 4% contamination (materials placed in the cart that are not recyclable) and 4% residual (materials that are technically recyclable but could not be recovered usually because of their small size).
- A net reduction in greenhouse gas of 29,027 tonnes can be attributed to the recycling program (includes the 387 tonnes from diesel fuel used in recycling trucks)



The set out rate (or proportion of carts placed at the curb on collection day) averaged 67% for the program in 2014. This does not indicate how many people use their blue carts since many do not necessarily put them out each collection. The participation rate (or proportion of residents using their recycling carts) will be calculated annually starting in 2016 as part of a waste characterization study.

Carts not being collected due to incorrectly placed or overfilled carts continue to occur; there were 1,110 occurrences in 2014. To put this in context, there were over 1.1 million blue carts tipped in 2014, a non-compliance rate of 0.1%. Other ongoing concerns include carts left out in back lanes for more than 24 hours and scavenging of high value materials. These issues are addressed through communications and through warnings and tickets issued by the Environmental Protection Officers (EPO's).

Multi-Unit Residential Properties

The Multi-Unit Residential Recycling (MURR) program was launched on October 6, 2014; approximately 207 tonnes of material was collected through the program in 2014, a greenhouse gas reduction of 448 tonnes over landfilling the same amount of material.

Program deployment went well and residents seem generally pleased to have the service in place. A challenge with the program is the high volume of garbage being found in the recycling containers. Cosmo's initial characterization established that approximately 18% of the materials being collected are non-recyclable. A multi-unit recycling program could be expected to have higher rates of garbage than curbside programs due to the use of large bins placed in publicly-accessible areas.

Customer Service for Recycling Programs

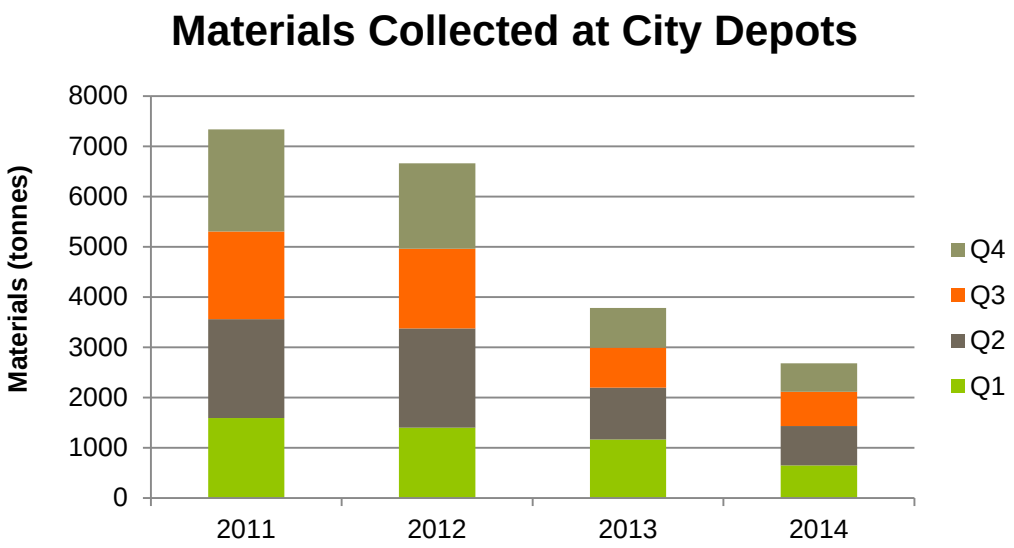
Resident inquiries on curbside and multi-unit recycling programs are responded to by the service providers, Loraas and Cosmo. Inquiries regarding the curbside residential recycling program continue to be low at an average of 0.6% or 368 inquiries per month.

Inquiries were fairly high for the MURR program in the first month at 276, mostly regarding container information. These inquiries decreased to 138 in December.

Recycling Depots

In 2014, 2,679 tonnes of material were collected at the depots contributing 2% to the City's diversion rate, a monthly average of 223 tonnes. Changes were made to the depots program including the closure of the Edmonton Avenue depot and depots on private land. These closures were in response to the decrease in material being received at the depots as shown in the figure below.

In 2014, the Edmonton Avenue depot was closed and the City ceased collections from any depots on private land. These closures were in response to the decrease in material being received at the depots as shown in the figure below. The four remaining depots now accept the same materials accepted in the MURR and curbside programs in a single stream with no sorting, as does all recycling at Civic facilities (started at the end of 2014). The bins at the depots remain the property of Cosmopolitan Industries Ltd. and all materials are collected by the City and processed at Cosmo's Material Recovery Facility. New signage and bin decals have been updated to communicate the change.



Materials from the recycling depots are collected and delivered to Cosmopolitan Industries by Civic staff Monday, Wednesday, Friday, and Saturday; and clean-up crews visit the depots Monday, Wednesday, and Friday.

Education and Engagement
Making sure Saskatoon residents know how to Put Waste in the Right Place.

Information about the City's waste and recycling programs are available online, through Facebook, Twitter, and at festivals and events.

Visitors to the City's website (Saskatoon.ca) and the SaskatoonRecycles.ca microsite access up-to-date information on anything they need to know to manage their waste including:

- collection schedules;
- how to use their blue, black, and green carts;
- landfill rates and hours; and
- other tips on reducing or diverting waste.

There were 164,809 page views on SaskatoonRecycles.ca.

Each household received a personalized print calendar with the garbage, recycling, leaves and grass, and household hazardous waste schedules. Residents can also:

- view their calendar online;
- download a PDF calendar from the website;
- sign up for collection reminders by e-mail, phone, or twitter; or
- add their schedule to their own online calendar.

Personalized online collection calendars were viewed by 24,589 unique households, 5,455 calendar PDF downloads, and 4,418 residents were receiving collection reminders.

The public can also find out about other local recycling opportunities through the Saskatchewan Waste Reduction Council's province-wide online database of information on where to recycle a variety of materials. The City of Saskatoon partners with the Council in promoting this online tool: http://www.saskwastereduction.ca/

Citizens were engaged at events using the "Spin and Sort" and "Yep, Nope" sorting game. Summer staff attended 12 events in 2014, where they encouraged children and adults to learn about waste management through interactive activities. Other communications occurred through the "Put Waste in the Right Place" campaign on radio, newspaper, social media, and online advertising.

Saskatoon Curbside Swap

Building community while keeping reusable items from ending up in the landfill.

Curbside Swaps are fun and environmentally friendly ways for residents to get rid of unwanted items that are still in good condition, as well as “hunt” for new treasures. In 2014, four curbside swaps were held in College Park, City Park, Buena Vista, and Meadowgreen. The City supported the community association to organize and promote the swap in their neighbourhood. The swaps were well attended as long as the weather held and feedback through a survey of participants showed that survey respondents wanted an event to occur the next year.

Composting Programs
Services such as voluntary curbside collection, drop-off depots, and education programs help residents divert organic waste from the landfill.

The Leaves and Grass Subscription Program served 3,900 households in 2014. Leaves, grass, and non-woody yard waste is collected at the curb from May to November on a bi-weekly basis. Materials are composted at the City's Highway 7 compost depot along with materials from public and commercial customers.

Two compost depots, one on McOrmond Drive and the other on Highway 7, provided residents the opportunity to drop off yard waste at no charge. These temporary locations accept leaves, grass, non-elm tree and shrub branches, as well as garden waste that would otherwise end up in the landfill.

More than 51,000 vehicle visits were made to the depots in 2014, including 40,000 visits made by residents, 9,400 visits from commercial haulers and 2,000 visits from City departments. An estimated 22,000 tonnes of compostable material was managed at the depots in 2014, resulting in the avoidance of approximately 5,000 tonnes CO_2e.

Approximately 150 commercial companies purchased $200 permits which provided unlimited access to the depots for the season. Commercial haulers brought in approximately 28% of the materials delivered to the depots.

The depot on McOrmond Drive closed at the end of the 2014 season. A new compost depot transfer station opened on Highway 5 in 2015.

Compost depot operations are overseen by the Depots Supervisor (Roland Rusnell).

Compost Education

The City provides composting education through a partnership with the Saskatchewan Waste Reduction Council (SWRC). The SWRC has been running composting education programs since 1993; and in partnership with the City since 1995. New Master Composters are trained each year (there is now over 200) and in turn engage the community through volunteer work providing education at events, presentations, workshops, and home visits. Home visits were a new initiative in 2014 that was expanded in 2015. Master Composters visit a new composter at their home to help them set up a composting system or troubleshoot an existing one.

In 2014, 16 new Master Composters were trained and they along with existing Master Composter volunteers attended 13 events and made 10 home visits.

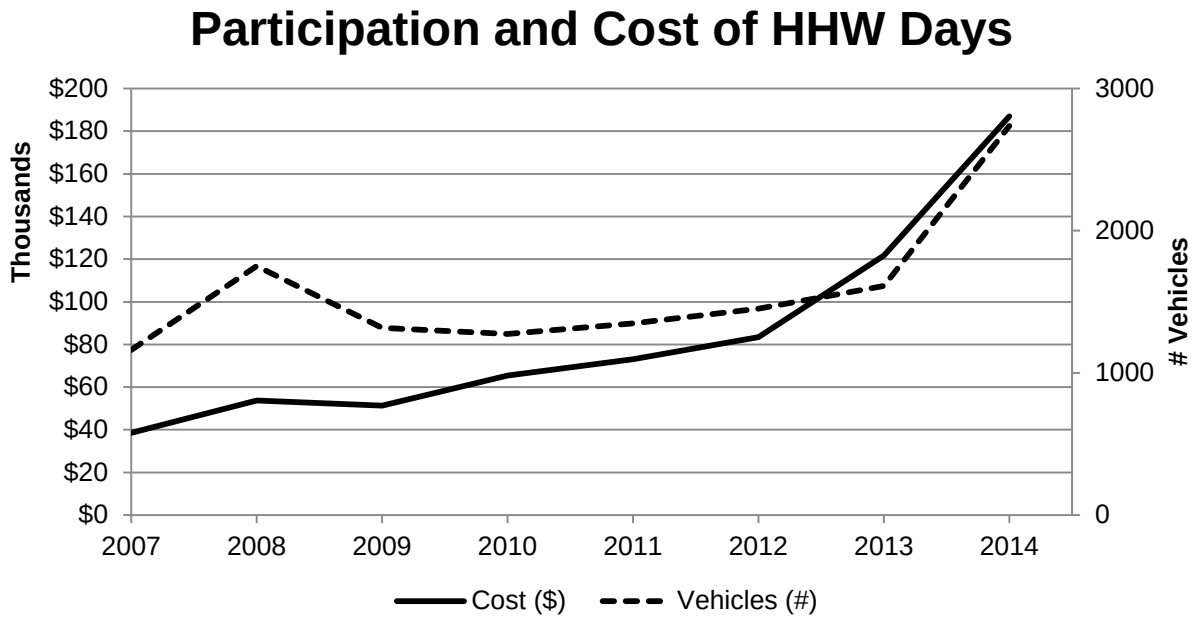
Compost bin rebates of $20 were also offered to residents in 2014 (an increase from $10 in previous years). 60 compost bin rebates were administered.

Composting, and the use of compost, will also be encouraged through the Healthy Yards program started in 2015; a partnership with the University of Saskatchewan Master Gardeners and the Food Bank and Learning Centre.

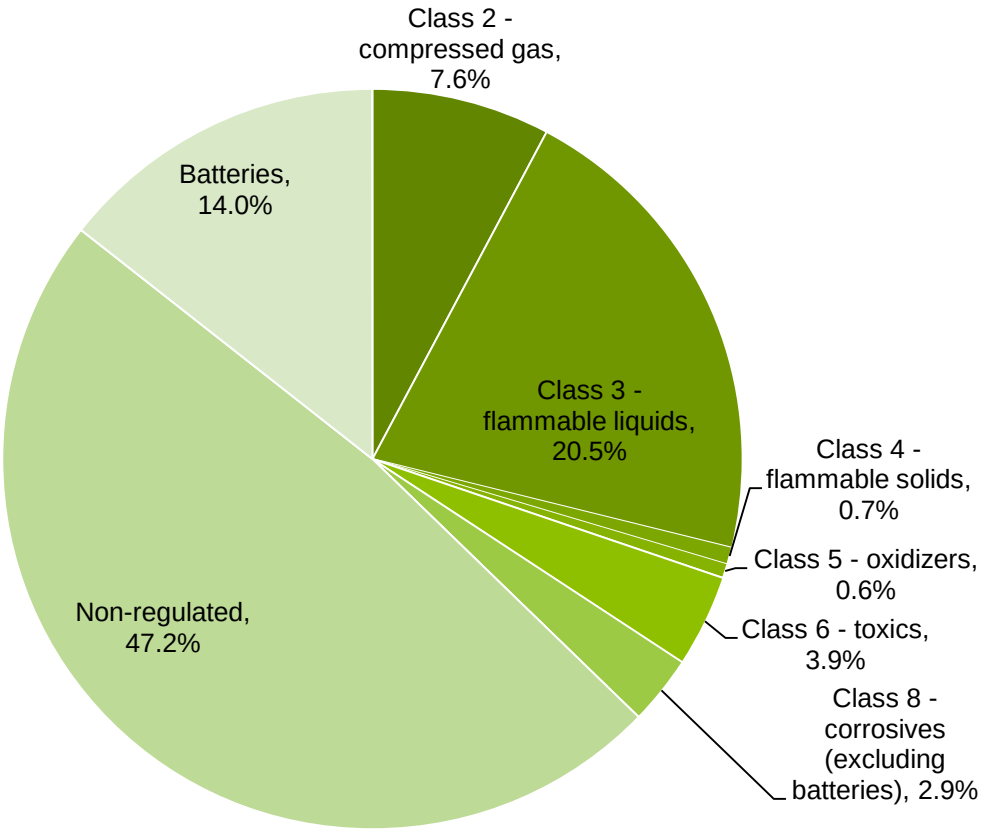
Hazardous Waste

Keeping hazardous waste out of the landfill, waterways, and environment.

In 2014, 12 Household Hazardous Waste Collection Days collected 72,126 kilograms (an increase over 2013 of 40%) of hazardous materials from 2,737 customers. The number of vehicles, the amount of hazardous materials collected, and the cost of the program have all risen since 2013.



Hazardous Materials Collected through HHW Days in 2014



Class 2 (compressed gas): aerosols, propane tanks, inhalers, fire extinguishers
Class 3 (flammable liquids): flammable liquids, paint and paint-related materials, adhesives, printing ink
Class 4 (flammable solids): flammable solids
Class 5 (oxidizers): oxidizing solids and liquids, organic peroxide
Class 6 (toxics): toxic liquids, pesticides, pharmaceuticals
Class 8 (corrosives): corrosive liquids and solids, mercury, ammonia solution
Batteries: alkaline, lead-acid, lithium
Non-regulated: oil, oil filters, oil containers, antifreeze, fertilizers, liquid cleaners, non-PCB light ballasts, fluorescent tubes, CFL bulbs, ink cartridges, lighters, treated railway ties
Other/miscellaneous: PCB light ballasts, sharps, smoke detectors, e-waste, test samples (unknowns)

Household hazardous waste materials are also responsibly managed at the landfill. An Eco-Centre for the recovery of oil, oil containers, and oil filters has been established in partnership with Saskatchewan Association for Resource Recovery Corporation (SARRC). The Eco-Centre (one of 36 across Saskatchewan) captures in excess of 20,000 litres of used oil, over 1,000 used oil filters, and more than 1,200 kilograms of oil containers each year. These materials are reused and recycled, saving approximately 53 tonnes of $C0_2e$ each year.

2015 Update to Our Environment: The City of Saskatoon's Environmental Leadership Report

Recommendation
That the report of the General Manager, Corporate Performance Department dated October 13, 2015, be forwarded to City Council for information.

Topic and Purpose
The purpose of this report is to provide the 2015 update to the City of Saskatoon's Our Environment Report.

Report Highlights
1. The 2015 update to the City of Saskatoon's 'Our Environment' Report is provided in the form of an online reporting tool highlighting the status of 12 selected indicators representing the key components of the state of Saskatoon's environmental health – air, land, water and waste.
2. Key findings include:
    - The waste diversion rate for 2014 of 22.5% was relatively unchanged from the 2013 rate of 22.7% and needs improvement to meet the target of 70%.
    - The amount of landfilled residential waste per capita is down to 249 kilograms per capita in 2014 from 340 kilograms per capita in 2007.
    - The percentage of residents choosing to walk, cycle or take transit to work has been relatively stable between 11.5% and 14.4 % for the past two decades and needs improvement to meet the target of 20%.
    - Saskatoon's air quality has been showing a slow downward trend over the past decade, with the average Air Quality Index ranking as 'Good' over the past 5 years, down from the ranking of 'Excellent' that it has for the previous 5 years.
    - The water quality both upstream and downstream of Saskatoon has consistently ranked as Good in the Water Quality Index since 2005.
    - The amount and distribution of new development investment has been added as a baseline indicator and illustrates that investment in development activities are balanced across the city.

Strategic Goals
The 2015 update addresses the Strategic Goal of Environmental Leadership. It includes the following success indicators from the Strategic Plan: waste diversion, water consumption, corporate greenhouse gas (GHG) emissions, the ecological footprint of Saskatoon, and community gardens. It further addresses the vision, priorities and strategies of the Strategic Plan in the areas of sustainable growth and transportation, protected lands, water quality, and reducing landfilled waste.

Background
On August 19, 2014 the Standing Policy Committee on Environment, Utilities & Corporate Services received Our Environment: The City of Saskatoon's 2014 Environmental Leadership Report.

Report

The first Our Environment report was released in 2014 based on the City of Saskatoon's (City) Strategic Plan Goals and success indicators. The report established baseline data for 44 environmental indicators in Saskatoon.

In 2015, the first online update has been created to update 12 selected indicators, represent key components of environmental health where data is available and highlight recently set Corporate Targets. The update builds on the baseline data in the 2014 Our Environment report. Additional indicators will be added in future online updates and new data posted when it is made available. The update can be found at saskatoon.ca/ourenvironment.

The "Where are we now?" section includes maps and charts to visually display the data in an easy to read and web-friendly format. The update compares the most recent data with the baselines published in the 2014 report and, when applicable, the targets adopted by the City. Graphics are used to indicate the trend shown by the data:

- An upward trending arrow for "improving"
- A horizontal arrow for "stable"
- A downward trending arrow for "needs improvement"

The "What are we doing?" section shows how the City is taking action to maintain or improve the environment. The section highlights three initiatives, provides a brief summary and provides a link to where more information can be found.

The "What can you do?" section is newly added as part of the update. It provides residents with opportunities to take action and get involved, highlighting simple things people can do in their homes, schools and workplaces, and ways to participate in city led initiatives.

The 12 selected indicators and their trends (Attachment 1) are:

Ecological Footprint	Needs Improvement
New Development Investment	Baseline
Protected Lands	Stable
Community Gardens	Improving
Corporate Greenhouse Gas Emissions	Needs Improvement
Community Greenhouse Gas Emissions	Needs Improvement
Transportation Choices	Needs Improvement
Air Quality	Needs Improvement
Water Quality	Stable
Water Consumption	Stable
Landfilled Waste	Improving
Waste Diversion	Stable

Communication Plan
Communications include the news media and the City's social media accounts along with the City's website, which has been updated to reflect the performance of key indicators for the Our Environment report.

Environmental Implications
As a report focused on environmental health, Our Environment provides an overview of key performance indicators relating directly to the City's Strategic Goal of Environmental Leadership. Where applicable, the implications associated with the indicators have been identified in the report.

Other Considerations/Implications
There are no policy, financial, privacy, or CPTED implications or considerations.

Due Date for Follow-up and/or Project Completion
The full Our Environment report is anticipated to be updated and published every 3 years, with the next full report in 2017. Updates on specific indicators are anticipated to be communicated through the City's website annually.

Public Notice
Public Notice pursuant to Section 3 of Policy No. C01-021, Public Notice Policy, is not required.

Attachment
1. Summary of Updated Indicators

Report Approval
Written by:	Katie Burns, Environmental Coordinator
Reviewed by:	Amber Jones, Manager of Education and Environmental Performance
	Brenda Wallace, Director of Environmental & Corporate Initiatives
Approved by:	Catherine Gryba, General Manager, Corporate Performance Department

Administrative Report – 2015 Update to Our Environment.docx

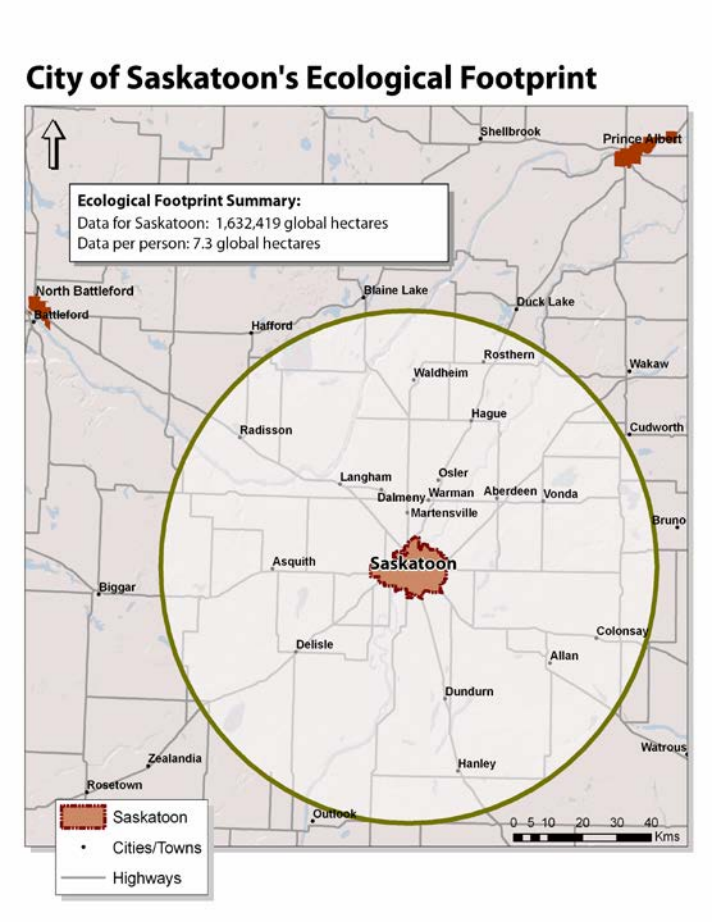
SUMMARY OF UPDATED INDICATORS

Ecological Footprint (needs improvement)

The Ecological Footprint is a tool that compares the total resources consumed by a community, to the amount of land it would take to support that consumption.
The ecological footprint is a success indicator in the City's Strategic Plan.

Where are we now?

In 2010, Saskatoon's Ecological Footprint was 75 times larger than the city's total land area. The average ecological footprint per resident was 7.3 global hectares which was 4% higher than the national average in Canada. A new Ecological Footprint report for Saskatoon will be released at the end of 2015.



Source: City of Saskatoon Ecological Footprint Analysis, 2011

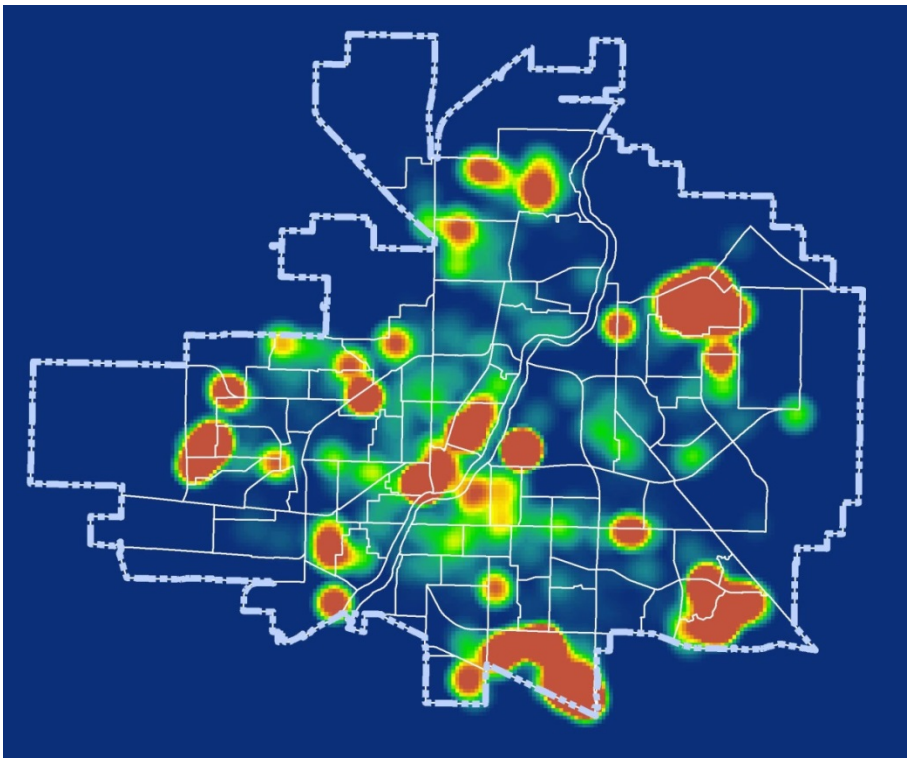
New Development Investment (baseline)

Saskatoon is growing. The location of new development and the amount that is being invested shows how the City's policies on the built environment are being put into action.

The City's Strategic Goal of Environmental Leadership and the success drivers of energy efficiency and responsible land use impact how we grow. A balance between investing in the downtown core, established neighbourhoods and new neighbourhoods with more sustainable design, will help conserve natural and agricultural lands, conserve water and energy, and reduce the cost of building new infrastructure like roads, water and sewer lines.

Where are we now?

Investment in new developments is spread throughout the city, with the greatest concentrations in the downtown and new Greenfield communities. In 2014, there were 4,968 building permits with a total value of $871,254,000. $2,112,000 of this value was for demolition permits. The total value of permits is higher in the red areas and the dark blue area has no values.



Source: City of Saskatoon – Planning & Development

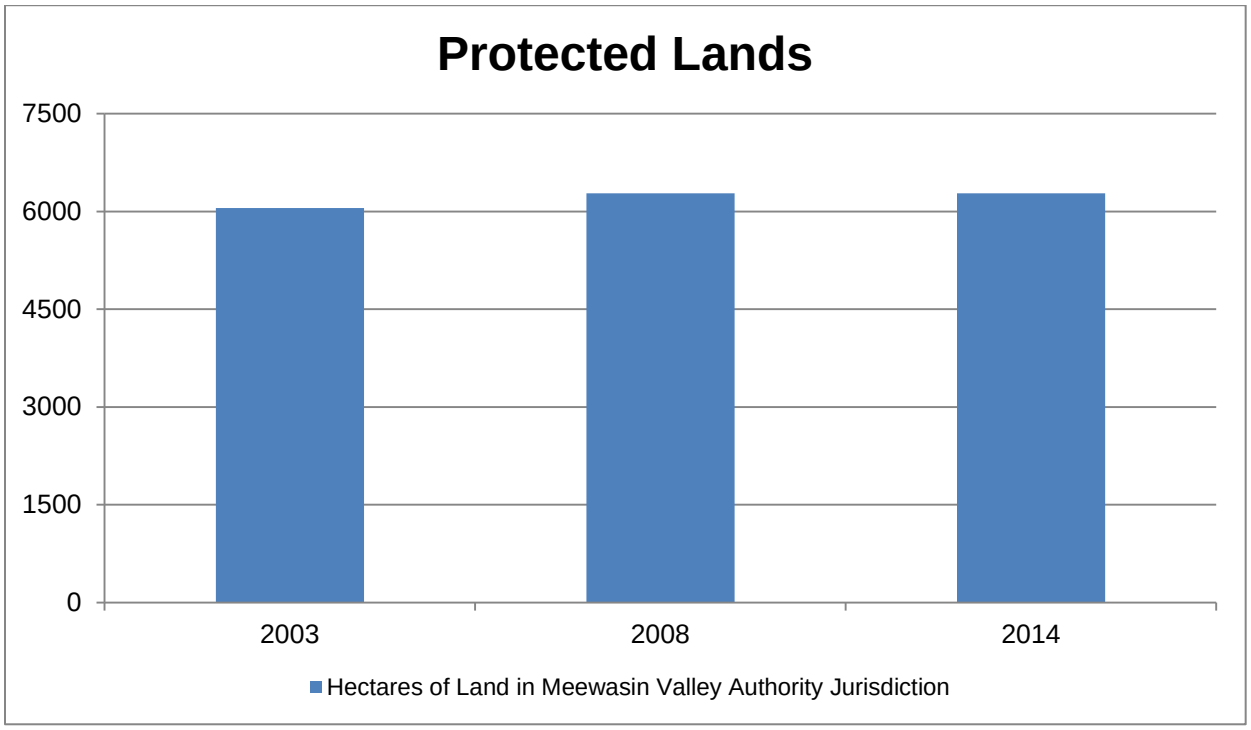
Protected Lands (stable)

The natural, undeveloped areas within our city support a diversity of plants and wildlife, perform “ecological functions” such as reducing and filtering storm water, storing greenhouse gases, removing harmful pollutants from the air, and contribute to our overall well-being and health.

Protected lands are an important part of our natural areas network and help meet the long-term Environmental Leadership strategy in the Strategic Plan to improve access to ecological systems.

Where are we now?

The amount of protected lands in the Meewasin Valley Authority jurisdiction has remained unchanged between 2008 and 2014.



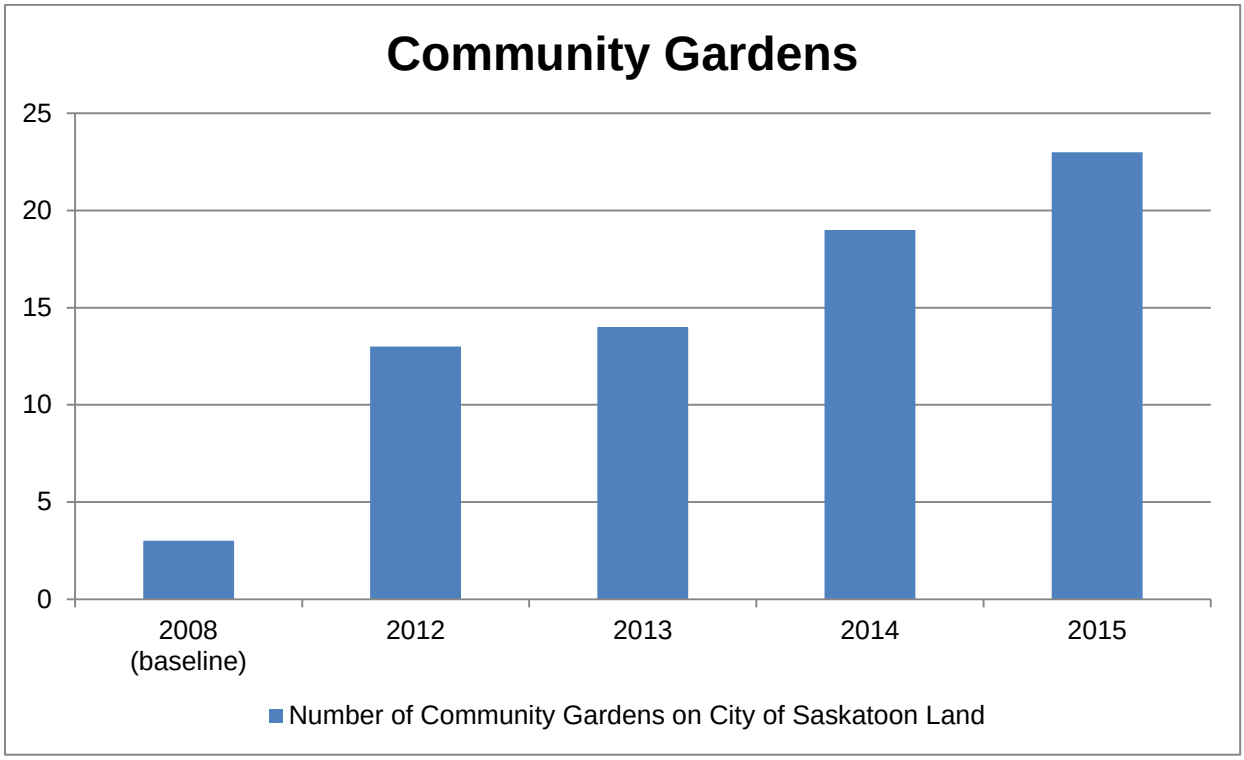
Source: Meewasin Valley Authority

Community Gardens (improving)

Growing food in our neighbourhoods provides fresh, healthy food that has a lower environmental impact. Community gardens on public land provide opportunities to grow food for residents that do not otherwise have access to land suitable for gardening.

The number of community gardens is one of the success indicators in the Strategic Plan.

Where are we now?
The number of community gardens on city-owned land is increasing.



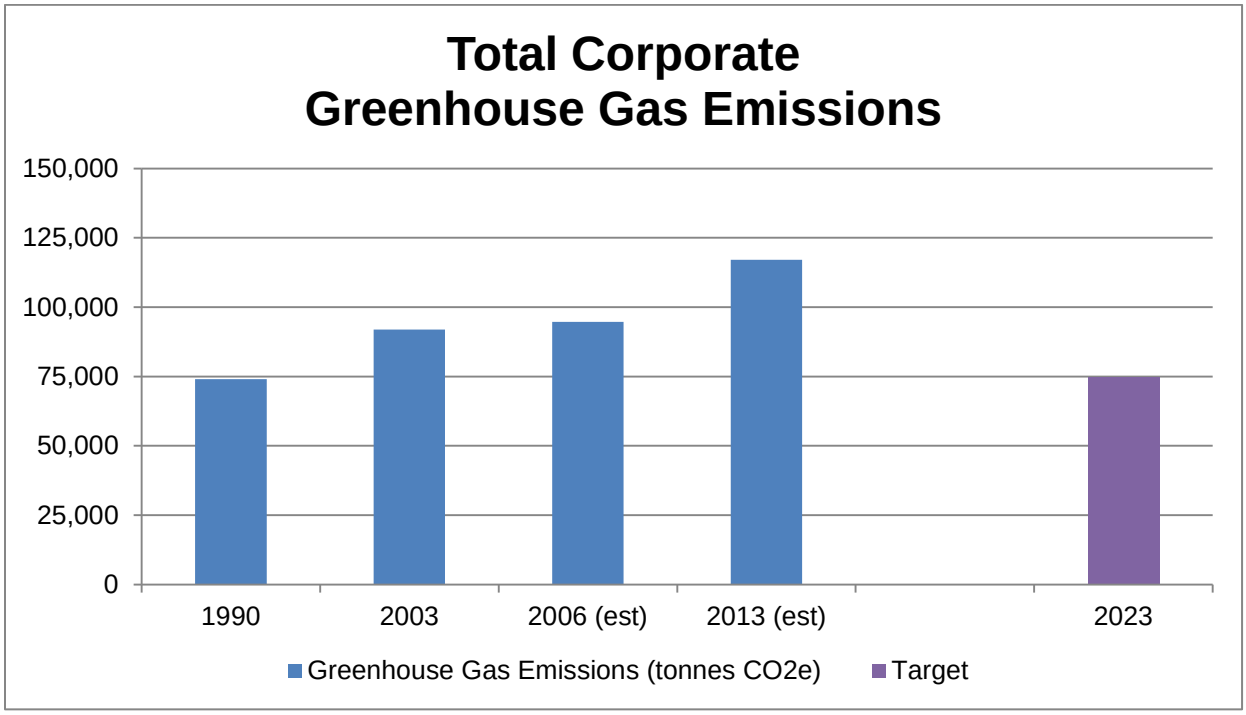
Source: City of Saskatoon – Community Development

Corporate Greenhouse Gas Emissions (needs improvement)

Greenhouse Gases (GHGs) are linked to climate change which is predicted to increase the frequency, and intensity of extreme weather events such as droughts, floods and storms. The City of Saskatoon has a role to play in reducing GHGs from its own operations and showing leadership in our community. The City of Saskatoon has adopted the target of 75,000 tonnes of CO_2e by 2023.

Where are we now?

The City of Saskatoon's corporate GHG emissions have increased since 2003. A new inventory is being compiled for 2014 emissions.



Source: ICLEI Energy Services, 2005; City of Saskatoon Environmental & Corporate Initiatives

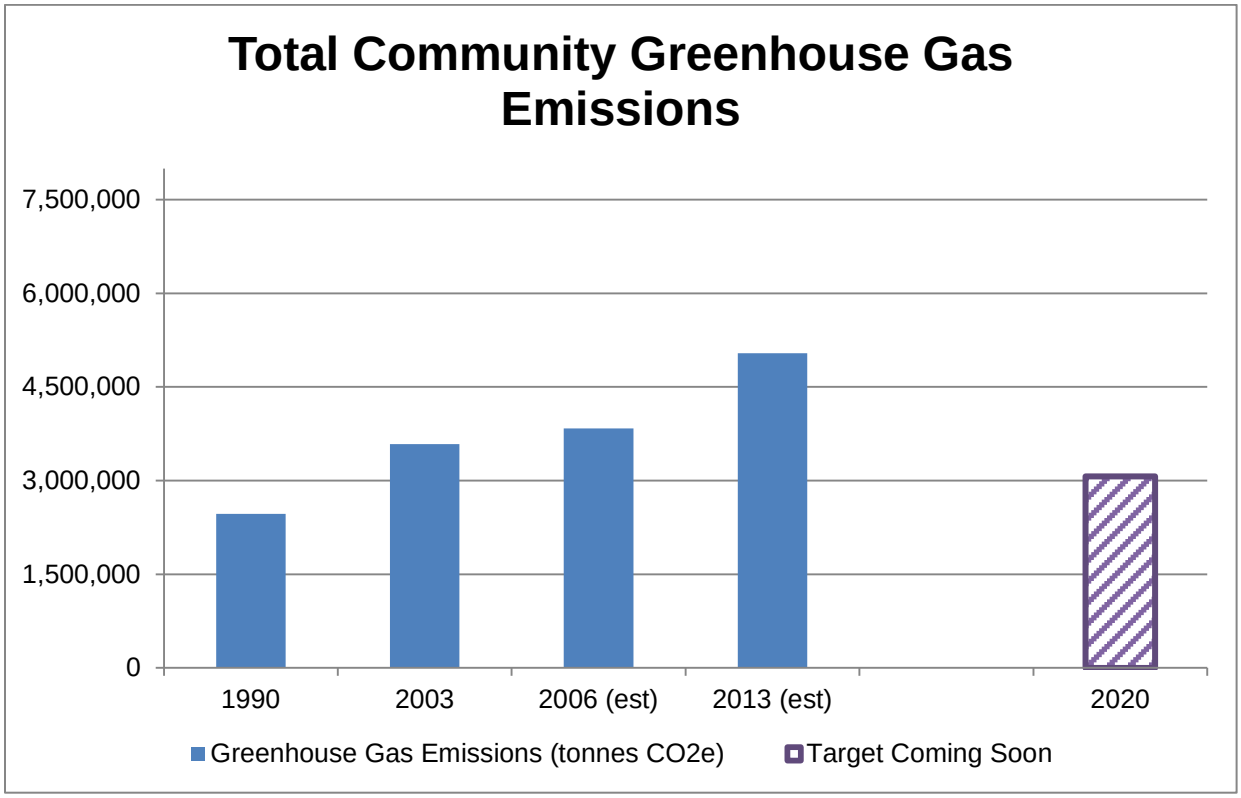
Community Greenhouse Gas Emissions (needs improvement)

The emissions from the community as a whole show the combined impact of businesses, institutions and residents.

The City of Saskatoon is in the process of adopting a target for community GHG emissions.

Where are we now?

The community's GHGs have increased since 2003. A new inventory is being compiled and the Saskatoon Environmental Advisory Committee is selecting a reduction target.



Source: ICLEI Energy Services, 2005; City of Saskatoon Environmental & Corporate Initiatives

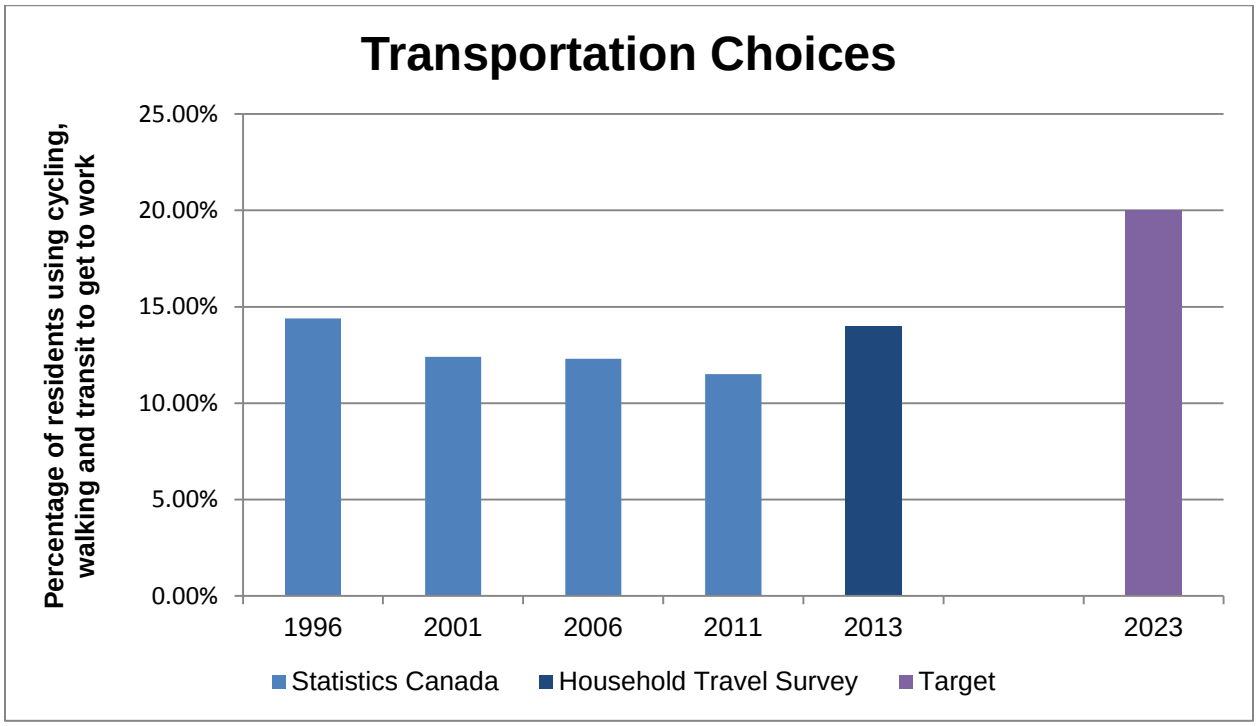
Transportation Modes (needs improvement)

Transportation impacts the environment, with vehicles generating more GHG emissions and requiring more land for road infrastructure than public transportation, cycling and walking.

The City of Saskatoon has adopted the target of 20% of residents using cycling, walking or transit to get to work by 2023, and is in the process of developing new targets for 2045 as part of the Growing Forward Growth Plan.

Where are we now?

The percentage of residents using cycling, walking or transit to get to work has been relatively stable since 2001, and needs improvement to meet the 2023 target adopted by City Council.



Source: Statistics Canada

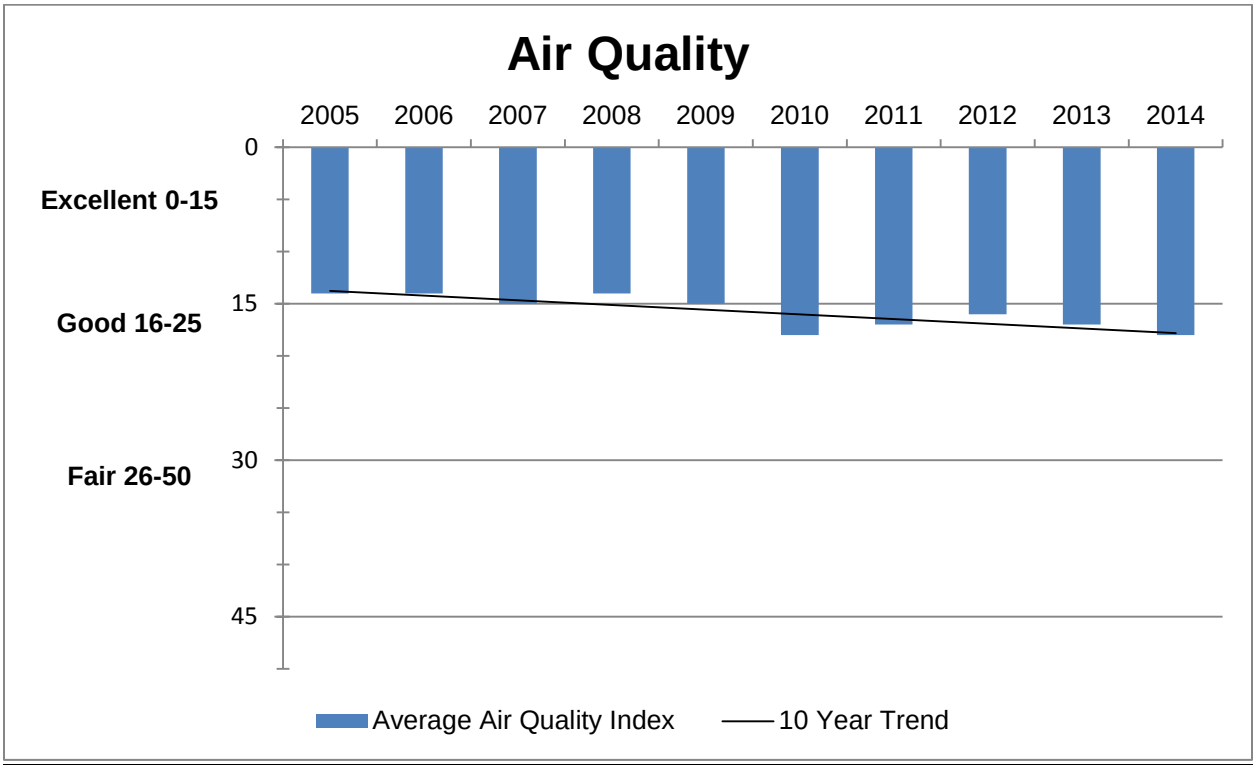
Air Quality (needs improvement)

Good air quality is important to our health and the environment. While Saskatoon has many favourable features for good air quality, sources of pollution make ongoing monitoring important.

The Strategic Plan vision statement for Environmental Leadership includes clean air.

Where are we now?

Saskatoon's average air quality was ranked as 'Good' by the Air Quality Index in 2014, and has been showing a slow downward trend over the past decade. This means that on average residents with severe respiratory ailments now may notice minor effects, when prior to 2009 the air quality was ranked 'Excellent' and there were no known health impacts.



Excellent	0-15	No known harmful effects to soil, water, vegetation, animals, materials, visibility or human health.
Good	16-25	No known harmful effects to soil, water, vegetation, animals, materials, visibility or human health. Persons with severe respiratory ailments sensitive to air pollution may notice some minor effects.
Fair	26-50	Adequate protection against harmful effects to soil, water, vegetation, animals, materials, visibility and human health. Persons with severe respiratory ailments sensitive to air pollution may need to modify their usual outdoor activities if experiencing effects.

Poor	51-100	Not all aspects of the environment and human health are adequately protected from possible adverse effects. The general population should consider reducing or rescheduling strenuous outdoor activities and higher-risk populations should reduce or reschedule outdoor activities.
Very Poor	>100	Continued air quality in this range could pose high risk to environment and public health.

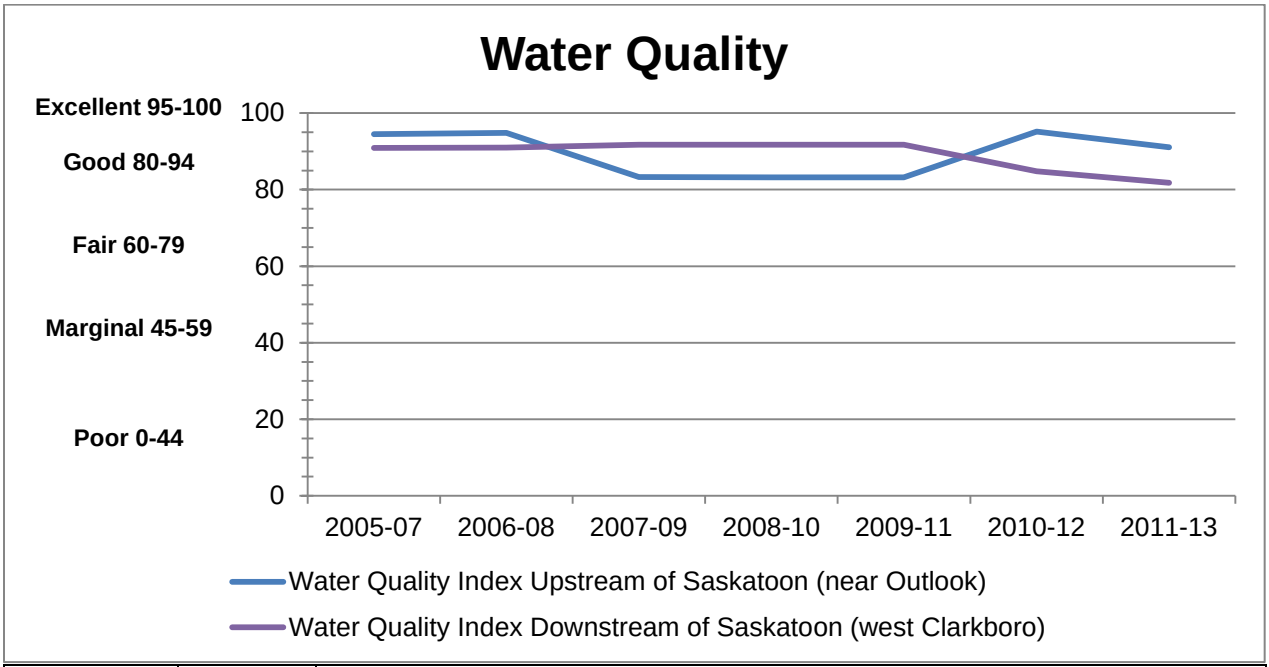
Source: Government of Saskatchewan: 2015 State of the Environment Report

Water Quality Index (stable)

Water is essential for our health and for our community to prosper. As water passes through our community, the impact can be determined through comparing upstream and downstream water quality.

The Strategic Plan has the long term strategy to reduce the impact of storm water run-off that is going into the river.

Where are we now?
The South Saskatchewan River, upstream and downstream of Saskatoon, has consistently averaged 'Good' water quality.



Rating	Value	Description
Excellent	95-100	Water quality is protected with a virtual absence of threat or impairment; conditions very close to desirable levels. These index values can only be obtained if all measurements are within objectives virtually all of the time.
Good	80-94	Water quality is protected with only a minor degree of threat or impairment; conditions rarely depart from desirable levels.
Fair	60-79	Water quality is usually protected, but occasionally threatened or impaired; conditions sometimes depart from desirable levels.
Marginal	45-59	Water quality is frequently threatened or impaired; conditions often depart from desirable levels.
Poor	0-44	Water quality is almost always threatened or impaired; conditions usually depart from desirable levels.

Source: Government of Saskatchewan, Water Security Agency, Annual Report for 2014-15 State of Drinking Water Quality in Saskatchewan

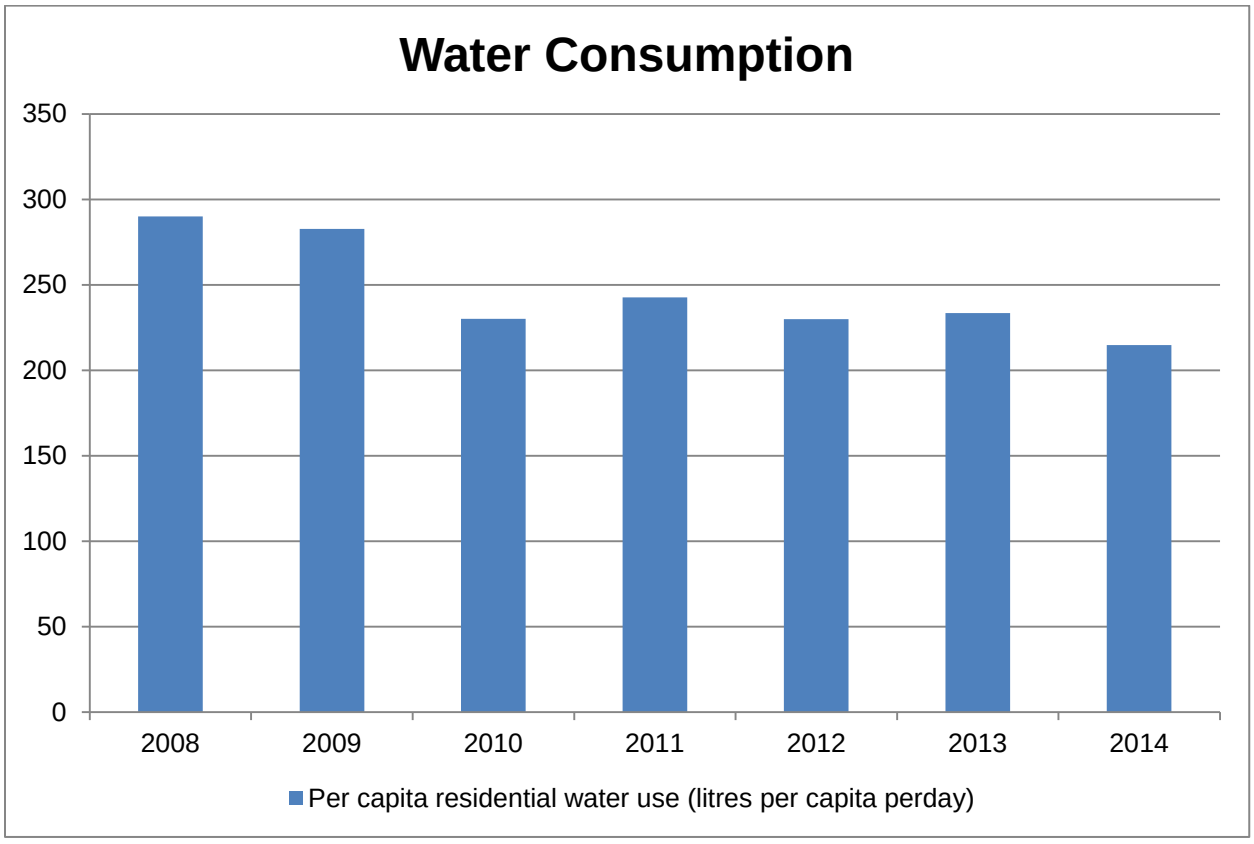
Water Consumption (stable)

Saskatoon benefits from an abundance of water from the South Saskatchewan River. The treatment of water and waste water; however, use significant energy and chemical inputs, generating environmental and financial concerns as the city grows.

Measuring the per capita water consumption is a success indicator in the Strategic Plan.

Where are we now?

Per capita residential use improved when new conservation-based water rates were introduced in 2010, and have remained fairly stable over the past 5 years.



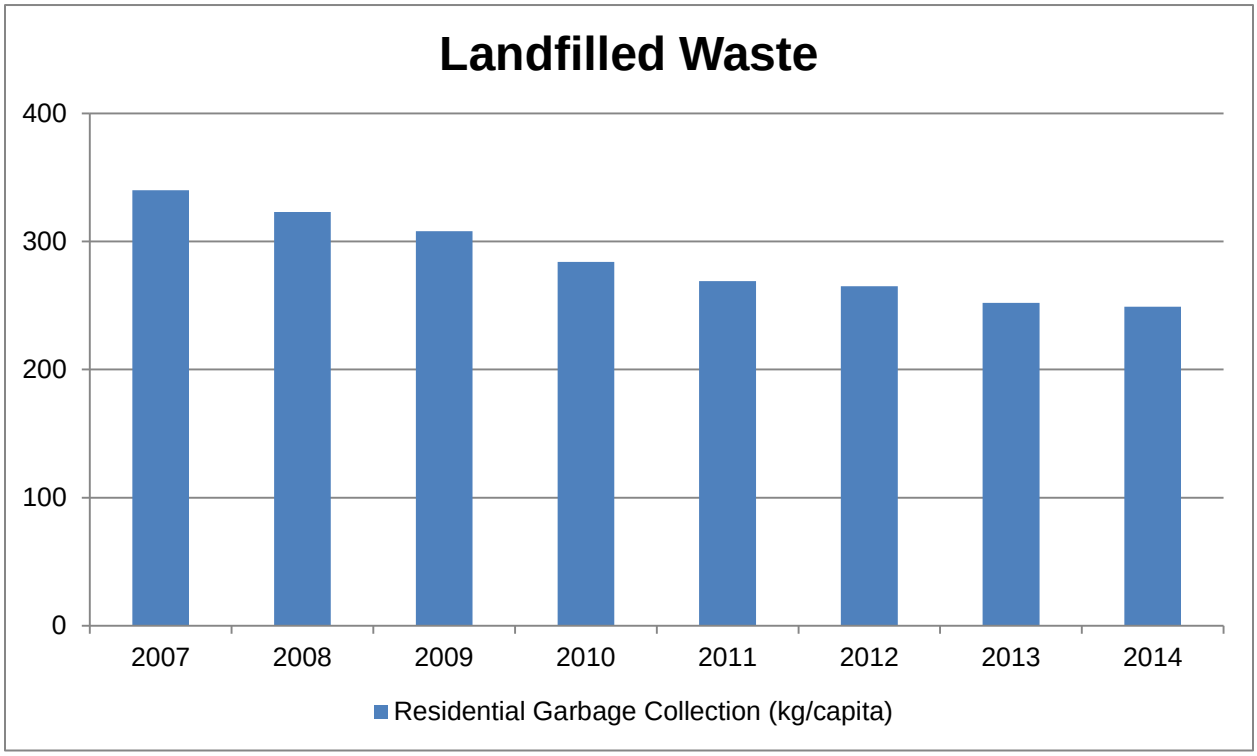
Source: City of Saskatoon – Saskatoon Water

Landfilled Waste (improving)

As our population grows the amount of waste we are generating increases and changes. The current landfill has a lifespan of 40 years and the construction of a new landfill would be costly.

Reducing the waste that is landfilled is a priority in the Strategic Plan.

Where are we now?
The amount of waste each resident sends to the landfill is decreasing.



Source: City of Saskatoon – Environmental & Corporate Initiatives and Public Works

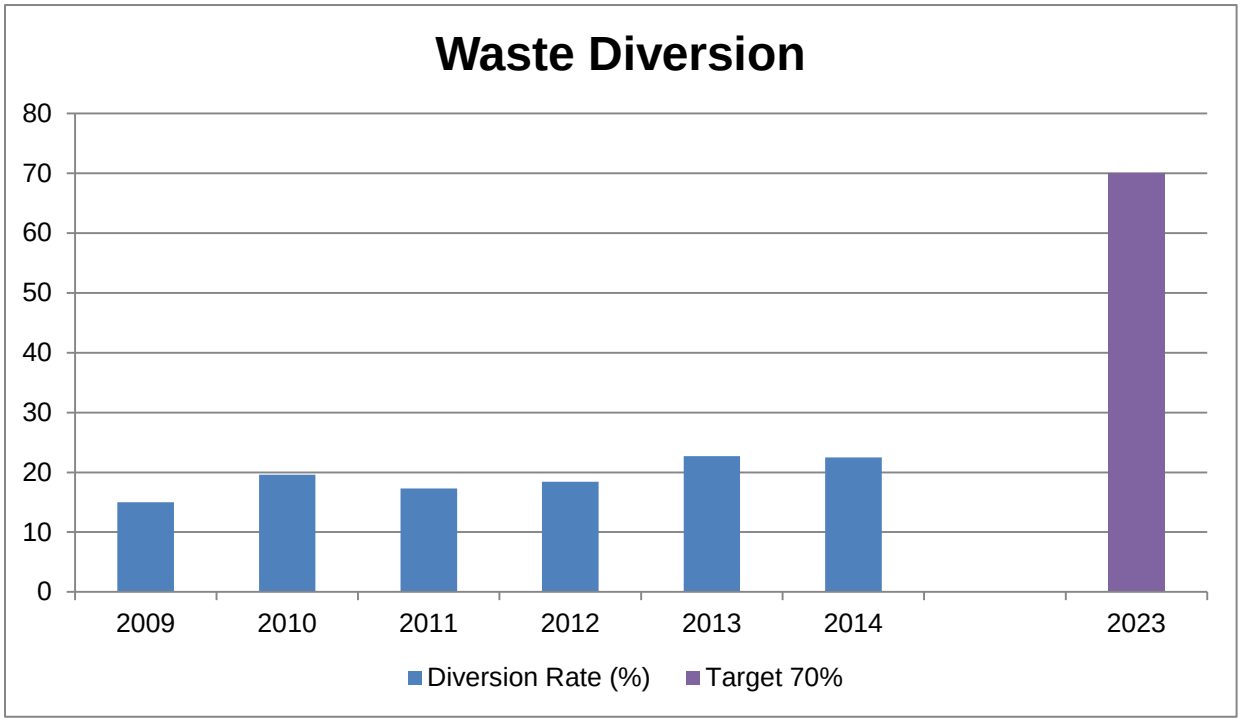
Waste Diversion (needs improvement)

The amount of material diverted from the landfill can reduce environmental impacts and extend the operating life of the current landfill.

The diversion rate is a success indicator in the Strategic Plan.

Where are we now?

The percentage of waste being diverted from the landfill has remained stable over the past year; however, improvement is needed to meet City Council's 2023 target of 70%.



Source: City of Saskatoon – Environmental & Corporate Initiatives and Public Works

Saskatoon Environmental Advisory Committee

Stormwater Management

Jill Bishop
August 27, 2012

Table of Contents

1. Executive Summary

Stormwater management refers to the strategies used to capture and remove precipitation runoff within municipalities. The conventional approach was to drain it directly into nearby surface waterways. However, runoff carries pollutants, which are transported with the stormwater. Therefore, much research has been devoted to "developing alternative approaches to conventional stormwater management focusing on rainwater management, infiltration of rainfall on site, and detention of runoff during large storm events, rather than piping it directly into urban streams."[1] Furthermore, climate change is impacting rainfall intensity, duration and frequency. Many municipalities are shifting their stormwater management practices; integrating source controls and utilizing technology to achieve precise design that encompasses changing variables.

This report will examine the stormwater management practices employed by municipalities in Canada, North America and Internationally. The focus will be on surface management practices that prevent the water from entering pipes. It will present a series of recommendations for Saskatoon stormwater management.

2. Introduction

Stormwater can be managed in a variety of ways. The conventional approach is to collect runoff from the street and send it directly into nearby surface waterways via stormwater infrastructure. The underground infrastructure used to convey stormwater is the minor system component. Management practices must also consider the overland flows, or the major system components. Major systems include the behavior of stormwater in excess of the minor system and the natural flow paths. The major system can be designed to include storage basins, swales, rain gardens and other methods that mimic natural stormwater storage and filtration.

Many municipalities are in a situation similar to Saskatoon, with stormwater infrastructure that was originally designed with a capacity that is overwhelmed with increasing runoff quantity. As cities grow, more hard surfaces generate more runoff because there is less permeable area available to absorb the stormwater. It is then forced along routes and into infrastructure that was designed in smaller capacity than is currently needed. Hence, municipalities are employing innovative designs for stormwater infrastructure, coupled with creative ways to keep stormwater out of the pipes.

Flood prevention is the primary goal of stormwater management. Thus, quantity is vital to stormwater design criteria. Design criteria refers to the amount of stormwater the infrastructure is designed to carry. Pollution is the result of sending water off the streets and into natural waterways. Pollution is often the secondary consideration, but is equally important from an environmental perspective. Water quality is often considered in stormwater design and especially in low impact development (LID). LID refers to methods of development that seek to maintain the pre-development infiltration rates of a property. This means a reduction of hard surfaces by employing permeable designs. This report will examine the best management practices (BMPs) employed elsewhere, focussing on practices that would benefit the city of Saskatoon.

3. Municipal Stormwater Management Practices in Canada

1) Toronto, ON

Design Standards

Toronto's minor system is designed for a two year storm event, and the major system is designed for a one in a hundred year event.[2] These storm descriptors are more accurately described in annual probability. A one hundred year storm has a one percent likelihood of occurring in any given year, whereas a two year storm has a fifty percent chance of occurring. In Toronto much of the infrastructure is old, and cannot accommodate larger design pipes feeding into the old and smaller diameter pipes. Toronto's older areas are served by combined sewers.[3] The city recommends utilizing hydrologic simulation modeling to determine the water balance targets, but is flexible where other innovative approaches can achieve on-site water balance qualities.[4] Planning should include an integrated approach that attempts to maintain the predevelopment runoff volume[5] and utilizes low impact development.[6] Designs that seek to maintain predevelopment volumes attempt to mimic natural infiltration rates after development. This means that developers accommodate for extra runoff from impervious surfaces by using storage and filtration methods.

Innovation and Education

Toronto was the first North American city to pass a bylaw[7] requiring green roofs on new developments with a floor space of greater than 2,000 square metres.[8] As a result they are quickly becoming a leading city for the implementation of green roofs. Toronto has developed a 25-year Wet Weather Flow Master Plan to mitigate stormwater pollution[9]. The plan employs educating residents and utilizes innovative source controls. Toronto is also employing quality monitoring to ensure that the correct modifications are implemented over their 25-year Wet Weather Flow Master Plan[10]. Monitoring will enable them to evaluate the success of their Master Plan.

Water Reduction Strategies

Toronto also has a mandatory downspout disconnection program which comes into effect over five years, and is introduced and enforced over quadrants of the city[11]. Toronto has an online Homeowners' Guide to Rainfall,[12] providing tools to prevent pollution and promote source control of stormwater. It includes rainwater harvesting, swales and rain gardens,[13] and an accessible Do It Yourself section for calculations and sizing for low impact landscape solutions.[14]

2) Winnipeg, MB

Design Standards

The city of Winnipeg requires minor system design capacity for a five year storm event,[15] and major systems either 25 year storm (local ditches) or 100 year storm for regional waterways.[16] This criteria is typical for Canadian new development designs. Hydraulic calculations are determined using detailed continuous methods including EPA-SWMM.[17] SWMM is dynamic rainfall runoff simulation modelling software, developed by the American Environmental Protection Agency. It simulates storm events, and enables developers to measure the performance of designs during recorded storm events.

Water Reduction Strategies

Downspouts must be disconnected from sewage lines,[18] and the same goes for sump pumps.[19] Winnipeg investigated the feasibility of Water Sensitive Urban Design (WSUD), but found climate and clay soil as difficulties.[20] In spite of these challenges, Winnipeg implemented design policies including retrofitting streets with WSUD,[21] and guiding new development design to incorporate watershed sustainability through low impact development.[22] They are preparing an urban design/streetscape standards for their downtown that include source controls such as green roofs, swales, rain gardens, and green roofs.[23] Source controls aim to contain precipitation where it falls, rather than conveying it to nearby waterways.

Innovation and Education

Winnipeg provides no visible education on stormwater management. The focus is on draining away from homes, and does not instruct regarding on site management. The city mandates that "generally a constructed wetland is to be about 5% of the total watershed area or drainage area, depending on the volume and quality of runoff."[24] They promote the use of constructed wetlands as stormwater retention emphasizing the benefits of preservation of natural streams and the constructed stormwater system.[25] Winnipeg now boasts of 48 naturalized stormwater systems throughout the city.[26]

3) Calgary, AB

Design Standards

Calgary mandates capacity of minor system components for a five year storm event.[27] Calgary has required this design criteria since 1952.[28] Prior to that, the city allowed for construction of minor systems with a design criteria of a two year event.[29] Major systems must accommodate a 1-in-100 year return period event.[30] These practices employ the unit area release rate method, rather than the rational method for the sizing of storm trunks.[31] The Calgary Guidelines explain the shortcomings of the rational method, "when the drainage area exceeds 30 ha, there is a marked inequity in trunk capacity (expressed as capacity per hectare drained) in the downstream direction."[32] The unit area release method seeks to avoid this inequity in trunk capacity by uniformly distributing the trunk capacity across the trunk tributary. See page 10 of the appendix for details on Calgary's unit area release method.

Water quality in Alberta is governed more strictly than in Saskatchewan. Pursuant to several Alberta regulations,[33] operation of stormwater systems requires a permit to operate which mandates water quality monitoring. Therefore, Calgary's stormwater systems are monitored for quality as per their stormwater permit.

Water Reduction Strategies

The city of Calgary has also identified the seven source control management practices most suitable for the climate, including vegetated swales, absorbent landscaping, porous pavement, rainwater harvesting, and green roofs.[34]

Innovation and Education

Education is central in an online video titled "The Bow is Below"[35], teaching residents about the watershed and how people impact the river. The city website provides education through 'how to' manuals on rain gardens,[36] and brochures on rain barrels.[37] The city claims that over 30% of Calgarians are now using rain barrels. The city's water conservation efforts are achieving results; they have experienced a decrease in per-capita water consumption and are on target to reduce water consumption by 30% in 30 years.[38]

4) Edmonton, AB

Design Standards

The *City of Edmonton's Design and Construction Standards, Volume 3: Drainage*[39] sets out guidelines for storm water management for the city. Edmonton does not allow for combined sewer systems,[40] and their minor systems must accommodate a five year return period event. Edmonton's system is mandated to increase the capacity of the infrastructure serving a large catchment area. [41] The city of Edmonton mandates that the major storm water system be designed to accommodate runoff rates and flow characteristic of a one hundred year return period event. It also has provisions regarding depths relevant to landscape gradients. The guideline mandate that a system design be computer tested against 4 event criteria, all of which are one hundred year events. Continuous modelling is required where storage facilities are connected in a series,[42] and computer simulation design recommends the use of the DHI – Mike Urban or Mouse computer models.[43] Like SWMM, these models enable simulations of designs.

Water Reduction Strategies

Edmonton also has a Low Impact Development BMP Design Guide,[44] setting out the best methods for installing swales, rain gardens, green roofs, permeable pavement and methods of rainwater harvesting.[45] The city's commitment to watershed protection has led to the construction of four wetlands and facilities to accommodate their long term strategy of pollution reduction in stormwater.[46]

Innovation and Education

The city of Edmonton has an innovative monitoring program, monitoring their four largest outfalls, which carry roughly 60% of the storm water from the city.[47] The sampling is automatic, and engaged when the water volume reaches a certain point. Monitoring parameters include TSS, BOD5, TP, TKN, (NO-2+NO-3)-N, NH3-N, Cl-, and *E. coli*.[48] Their monitoring program has enabled Edmonton to establish total loading goals for the quality of the river upon receipt of all effluent from the city.

The city of Edmonton website provides public education on low impact development and on site management of precipitation runoff. They also provide economic statistics to encourage runoff harvest as a way to reduce water use and cost.

5) Red Deer, AB

Design Standards

According to Red Deer's stormwater Management Drainage systems guidelines, minor stormwater systems must facilitate storms of a 1 in 5 year return period, "where reasonably attainable in the opinion of the engineer".[49] The major system shall be designed to convey and store stormwater from a 1 in 100 year storm event.[50] The modelling software utilized in Red Deer is XP-SWMM.[51] Continuous simulation should be routed through the model to determine storage characteristics for the catchment.[52]

Water Reduction Strategies

The city sells rain barrels[53] and has a rain barrel decorating contest[54]. City bylaws prohibit the connection of downspouts to any wastewater sewer, unless approved by the Director.[55]

Innovation and Education

Red Deer provides no visible public education on stormwater management. Their rain barrel decorating challenge is an innovative strategy to promote the use of rainwater harvesting equipment.

6) Kelowna, BC

Design Standards

In Kelowna, minor system design must accommodate a 1-in-5 year storm event.[56] Flows resulting from 2-year storm events are to be routed through a form of water quality treatment facility to remove suspended solids and floatables[57]. The major system design must accommodate a 100-year storm event.[58] It does not appear that software must feature continuous simulation modeling, but it must demonstrate surcharges in a variety of simulations.[59] Surcharges occur when the system experiences an overload of stormwater. The resulting in backflow occurs in low lying portions of the system as water from throughout the catchment exits the system by 'surcharging' out of the drains and onto the surface. Kelowna design simulations must show the problem areas and establish the storm intensity that will cause such backflow or surcharge.

Water Reduction Strategies

The city of Kelowna has a new consolidated zoning bylaw that mandates green development[60] and states that the "run-off entering storm sewers should be minimized through appropriate site design"[61]. Aside from that, the city does not appear to promote low impact development. Roof leaders may only connect directly to the storm drains where there is a geotechnical requirement.[62]

Innovation and Education

Kelowna does not provide public education on stormwater management. Their bylaw that mandates green development is an innovative way to ensure sites contain some stormwater.

7) Victoria, BC

Design Standards

The *British Columbia Local Government Act* permits municipalities to regulate runoff and stormwater.[63] The Capital Region District monitors the quality of stormwater.[64] The Victoria region is served by a combined sewer system and overflows sometimes spill into sensitive waters.[65] Their design criteria differ from conventional separate sewer models – but the area is upgrading their Northwest Trunks to accommodate design storms with a return period of 100 years.[66]

Water Reduction Strategies

The region promotes low impact development to prevent combined system overflows.[67] This is a strategy employed elsewhere in North America and Internationally.

Innovation and Education

The capital region district of Victoria provides education on green roofs, swales, permeable paving, and rain gardens.[68] Their promotion and education do not seem to create the results experienced elsewhere; perhaps due to lack of incentive. They do not practice stormwater management in a particularly innovative manner.

4. Municipal Stormwater Management Practices in America

The United States Environmental Protection Agency's *Clean Water Act*[69] prohibits all unauthorized discharges into surface water. Authorization is provided through a permit, which requires post construction inspection and monitoring.[70] There are different permits and subsequent monitoring requirements for separate systems and combined systems, but each require quality monitoring and define the parameters of monitoring programs.

1) Seattle, WA

Design Standards

Seattle employs Green Stormwater Infrastructure, employing an integrated model for design criteria.[71] "The State of Washington (2004) has adopted an extremely stringent channel protection criterion that requires the duration of post-development peak stormwater discharges match pre-development durations for the entire range of storms between 50% of the one-year storm and the 50-year event. Designers must use a continuous hydrologic simulation model (e.g. HSPF) to demonstrate compliance".[72] This means that the development must mimic original, pre-development infiltration rates, and developers must show compliance by running the development through a simulation storm. The designs employ green infrastructure rather than focussing on extensively on minor system components, and are designed to accommodate variables prevalent to a changing climate.

Water Reduction Strategies

Seattle had 62 green roofs as of December 2009[73]. The city has a green factor landscape design requirement, which mandates low impact development[74] of 30% equivalent plant coverage in residential zones and 50% in multi-family residential zones[75]. The aim is for development to closely resemble natural infiltration rates, which decrease runoff. Permeable paving, rainwater harvesting and green roofs all contribute to a better score on the green factor[76]. One of Seattle's most innovative projects was the Street Edge Alternatives Project[77], which retrofitted a residential street with low impact development. "City engineers designed the system to reduce the peak discharge rate and volume from a two-year 24-hour storm event (1.68 inches) to predevelopment conditions".[78]

Innovation and Education

Seattle provides education on the low impact development that they mandate. Their mandate is innovative and provides a score based on how well sites resemble pre-development infiltration rates. This demonstrates commitment to stormwater management.

2) Portland, OR

Design Standards

Portland design criteria is a 1-in-10 year return period storm,[79] and they utilize Lidar technology[80]. They employ continuous simulation models in their facilities design.[81] Their permit (under the *Clean Water Act*) requires that they conduct stormwater quality monitoring[82]. They must monitor the parameters set out in the American Environmental Protection Agency's Separate Stormwater Sewer (MS4) Permit: 3 times yearly conventional field monitoring of mercury, pesticides, metals, and nutrients.[83]

Water Reduction Strategies

The city of Portland implemented a "Grey to Green"[84] initiative in 2008. The initiative utilizes green roofs (ecoroofs) and green streets (featuring low impact development)[85], but also emphasizes revegetation with native plants in natural areas. This design facilitates water filtration, and will "better able to adapt to climate changes"[86]. Stormwater is managed through restoration projects that improve water quality, reduce storm water pollution, and provide erosion control – ultimately enhancing fish and wildlife habitat.[87] Additionally, the city encourages Portlanders to plant trees. This is facilitated through utility bill rebates and the purchase of trees at discounted rates[88].

Innovation and Education

Portland's new design policy requires "design and construction of all new city-owned facilities to include an ecoroof (green roof)"[89] This demonstrates the municipality's commitment to "greening" the city. They classify the roofs into several categories, one of which is a roof garden and designed for pedestrian use and enjoyments[90]. Roof gardens enhance properties by creating recreation space on the roof of a building. Like a typical green roof, they have double the life expectancy of a conventional roof, and mitigate some of the heat island effects. The city provides education on green roofs and low impact development as ways of mitigating stormwater runoff.

3) Minneapolis, MN

Design Standards

Minneapolis uses topographic information from United States Geological Survey topographic maps, or from MetroGIS (a regional geographical information system database). This data is used in a continuous simulation model. The Minnesota Pollution Control Agency General Stormwater Permit requires statewide design criteria[91], and water quality monitoring[92]. As a component of their Pollution Permit, the city of Minneapolis is required to monitor water quality at 10 locations.[93] The city's design manual indicates the frequency and type of sample required for the permit.[94] According to the design manual, in addition to daily precipitation monitoring, they monitor for total suspended solids, total phosphorus, metals, nutrients, and the biological properties of the effluent.

Water Reduction Strategies

Minneapolis uses integrated stormwater management, looking "at both the movement and content of stormwater".[95] Water retention and quality are essential to the integrated model employed across Minnesota.[96] The Minnesota Stormwater Design Manual instructs on the design of both extensive and intensive green roofs[97], including the plant list and instruction on engineering best practices[98]. The manual also promotes using compost as a soil amendment in post-construction to reduce erosion and increase infiltration,[99] and porous paving and rainwater harvesting.[100] Their stormwater ordinance requires redevelopment sites (private or public) of 1 acre or larger to include on-site stormwater management. Since its adoption, the ordinance has resulted in approximately 700 structural BMPs at over 370 sites within the city.[101] Minneapolis also requires the disconnection of roof downspouts from the sanitary sewage system under their Rainleader Ordinance.[102] Removal of rainwater from sanitary systems prevents combined sewage overflows.

Innovation and Education

Minneapolis has a Stormwater Quality Credits Program that allows residents and business owners a credit of up to 50 percent of monthly stormwater charges.[103] "The purpose of the quality credits program is to encourage

city residents to manage rainwater in ways that help deal with problems arising from stormwater runoff in an urban environment."[104] The credit is based on the percentage of the impervious surface runoff captured by best management practices that contain stormwater on properties.[105] However, the credits program has not been well received, and some suggest that increasing water delivery prices would serve as a better incentive.[106] As a component of their Environmental Protection Act National Pollutant Discharge Elimination System stormwater permit, Minnesota must provide public outreach.[107] Therefore, the state provides accessible education on stormwater pollution and prevention.

4) Philadelphia, PA

Design Standards

The pipe capacity in Philadelphia must convey the peak runoff from a ten-year 24-hour rainfall event.[108] This is larger than the norm in Canada, likely because Philadelphia features combined and separate sewer infrastructure and must factor the likelihood of an overflow into their calculations. They also have a permit requiring stormwater monitoring and employ continuous simulation modelling in their design standards.

Water Reduction Strategies

Philadelphia employs low impact development to prevent combined system overflows. They promote downspout disconnection to reduce the amount of non-sewage in the sanitary system.[109] Philadelphia also uses integrated site design[110] which includes soil infiltration testing.[111] Integrated site design considers soil infiltration rates and overland flows to ensure best management of precipitation on-site.

Innovation and Education

In 2007 the city instituted a tax credit program for businesses installing a green roof and committing to maintain it for five years.[112] Eligible roofs must cover 50% of the rooftop (or 75 percent of the area structurally able to support a green roof).[113] Philadelphia would then provide a tax credit for 25 percent of the cost of installation, to a maximum of $100,000.[114] The goal was to reduce impervious areas and subsequently reduce runoff. The city is currently undertaking a 25-year plan to turn at least one-third[115] of its impervious surfaces into green areas, thus implementing swales, rain gardens, pervious pavement and other low impact development strategies. A 2010 report found that Philadelphia had 64 planned and constructed green roofs at that time, totalling 826,924 square feet of green roof.[116] The report predicts that Philadelphia will be one of the greenest cities in the USA by 2015.[117]

These incentives are coupled with education programs that empower residents to make the changes needed to reduce runoff in Philadelphia.

5) Chicago, IL

Design Standards

Chicago has both combined and separate storm sewers. They must be designed to convey at least a 5 year return period storm event "without surcharge".[118] Chicago utilizes continuous simulation modelling software (including SWMM) to design their stormwater management infrastructure.[119] They also encourage geotechnical investigations, enabling integrated designs that consider soil permeability for infiltration areas.[120]

Water Reduction Strategies

Chicago has identified a number of consequences stemming from poor stormwater management in the municipality. They include backflows into Lake Michigan, flooding, and combined sewer overflow (CSO).[121] The disconnection of downspouts is also encouraged, when feasible, under the plumbing provisions set out in the Municipal Code, Article XI, Section 18-29-1101.2.3.[122] Integration of stormwater best management practices is identified as the most effective way to prevent flooding and CSOs. In 2007, the city launched a summer rain garden assistance program,[123] and currently has a rain garden brochure available for residents.[124] The city also promotes rain gardens. "Between 2005 and 2007, Chicago...had a Green Roof Grants Program that assisted with the costs of more than 70 green roof projects"[125] As a result, Chicago now boasts about 500 green roofs, spanning 2 million square feet[126]. While this may seem like a lot, it is only 1% of the rooftops in Chicago.

Innovation and Education

The city of Chicago provides education on its website. They cover topics ranging including green design, rainwater harvesting and permeable paving. Chicago was one of the first American cities to use low impact development as a strategy to reduce stormwater, and their innovations have caught on elsewhere.

5. Municipal Stormwater Management Practices Internationally

1) Berlin, Germany

Water Reduction Strategies

Berlin has greened 5-30% of the roof space in the city[127]. It is estimated that Germany adds about 11 million square metres of green roofing each year.[128] Berlin has been using the Green Area Ratio since 1997. Green Area Ratio is an "urban site sustainability metric requiring green infrastructure enhancements on private properties"[129]. This method has been applied elsewhere,[130] due to its success in Germany. While neighbourhoods are bound to Green Area Ratio by law[131], Berlin is criticized for a lack of enforcement and monitoring[132].

Innovation and Education

Berlin utilizes rainwater harvesting[133] and provides incentives for on-site stormwater management through a calculation of the impervious surface coverage of the site. Property owners are charged for stormwater based on the calculation and can achieve discounts through low impact development and harvesting strategies.[134] Potsdamer Plaz is a shopping center in Berlin which demonstrates the city's commitment to going green. They incorporated a pond for storing and cleaning stormwater, which is then used by the facility for toilet flushing and irrigation.[135] Another aspect of Berlin's commitment to going green is educating residents on strategies and benefits of stormwater management.

2) London, United Kingdom

Design Standards

In England the design flood used for culverts is a 100-year return period is used where there would be severe consequence for a flood, whereas 10-year return period design is sufficient for agricultural areas where the impact of a surcharge would be less severe.[136] The majority of London's sewer system was built in the 19th

century, and as such only has the capacity for a 1 in 10 year storm. New construction in the city is designed for a 1 in 30 year storm.[137] Much of the sewer network is a combined system, and the city of London[138] estimates that 39 million tonnes of untreated sewage is discharged annually.[139] The city is addressing the discharges by constructing two new relief sewers.[140] While the design criteria is larger than the norm in Canada, this is because London uses combined sewers and pipes must accommodate precipitation and raw sewage.

Water Reduction Strategies

In the United Kingdom, "all new houses must be rated under the Code for Sustainable Homes".[141] Non-domestic buildings are also rated using the Building Research Establishment Environmental Assessment Method, but it is not mandatory.[142] Rainwater harvesting is a component of these models. The use of permeable paving is encouraged by the city of London,[143] as are the construction of green roofs and walls.[144] Greening of roofs and walls is encouraged because it mitigates the heat island effect.[145] The goal for Londoners is to follow the SuDS plan and keep runoff as near to the source as possible.[146] This is achieved by the provision in Schedule 3 of the *Flood and Water Management Act*: "development will be required to prevent the first 5mm of a rainfall event discharging into the sewer system".[147] Compliance with this provision is achieved through harvesting rainwater and/or infiltrating it on site. London's Climate Change Partnership published a report in 2009 recommending economic incentives to facilitate the use of integrated low impact development,[148] and one which will apply not only to new developments. Some see the Code for Sustainable Homes as a lost opportunity, suggesting it should apply to retrofits and non-residential development.[149]

Innovation and Education

Cities in the United Kingdom employ a Sustainable Urban Drainage Systems (SUDS). The culvert design and operation guide requires monitoring for environmental impact (water quality)[150] and for structural performance.[151] SUDS uses an integrated design which incorporates the hydraulic characteristics of a watershed.[152] Peak flow estimation encompasses a variety of factors including "soils, geology, topography and drainage"[153] of the catchment. The SUDS Manual recommends finding an exact runoff rate rather than a "consistent agreed method for storage design".[154] This is accomplished by using catchment-specific data, and educating developers on the hydraulic factors relevant to finding exact runoff rates.

3) Melbourne, Australia

Design Standards

Melbourne developments must comply with the Australian Runoff Quality Guide.[155] Water quality is monitored and is to be treated to the best practise reductions of nutrients and suspended solids as specified in the Urban Stormwater: Best Practice Environmental Management Guidelines.[156] Melbourne employs continuous simulation modelling to account for antecedent conditions on the design of stormwater management systems (MUSIC),[157] and utilizes an integrated and distributed approach that treats the water through WSUD[158] They use design criteria for a five year storm event for their minor systems and a one hundred year design storm for their major systems.[159] This is also the norm in Canada.

Water Reduction Strategies

The city of Melbourne has an incentive program for water sensitive urban design (WSUD)[160]. They promote swales, wetlands, porous paving, rain gardens, green roofs, and rainwater harvesting.[161] In 2011 "Melbourne Water spent $4.6 million...helping local councils implement Water Sensitive Urban Design to improve the health of waterways under the Living Rivers Stormwater Program".[162]

Innovation and Education

Melbourne is innovative in their approach to water sensitive urban design. They are forced to treat rainwater like the resource it is, and implement innovative ways of capturing it. The municipality offers accessible education on installing rain gardens[163] and rain harvesting systems. Furthermore, the region has a guide for the development of constructed wetlands.[164] The design of drainage mandates consideration of ground topography and geomorphology.

4) Auckland, New Zealand

Design Standards

The design criteria for primary (minor) stormwater systems in Auckland are 5 to 10% annual exceedance probability[165], which equates five to ten-year storm capacity. Modelling is designed based on four hydrological soil groups[166] and employs continuous simulation modelling[167]. The city began integrated catchment studies in 2001, monitoring water quality and the behavior of stormwater in five catchments.[168]

Water Reduction Strategies

Auckland has a detailed On-site Stormwater Management Manual, including provisions for improving water quality through the design. [169] Auckland's State of the Environment Monitoring Programme[170] assigns protocols for monitoring where there is change in the environment due to stormwater discharge. The Blueprint for Monitoring in Urban Receiving Environments[171] sets out the recommended parameters for monitoring. They conduct monitoring of their river and compile the results in a yearly report. Sampling parameters include nutrients, total suspended solids, and metals.[172]

Innovation and Education

Auckland has educational guides for contractors and residents on operation and maintenance of wetlands, swales, rain gardens, and permeable pavement.[173] They have identified that source control is the best way to prevent pollution by stormwater, hence the city promotes low impact design and has developed a manual.[174]

6. Stormwater Management in Saskatoon

Design Strategies

The City of Saskatoon employs XP-SWMM continuous modelling, and Light Detection and Ranging (LiDar) topography data.[175] XP-SWMM is dynamic rainfall runoff simulation modelling software, first developed by the American Environmental Protection Agency. LiDar is a technology that uses near infrared light to produce high definition, three dimension topography data. Highly accurate topography data enables sophisticated design and accurate results from modelling software. The guidelines for design in Saskatoon are set out in the *City of Saskatoon New Neighbourhood Design and Development Standards Manual*.[176] In Saskatoon the major system components[177] are designed to accommodate a 1-in-100 year design storm event.[178] This is typical in Canada. Saskatoon's minor system components are designed to accommodate 1-in-2 year event.[179] This is smaller than most other city's design criteria for the minor system.

Water Quality Monitoring

Saskatoon monitors the biological properties of the river and some stormwater outfalls,[180] but does not currently have a program for monitoring other properties such as total dissolved solids and metals. The *Environmental*

Management and Protection Act (EMPA) of Saskatchewan does not currently regulate storm water quality or management, but reserves the right to do so[181] and prohibits the discharge of effluent harmful to the environment.[182] The province has the authority and jurisdiction to regulate storm water discharge, and may do so in the future. Alternatively, the province of Alberta *Environmental Protection and Enhancement Act*[183] and other pursuant regulations require municipal stormwater discharge to operate under a permit requiring monitoring. American municipalities are similarly mandated under their permits pursuant the *Clean Water Act*[184] . The city does not operate under a stormwater permit at this time, but since other provinces and the United State mandate operating permits, Saskatchewan may follow suit in the future.[185]

Water Reduction Strategies

The City of Saskatoon sells rain barrels[186] and provides education on Xeriscaping;[187] a form of low impact landscaping that utilizes natural plants which require less watering than typical lawns. Rain barrels decrease the amount of precipitation runoff that enters the minor system during a storm event. Thus, rainwater harvesting is a preliminary step in source management of stormwater and the accompanying pollution.

Innovation and Education

Saskatoon educates residents on Xeriscaping. It is a form of low impact development, but does not facilitate the storage of runoff like a rain garden. However, since the plants used do not require as much water as a conventional lawn, it is likely that Xeriscaped yards are more permeable than other yards because the water tables may not be as full. Saskatoon does not practice any particularly innovative stormwater management strategies, but has demonstrated a commitment to surface storage of runoff by the development of retention ponds.

See tables below for how Saskatoon compares to other municipalities in the use of stormwater management practices.

Table 1 - Comparison of Canadian Cities Use of Stormwater BMPs

City	Ponds	WQ monitor	1:5 pipes	Int. Model	Continuous Modelling	Rain Harvest	Rain Garden	Green Roofs	Pollution Prevention	Educate	Swales	Perm Paving	Down-spout
Saskatoon	♦	♦			♦	♦					♦		
Winnipeg	♦		♦		♦	♦	♦	♦	♦	♦	♦	♦	♦
Calgary	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦		♦
Edmonton	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	
Toronto	♦	♦		♦	♦	♦	♦	♦	♦	♦	♦	♦	♦
Victoria		♦				♦	♦	♦	♦	♦	♦	♦	
Kelowna	♦	♦	♦	♦		♦							
Red Deer	♦	♦	♦		♦	♦					♦		♦

♦ Denotes use of BMP

Table 2 - Comparison of Saskatoon to American Cities Use of Stormwater BMPs

City	Ponds	WQ monitor	1:5 pipes	Int Model	Continuous Modelling	Rain Harvest	Rain Garden	Green Roofs	Pollution Prevention	Educate	Swales	Perm Paving	Down-spout
Saskatoon	♦	♦			♦	♦					♦		
Seattle	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦
Minneapolis	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦
Philadelphia	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦
Chicago	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦
Portland	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦

♦ Denotes use of BMP

Table 3 - Comparison of Saskatoon to International Cities Use of Stormwater BMPs

City	Ponds	WQ monitor	1:5 pipes	Int Model	Continuous Modelling	Rain Harvest	Rain Garden	Green Roofs	Pollution Prevention	Educate	Swales	Perm Paving	Down-spout
Saskatoon	♦				♦	♦					♦		
Berlin	♦	*	*	*	*	♦	♦	♦	♦	♦	♦		
London		♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	
Auckland	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	
Melbourne	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦

♦ Denotes use of BMP

Ponds = wetland retention ponds
1:5 Pipes = at least a 5-year return period storm design criteria (or 1-in-5 year event)
Int. Model = Integrated Design Modelling
Perm Pave = Permeable Pavement
Downspout = Downspout disconnection program.
*Not Ascertainable due to Language Barrier.

7. Recommendations for Saskatoon

- The city should adopt a larger design criterion for the city's stormwater infrastructure. The minor system components designed for two year storm events should be scaled to accommodate a five year storm.
- The city should mandate developers install retention ponds for the purpose of storing and improving the quality of stormwater.
- Saskatoon should enforce water bylaws that mandate disconnection of downspouts. The city should also mandate disconnection of downspouts existing previous to the bylaw.
- Saskatoon should implement a stormwater quality monitoring program.
- The city of Saskatoon should provide education and incentives for low impact development and rainwater harvesting. This should be coupled with an increase to water prices, which will provide financial incentive to harvest runoff for use in yards and gardens.
- Saskatoon should adopt a pollution prevention program, which includes a prohibition on the use of phosphorus fertilizers in the city.
- The city of Saskatoon should mandate low impact development and rainwater harvesting in all new developments. They should follow Toronto's example and mandate green roofs on all commercial buildings over a specified size.
- Saskatoon should use integrated watershed management to address the uncertainties in hydrological elements of simulation. Simulations would benefit from the use of storm generation models and downscaling data from global climate models. This will ensure that designs are the most technically accurate in predicting future precipitation.

- **Step 1: Basic Recommendations**

Saskatoon would benefit from adopting a larger design capacity. Saskatoon's minor stormwater systems are likely insufficient to convey the increased run-off that will accompany climate change. All but two of the municipalities examined in this report require at least a five year design storm criteria for minor components. Saskatoon still employs the two year event design criteria for new storm water sewer systems and should mandate the use of larger pipes in all new developments. While this is complicated by the small size of stormwater mains that lead to outfalls, it may be necessary to twin some of those routes to accommodate for larger capacities of stormwater. Saskatoon already integrates stormwater retention ponds in a number of new developments, and should continure this practice. Each location should have a few ponds serving as a filtration system. This will achieve water purification before it enters the river.

The city must diligently enforce water bylaws and the provincial *Water Act* which prohibit combining stormwater with sanitary waste. Sump pumps from homes must be disconnected from the sanitary sewage system, and fines must be enforced for non-compliance. Stormwater levels will increase with climate change, and stormwater effluent in sanitary sewers must be removed. The city could be found liable for negligence if there is a backup resulting from failing to enforce bylaws. Furthermore, municipalities must be mindful of the distinction between policy and operational decisions, as liability may be imposed upon decisions considered operational in nature. The city should employ a technique similar to Toronto; mandating and inspecting compliance by quadrant of the city. In this manner, the connections made prior to the bylaw could be disconnected wherever possible.

The final component to the basic improvements needed in Saskatoon is a water quality monitoring program. Stormwater effluent may eventually be provincially regulated for quality, but in the meantime the city of Saskatoon would benefit from a monitoring program that alerts them of pollution spills and the quality of effluent flowing into the river. Furthermore, it would enable the city to monitor the results of low impact development programs and the success of pollution prevention strategies.

- **Step 2: Low Impact Development**

In addition to the approaches above, Saskatoon should install rain gardens, swales and permeable paving. These low impact development techniques are inexpensive, improve aesthetics, and hold rainwater on the surface for several hours as it infiltrates into groundwater tables. Ultimately, low impact development keeps water out of the underground stormwater infrastructure, and reduces the peak flows that can overwhelm the system. The city should empower residents to install low impact development on personal property. This can be achieved through basic educational days and an educational section on the city's website.

The city should also implement the use of rain barrels for harvesting rain. These should be mandated on all new public and private developments. This can be achieved in a similar manner to the rain gardens; educate and equip Saskatoon to implement rainwater harvesting. It keeps water out of the sewers, and reduces water consumption.

Increasing the price of potable water delivery serves as an incentive for rain water harvesting. Not only does the increase serve as incentive to conserve water and use the rain barrels for watering yards, but it ensure that waterworks does not experience a deficit. They require constant revenue to ensure that constant water is supplied, and the correct increase should be determined through application of formulas that account for a percentage decrease in potable water consumption.

Saskatoon should employ a pollution prevention strategy that prohibits the use of phosphorus fertilizers and other stormwater contaminants. Phosphorus is a common pollutant in stormwater, and prohibition of its use would reduce the total pollutant load in stormwater.

- **Step 3: The Innovative Option**

The city of Saskatoon should ultimately utilize stormwater as a resource rather than sending it downstream. The city should therefore mandate the rainwater harvesting practices set out above. It is recommended that Saskatoon require all new developments include an efficient rainwater harvesting system. Public buildings should be equipped with cooling systems that employ the harvested rainwater, and utilize the clear water for toilets and watering yards. Unlike grey water, clear water from runoff use is not prohibited by legislation. Bylaws that require water harvesting will ultimately extend the lifespan of the aging infrastructure in parts of Saskatoon.

The city should mandate green roofs. Saskatoon should mimic Toronto's bylaw requiring new construction with a floor space of over 2,000 square meters to devote 20-60% of its roof to vegetation.[188] See the appendix at table 1 for details. Saskatoon should educate property owners of the benefits of green roofs. Green roofs are a vital component of low impact development. They reduce run-off, and will also reduce the heat island effect. Green roofs serve to purify the rainwater on the roof, and to capture some of the flow. Green roofs can be designed for cold climates, and like other green developments, they decrease the city's reliance on aging underground stormwater infrastructure.[189] Furthermore, the

temperature stability of green roofs reduces the amount of energy consumed by heating and air conditioning the building. Green roofs are used in Calgary and Minneapolis and are therefore suitable for cold climates.

Saskatoon should also employ integrated watershed management that accounts the uncertainties of hydrological elements of simulation. This integrated approach is used widely by other municipalities in light of the variables that accompany climate change. Integrated management is achieved by utilizing software that generates stochastic rainfall data that exceeds historic rainfall data for the region. Furthermore, the city would benefit from preparing for climate change by downscaling data from global climate models. This innovative approach would ensure that Saskatoon's stormwater system was prepared for climate change and the excessive runoff predicted.

8. Conclusion

Conventional methods of stormwater management are very expensive. While Saskatoon should use larger design criteria for new developments, it would be unfathomable to retrofit the entire system. Source controls are the most efficient and effective way to reduce runoff and preserve existing infrastructure. Therefore, the city should focus on low impact development and rainwater harvesting and storage, as inexpensive ways to keep the runoff on the surface and out of the underground infrastructure. This will extend the life of the infrastructure and prevent flooding by reducing the volume of stormwater. Ultimately, innovative methods will save the city money while protecting the environment.

Endnotes

[1] Marsalek, Jiri, and Hans Schreier, "Innovation in Stormwater Management in Canada: The Way Forward", *Water Quality Research Journal of Canada* at page 1 citing U.S. EPA. 2000. *Low Impact Development (LID): A literature review.* Report EPA-841-B-00-005, Office of Water,Washington, D.C.
[2] *Wet Weather Flow Management Guidelines.* Toronto, November 2006 at page 47. Online: http://www.toronto.ca/water/protecting_quality/wwfmmp/pdf/wwfm_guidelines_2006-11.pdf (WWFM Guidelines Toronto)
[3] City of Toronto Website, About the Sewers on Your Street. Online: http://www.toronto.ca/water/sewers/about.htm
[4] WWFM Guidelines Toronto, *supra* note 2, at 2.2.1.2 General Guidelines.
[5] *Ibid* at page 89
[6] *Ibid* at page 87.
[7] Green Roof Bylaw (Toronto Municipal Code Chapter 492, Green Roof) Online: http://www.toronto.ca/legdocs/municode/1184_492.pdf
[8] "Those large developments must devote 20-60% of the roof to vegetation, depending on the size of the building" *Toronto's new green roof law a first for North America* http://www.mnn.com/earth-matters/politics /stories/torontos-new-green-roof-law-a-first-for-north-america.
[9] Toronto Wet Weather Flow Master Plan: 25-year strategy. Online: http://www.toronto.ca/water/protecting_quality/wwfmmp/25year_plan.htm
[10] Toronto Wet Weather Flow Master Plan (WWFMP), 2011. Online: http://www.toronto.ca/water/protecting_quality/wwfmmp/index.htm
[11] Toronto Downspout Disconnection Rollout. Online: http://www.toronto.ca/water/protecting_quality/threephase.htm
[12] Toronto Homeowners' Guide to Rainfall - LID. Online: http://www.riversides.org/rainguide/riversides_hgr.php?cat=1&page=87&subpage=88
[13] Toronto Homeowners' Guide to Rainfall – Landscape Solutions. Online: http://www.riversides.org/rainguide/riversides_hgr.php?cat=2&page=39&subpage=92
[14] Toronto Homeowners' Guide to Rainfall – Do it yourself. Online: http://www.riversides.org/rainguide/riversides_hgr.php?cat=3&page=134
[15] Winnipeg City-UDI Task Group on Criteria for Stormwater Management. Online: http://www.winnipeg.ca/waterandwaste/pdfs/drainageFlooding/stormwaterManagementCriteriaFeb2001.pdf at table 1. (Winnipeg Criteria)
[16] *Ibid.*
[17] *Ibid* at Table 2
[18] City of Winnipeg Website – Downspouts. Online: http://www.winnipeg.ca/waterandwaste/drainageFlooding/lotGrading/downspouts.stm
[19] City of Winnipeg Website – Sump Pump Discharge. Online: http://www.winnipeg.ca/waterandwaste/drainageFlooding/lotGrading/sumpPumpDischarge.stm
[20] Sustainable Water and Waste: An Our Winnipeg Direction Strategy, City of Winnipeg at page 40. Online: http://winnipeg.ca/interhom/ CityHall/OurWinnipeg/pdf/SustainableWater&Waste.July15.2010.pdf (Sustainable Water)
[21] *Ibid,* at page 53.
[22] *Ibid*
[23] *Ibid.*
[24] Winnipeg Criteria, *supra* note 15, at 4.4
[25] Sustainable Water and Waste: An Our Winnipeg Direction Strategy, City of Winnipeg. at page 45 Online: http://winnipeg.ca/interhom/ CityHall/OurWinnipeg/pdf/SustainableWater&Waste.July15.2010.pdf (Sustainable Water)
[26] Wetlands workshop, June 19, 2012, Saskatoon.
[27] *The City of Calgary Water Resources – Stormwater Management and Design Manual 2011* at page 72 City of Calgary Urban Development Publications Online: http://www.calgary.ca/PDA/DBA/Pages/Urban-Development/Urban-Development.aspx (Calgary Design Manual)
[28] *Ibid.*
[29] *Ibid.*
[30] *Ibid* at page 73.
[31] *Ibid* at page 72
[32] *Ibid.*
[33] *Environmental Protection and Enhancement Act,* RSA 2000, c E-12 and Calgary Design Manual, *The City of Calgary Water Resources – Stormwater Management and Design Manual 2011* at page 72 City of Calgary Urban Development Publications Online: http://www.calgary.ca/PDA/DBA/Pages/Urban-Development/Urban-Development.aspx (Calgary Design Manual) at page 57.
[34] Calgary Design Manual, *ibid*, note 22 at page 310.

[35] City of Calgary Website, Bow is Below Education Page. Online: http://www.calgary.ca/UEP/Water/Pages/Water-and-wastewater-systems/The-bow-is-below/Only-Rain-Down-the-Storm-Drain.aspx (Bow is Below)
[36] City of Calgary Website, Rain Garden Education. Online: http://www.calgary.ca/UEP/Water/Documents/Water-Documents/Yard_Smart_Rain_Garden.pdf (Calgary Rain Garden)
[37] City of Calgary Website, Rain Barrel Information. Online: http://www.calgary.ca/UEP/Water/Pages/Water-conservation/Lawn-and-garden/Water-wise-gardening-and-plants/RainBarrel.aspx and Calgary Rain Barrel Brochure. Online: http://www.calgary.ca/UEP/Water/Documents/Water-Documents/Yard_Smart_Rain_Barrel.pdf
[38] Do Nothing to Save Water, City of Calgary Website. Online: http://www.calgary.ca/UEP/Water/Pages/Water-conservation/Rethink-water/Do-Nothing-to-Save-Water.aspx
[39] *The City of Edmonton's Design and Construction Standards Volume 3: Drainage*. Online: http://www.edmonton.ca/city_government/urban_planning_and_design/city-design-construction-standards.aspx (Edmonton Design Manual)
[40] *Ibid*, at 12.6.3
[41] *Ibid,* at 12.4.2
[42] *Ibid,* at 12.5.7
[43] *Ibid,* at 13.6.2 Selection of Computer Models
[44] The City of Edmonton, Low Impact Development Best Management Practices Design Guide Edition 1.0 – November 2011. Online: http://www.edmonton.ca/environmental/documents/PDF/LIDGuide.pdf (Edmonton LID Guide).
[45] *Ibid* at page 38.
[46] The City of Edmonton, Stormwater Quality Control Strategy. Online: http://www.edmonton.ca/environmental/wastewater_sewers/stormwater-quality-control-strategy.aspx
[47] Ross Bulat, Edmonton Stormwater Management. Telephone interview July 17, 2012.
[48] City of Edmonton, Water Quality Monitoring Locations Presentation.
[49] The City of Red Deer Design Guidelines, Section 10 – Stormwater Management Drainage Systems at 1.3 Major/Minor Systems Online: http://www.reddeer.ca/NR/rdonlyres/FA46A0BC-D351-4F18-B5FD-E41DC63DFBCE/0/Section10StormwaterManagementStandards.pdf
[50] *Ibid*
[51] *Ibid* at 1.6 Computer Modeling.
[52] *Ibid*
[53] Red Deer Rain barrel Sale and Information. Online: http://www.reddeer.ca/City+Government/News+Releases/Archive/2008/June/Rain+barrel+sale+on+Saturday.htm
[54] Red Deer Rain barrel decorating Challenge. Online: http://www.reddeer.ca/City+Government/News+Releases/Archive/2008/June/Rain+barrel+decorating+challenge.htm
[55] Red Deer Bylaw No. 3464/2011 The Utility Bylaw at S. 79 Connection to Wastewater Sewer. Online: http://www.reddeer.ca/NR/rdonlyres/023646C6-6F02-41BA-987E-EBCA24717651/0/UtilityBylaw34642011RepealsUtilityBylaw321598.pdf
[56] Schedule 4 of Bylaw 7900 City of Kelowna Design Standard at 3.2 Minors System Design, Service Level, at Schedule 4 3. Drainage at page 3 of 19. Online: http://www.kelowna.ca/CityPage/Docs/PDFs/%5CBylaws%5CSubdivision,%20Development%20and%20Servicing%20Bylaw%20No.%207900/Schedule%204%20-%20Design%20Standards.pdf (Kelowna Design Standards)
[57] *Ibid* at Water Quality Treatment, Schedule 4 3. Drainage at page 6 of 19
[58] *Ibid* at 3.3 Major System Design, Schedule 4 3. Drainage at page 7 of 19
[59] *Ibid* at Run-off Analysis, Computer Simulation of Run-off, Schedule 4 3. Drainage at page 2 of 19
[60] City of Kelowna, Bylaw No. 10462 Text Amendment No. TA10-0011 – Adding New Kelowna Central Green Comprehensive Development Zone. Online: http://www.kelowna.ca/CityPage/Docs/PDFs/Council/Meetings/Council%20Meetings%202011/2011-05-03/Regular%20Meeting/Item%205.4%20-%20BL10462%20(TA10 0011),%20Central%20Green%20Comprehensive%20Development%20Zone.pdf
[61] *Ibid* at 2.9(f) at page CD 22-28
[62] Kelowna Design Standards *supra,* note 54 at Roof Leaders, Schedule 4 3. Drainage at page 5 of 19.
[63] British Columbia *Local Government Act* [RSBC 1996] CHAPTER 323 s. 907 Online: http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/96323_30
[64] Capital Region District, Stormwater Quality Monitoring and Reporting. Online: http://www.crd.bc.ca/watersheds/monitoring.htm
[65] *Capital Regional District Core Area Liquid Waste Management Plan,* Chapter 13 Management of Wastewater Overflows at 13.10. Online: http://www.crd.bc.ca/wastewater/lwmp/documents/chap13.pdf
[66] *Ibid* at Table 13.2 on page 13.12
[67] *Low Impact Development Overview*, Capital Region District, Online: http://www.crd.bc.ca/watersheds/lid/index.htm
[68] Ibid, bottom of page.
[69] United States Environmental Protection Agency's *Clean Water Act* 33 U.S.C. §1251 et seq. (1972)

[70] Illinois Department of Transportation Stormwater Management Program online http://www.dot.state.il.us/desenv/environmental/stormwater.html
[71] Seattle Department of Planning and Development, Stormwater Code Modelling. Online: http://www.seattle.gov/dpd/Codes/StormwaterCode/Modeling/default.asp
[72] The Minnesota Stormwater Manual at page 256. Online: http://www.pca.state.mn.us/index.php/view-document.html?gid=8937 (Minnesota Manual)
[73] Or 359,375 square feet of green roof. McIntosh, Annika. *Green Roofs in Seattle, a survey of vegetated roofs and rooftop gardens,* City of Seattle and the University of Washigton green Futures Lab, Agust 2012 at page 6 Online: http://www.seattle.gov/DPD/cms/groups/pan/@pan/@sustainableblding/documents/web_informational/dpdp020213.pdf
[74]Seattle Department of Planning and Development, Green Factor. Online: http://www.seattle.gov/dpd/Permits/GreenFactor/Overview/
[75] Seattle City Green Building Resources. Online http://www.seattle.gov/DPD/GreenBuilding/Resources/TechnicalBriefs/DPDS_009485.asp#seattleincentives
[76] Land Ordinance 123495 Office of the City Clerk, Seattle Online http://clerk.ci.seattle.wa.us/~scripts/nph-brs.exe?s1=&s3=&s4=123495&s2=&s5=&Sect4=AND&l=20&Sect2=THESON&Sect3=PLURON&Sect5=CBORY&Sect6=HITOFF&d=ORDF&p=1&u=%2F%7Epublic%2Fcbory.htm&r=1&f=G
[77] Seattle Public Utilities, Street Edge Alternatives Online http://www.seattle.gov/util/About_SPU/Drainage_&_Sewer_System/GreenStormwaterInfrastructure/NaturalDrainageProjects/StreetEdgeAlternatives/index.htm
[78]Natural Resources Defense Council. Online: http://www.nrdc.org/water/pollution/storm/chap12.asp
[79] *City of Portland Bureau of Environmental Services Sewer and Drainage Facilities Design Manual* – Revised June 2007 at Page 6-4 Online: http://www.portlandonline.com/bes/index.cfm?c=43428&a=360710
[80] *Stream Centerlines, City of Portland Data Quality Information*. Online http://www.portlandonline.com/cgis/metadata/viewer/display.cfm?Meta_layer_id=53227&Db_type=sde&City_Only=True
[81] *Portland Stormwater Management Manual* – August 1, 2008, Chapter 2: Facility Design at page 2-23. Online: http://www.portlandonline.com/bes/index.cfm?a=202883&c=47954
[82] *Permit Year 15 Annual Compliance Report*, see water quality monitoring reports throughout. Online: http://www.portlandonline.com/bes/index.cfm?c=50289&a=362659
[83] National Pollution Discharge Elimination System, Municipal Separate Stormwater System (MS4) Discharge Permit. See Table B-1, Environmental Monitoring. Online: http://www.deq.state.or.us/wq/wqpermit/docs/individual/npdes/ph1ms4/portland/PortlandMS4Permit201101131.pdf
[84] Portland Bureau of Environmental Services, Grey to Green. Online: http://www.portlandonline.com/bes/index.cfm?c=47203
[85] Portland Bureau of Environmental Services, Grey to Green Elements. Online: http://www.portlandonline.com/bes/index.cfm?c=47203&a=193188#revegetation
[86] *Ibid.*
[87] Portland Bureau of Environmental Services, Watershed Revegetation Program. Online: http://www.portlandonline.com/bes/index.cfm?c=44717&a=394076
[88] Portland Bureau of Environmental Services, Tree Planting. Online: http://www.portlandonline.com/bes/index.cfm?c=50795 Portland has a Treebate program; if you plant a tree on your residential property, the city of Portland offers a rebate on your utility bill. Trees planted in streets and yards are offered at a discounted rate through the Friends of Trees Program.
[89] Andrews, Scott, et al. *Green and Sustainable Building Policy – Case Study Analysis for Public Decision Makers*. Seattle, WA, May 2007. Online: http://www.docstoc.com/docs/73161191/Chicago at page 25 citing the *Green Building Policy Update*, *Binding City Policy* BCP-ENB-9.02
[90] *Stormwater Solutions Handbook* - Environmental Services - City of Portland Oregon. Online: http://www.portlandonline.com/bes/index.cfm?c=43110&a=129056 at page 10.
[91] The Minnesota Stormwater Manual at page 256. Online: http://www.pca.state.mn.us/index.php/view-document.html?gid=8937 (Minnesota Manual)at page 306
[92] *Ibid*.
[93]Minnesota Pollution Control Agency Authorization to Discharge Stormwater Under the National Pollutant Discharge Elimination System/State Disposal Discharge Permit Program. Online: http://www.minneapolismn.gov/www/groups/public/@publicworks/documents/webcontent/convert_270371.pdf at page 22.
[94]*Ibid* at page 23 includes loading calculations.
[95] Minnesota Manual, *supra* note 90, at 1.4
[96] *Ibid* throughout.
[97] *Ibid* at page 350-351
[98] *Ibid* at page 745-747.
[99] *Ibid* at pages 338-339.

[100] *Ibid* at pages 352-355.
[101] Rooftops to Rivers, *Composite Case Studies* at page 3. Online: http://www.nrdc.org/water/stormwater/files/RooftopstoRivers_composite.pdf
[102] *CSO Solutions, Chapter 56 Prohibited Discharges to Sanitary or Combined Sewer*. Online: http://www.minneapolismn.gov/www/groups/public/@publicworks/documents/webcontent/convert_270249.pdf
[103] A Guide to the Stormwater Quality Credits Program Online http://www.minneapolismn.gov/www/groups/public/@publicworks/documents/webcontent/convert_276373.pdf
[104] *Ibid* at page 1.
[105] *Ibid* at page 4-6.
[106] Krause, Michael. *Minneapolis Earns Stars and Scars by Charging for Hardscape*, From the Fifth Annual Greening Rooftops for Sustainable Development , Conference Proceedings, Minneapolis, April 29-May 1, 2007. Online: Water Laws Website http://www.waterlaws.com/commentary/bulletins/GreenRooftops.html
[107] Official Website of the City of Minneapolis, Catch Basin Stenciling. Online http://www.minneapolismn.gov/publicworks/stormwater/stenciling
[108] Philadelphia Stormwater Manual v 2.0 at 7-96 as specified within §14.1603.1 Stormwater controls, of the Philadelphia Code online http://www.phillyriverinfo.org/WICLibrary/chapter%207.pdf
[109] Philadlphia, Pennsylvania – A Case Study of How Green Infrastructure is Helping Manage Urban Stormwater Challenges at page 1 online http://www.nrdc.org/water/pollution/rooftopsII/files/RooftopstoRivers_Philadelphia.pdf
[110] Philadelphia Stormwater Manual v2.0, Chapter 4, Integrated Site Design http://www.pwdplanreview.org/WICLibrary/chapter%204.pdf
[111] *Ibid* at page 4-8.
[112] Crockett, Christopher S., Jeremy Chadwick, and Joanne Dahme. "Green Philly," *Living Architecture Monitor*, 2010, Vol. 12. No. 10. p 13-15. Online: http://www.nxtbook.com/dawson/greenroofs/lam_2010spring/index.php?startid=15#/18.
[113] Philadlphia, Pennsylvania – A Case Study of How Green Infrastructure is Helping Manage Urban Stormwater Challenges at page 3 online http://www.nrdc.org/water/pollution/rooftopsII/files/RooftopstoRivers_Philadelphia.pdf
[114] City of Philadelphia. "Bill No. 070072 (2007) (enacted), online: http://dvgbc.org/sites/default/files/resources/Green%20Roof%20Tax%20Credit.pdf
[115] City of Philadelphia Water Department. "Green City, Clean Waters–Philadelphia Combined Sewer Overflow Control Long Term Control Plan Update," Summary Report. June 2011. p. 4.
[116] Living Architecture Monitor, Spring 2010. Online: http://www.nxtbook.com/dawson/greenroofs/lam_2010spring/index.php?startid=14
[117] *Ibid*.
[118] *City of Chicago Department of Water Management 2012 Regulations for Sewer Construction and Stormwater Management* at 3.2.2 *online: https://www.cityofchicago.org/content/dam/city/depts/water/general/Engineering/SewerConstStormReq/2012Regs.pdf*
[119] Chicago Stormwater Ordinance Manual - Appendix B at B-7 Online https://www.cityofchicago.org/content/dam/city/depts/water/general/Engineering/SewerConstStormReq/2012StormManual.pdf
[120] *Ibid* at 3.2.1.1
[121] A Guide to Stormwater Best Management Practices – Chicago's Water Agenda, City of Chicago at page 6. Online: http://www.cityofchicago.org/dam/city/depts/doe/general/NaturalResourcesAndWaterConservation_PDFs/Water/guideToStormwaterBMP.pdf
[122] City of Chicago Department of Water Management 2012 Regulations for Sewer Construction and Stormwater Management at 3.1.1 online: https://www.cityofchicago.org/content/dam/city/depts/water/general/Engineering/SewerConstStormReq/2012Regs.pdf
[123] 2007 Chicago Rain Garden Assistance Program. Online: http://www.raingardennetwork.com/ChicagoRGP2007.htm
[124] City of Chicago Rain Garden Brochure. Online: http://www.cityofchicago.org/dam/city/depts/doe/general/NaturalResourcesAndWaterConservation_PDFs/Sustainable%20Backyards/ChicagoRainGardenBrochure2010.pdf
[125] City of Chicago. "Green Roof Grants Programs," Online: www. cityofchicago.org/city/en/depts/doe/supp_info/green_roof_grantsprograms.html.
[126] Kamin, Blair. *Ten years of green roofs in Chicago: Mayor Daley's green thumb and iron fist have produced impressive gains, but the movement remains in its infancy,* Cityscapes, Chicago Tribune, April 20, 2010. Online: http://featuresblogs.chicagotribune.com/theskyline/2010/04/theres-been-so-much-hype-about-green-roofs-in-chicago-that-i-went-to-the-willis-tower-sky-deck-last-week-expecting-to-see.html
[127] World Green Infrastructure Network, Green Roof Statistics. Online: http://www.worldgreenroof.org/Statistics.html
[128] *Ibid.*
[129] Keeley, Melissa "The Green Area Ratio: an urban site sustainability metric", *Journal of Environmental Planning and Management*, (2011) 54:7, 937-958 online http://dx.doi.org/10.1080/09640568.2010.547681

[130] *Ibid* at page 939. Application in Malmo, Sweden, throughout South Korea, and in Seattle, Washington USA.
[131] In 2009 Green Area Ration was legally binding in nine of Berlin's most dense neighborhoods. *Ibid* at page 940.
[132] *Ibid* at 955.
[133] "Rainwater Harvesting And Utilisation - An Environmentally Sound Approach for Sustainable Urban Water Management: An Introductory Guide for Decision-Makers." *United Nations Environment Programme Division of Technology, Industry and Economics* Online: http://www.unep.or.jp/Ietc/Publications/Urban/UrbanEnv-2/9.asp
[134] Puddephatt, Jane and Viv Heslop. *Low impact urban design and development – What we can learn from overseas.* Online: http://www.vivacity.co.nz/includes/LIUDD_policy_07.pdf at page 16
[135] "How Germany Became Europe's Green Leader: A Look at Four Decades of Sustainable Policymaking". *Solutions for a Sustainable and Desirable Future*, Volume 2, Issue 5, October 2011. Online http://www.thesolutionsjournal.com/node/981
[136] *Ibid* at 181
[137] City of London Strategic Flood Risk Assessment Document: 1 Version: 12, May 2012 at page 40 Online: http://www.cityoflondon.gov.uk/ services/environment-and-planning/planning/heritage-and-design/Documents/strategic-flood-risk-assessment-2012.pdf (London Flood Assessment)
[138] *Ibid.*
[139] *Ibid,* at page 44.
[140] *Ibid.*
[141] Way, C., Martinson, Brett, Heslop, S. and Cooke, R. (2010) "Rainwater harvesting: environmentally beneficial for the UK?" *Water Science and Technology: Water Supply*, 10 (5). pp. 776-782. At page 776.
[142] *Ibid*.
[143] London Flood Assessment. *Supra*, note 136, at page 49
[144] *Ibid* at page 50. Green roofs and walls can be particularly helpful in cities, where the limited space may preclude most other types of SuDS.
[145] *Ibid.*
[146] *Ibid* at 51
[147] *Ibid* citing schedule 3 at page 50.
[148] *Economic incentive schemes for retrofitting London's existing homes for climate change impact.* London's Climate Change Partnership, 2009, Online: http://www.london.gov.uk/lccp/publications/docs/lccp-eco-incentives.pdf
[149] Broome, Jon. *Code for Sustainable Homes: Too Little Too Late, or Just the Next Stage*? Building for a Future, 2006. Online: http://www.buildingforafuture.co.uk/summer06/code_for_sustainable_homes.pdf
[150]Culvert Design and Operation Guide. CIRIA, C689. London, 2012 at page 45
[151] *Ibid* at page 133.
[152] *Ibid* at page 77.
[153] *Ibid* at 55
[154] *Ibid* at 56
[155] Melbourne Water 2009 Water Plan at page 105. Online: http://www.esc.vic.gov.au/getattachment/605e8199-df87-49b2-969d-670d22062786/Water-Plan-Melbourne-Water.pdf
[156] Victorian Stormwater Committee 1999, at page 7. Online: http://www.melbournewater.com.au/content/library/online_ services/land_development/Principles_for_Provision_of_Waterway_and_Drainage_Services_for_Urban_Growth.pdf (Victorian Stormwater Committee)
[157] WSUD Engineering Procedures: Stormwater, Chapter 2 Hydrologic design regions of Victoria at 2.2. Online: http://wsud.melbournewater.com.au/download/chapter02.pdf
[158]Victorian Stormwater Committee. *Supra*, note 155 at page 24.
[159]*Ibid* at page 7.
[160] Water Sensitive Urban Design, Rooftop Greening: Overview. Online: http://wsud.melbournewater.com.au/content/treatment_measures/rooftop_greening/overview.asp
[161] *Ibid*.
[162] Melbourne Water, Annual Report, Part 4, Waterways. Online: http://www.melbournewater.com.au/content/publications/reports/annual_report.asp
[163] Melbourne Water, Raingardens. Online: http://raingardens.melbournewater.com.au/
[164] Melbourne Water, Constructed Wetlands Guidelines. Online: http://www.melbournewater.com.au/content/library/wsud/Constructed_wetlands_guidelines.pdf
[165] Development and Connection Standards – Water, Wastewater and Stormwater Design and Policy Manual for Auckland City Council Isthmus, 4th Edition Mar 2009 at page 100. Online: http://www.aucklandcity.govt.nz/council/documents/developmentconnect/docs/dcsstormwater.pdf (Auckland Design Manual)

[166] *Guidelines for stormwater runoff modelling in the Auckland Region* – Auckland Regional Council. Online: http://www.arc.govt.nz/albany/fms/main/Documents/Plans/Technical%20publications/101-150/TP108%20Part%20A.pdf
[167] Auckland Design Manual, *supra,* note 164. Appendix at page O-13.
[168] Auckland Council. Stormwater. Online: http://www.aucklandcity.govt.nz/council/services/stormwater/aucklandcity.asp#integrated
[169] So long as the appropriate water quality controls are incorporated into the design, typically no further quality provisions are required. Auckland City OSM Manual. Online: http://www.aucklandcity.govt.nz/council/documents/onsite/docs/remainder.pdf at 5.2
[170] Auckland Council. State of the Environment freshwater monitoring programme. Online: http://www.arc.govt.nz/environment/water/water-monitoring/state-of-the-environment-freshwater-monitoring-programme_home/state-of-the-environment-freshwater-monitoring-programme_home.cfm
[171] Blueprint for monitoring urban receiving environments, Auckland Regional Council, TP 168 revised edition - August 2004. Online: http://www.arc.govt.nz/albany/fms/main/Documents/Plans/Technical%20publications/151200/TP168%20Blueprint%20for%20monitoring%20urban%20receiving%20environment%20-%20revised%20edition%20Aug%202004.pdf
[172] State of the Environment Monitoring, River Water Quality Annual Report 2010 March 2012 Technical Report 2012/006. Table 4 Online:http://www.aucklandcouncil.govt.nz/EN/planspoliciesprojects/reports/technicalpublications/Pages/technicalreports2012.aspx
[173] Auckland Council. Stormwater Guides. Online: http://www.aucklandcouncil.govt.nz/EN/environmentwaste/stormwater/Pages/stormwaterguideshome.aspx
[174] Low Impact Design Manual for the Auckland Region. Online: http://www.arc.govt.nz/albany/index.cfm?34F6B217-145E-173C-98A4-BA60099502FD#TP124
[175] Interview with City of Saskatoon Stormwater Design Technician, July 26, 2012 (COS Storm Interview)
[176] *City of Saskatoon New Neighbourhood Design and Development Standards Manual – Section Six, Storm Water Drainage System*, January 2012, available online: http://www.saskatoon.ca/DEPARTMENTS/Infrastructure%20Services/StrategicServices/Documents/Design%20and%20Development%20Standards%20-%20SECTION%20SIX%20- %20January%202012.pdf retrieved June 12, 2012 (Saskatoon Design Manual).
[177] Overland flows and above ground storage basins comprise the major component of stormwater systems.
[178] Saskatoon Design Manual, *supra* note 3 at 3.2, Major System.
[179] Ibid at 3.1 Minor System.
[180] City of Saskatoon Water Quality Reporting Inquiries. July 16, 2012.
[181] Environmental Management and Protection Act (EMPA) of Saskatchewan at section 81 (1)(bbb)
[182] Ibid at section 4(1).
[183] *Environmental Protection and Enhancement Act,* RSA 2000, c E-12
[184] Clean Water Act Compliance Monitoring. Online http://www.epa.gov/compliance/monitoring/programs/cwa/index.html
[185] *Ibid.*
[186] Rain Barrels – City of Saskatoon Website, Accessed Online http://www.saskatoon.ca/DEPARTMENTS/Utility%20Services/Environmental%20Services/ Water%20Conservation/Pages/LowFlowShowerHeads.aspx
[187] Seven Steps of Xeriscaping Online http://www.saskatoon.ca/SiteCollectionDocuments/us/xeriscaping.pdf
[188] *Toronto's new green roof law a first for North America* **Online:** http://www.mnn.com/earth-matters/politics /stories/torontos-new-green-roof-law-a-first-for-north-america.
[189] *Green City, Clean Waters. The City of Philadelphia's Program for Combined Sewer Overflow Control – A Long Term Control Plan Update*. The Philadelphia Water Department September 1, 2009 at page 3. Online: http://www.phillywatersheds.org/ltcpu/LTCPU_Summary_LoRes.pdf

Saskatoon Environmental Advisory Committee

Appendix to Stormwater Management

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1. Introduction to Stormwater Management

Stormwater management refers to the strategies used to capture and remove run-off within municipalities. The traditional approach was to drain it directly into nearby surface water ways. "Considerable research efforts have been invested in developing alternative approaches to conventional stormwater management focusing on rainwater management, infiltration of rainfall on site, and detention of runoff during large storm events, rather than piping it directly into urban streams."[1] Many municipalities are employing new approaches, showing that "rather than something to be disposed of, stormwater (is) a resource to be cleansed and enjoyed."[2] This report will examine a number of methods for harvesting and containing stormwater, rather than sending it directly into the South Saskatchewan River.

Storm water systems are comprised of a major and minor system concept. Minor systems refer to the elements normally associated with rainwater drainage; the underground sewer system, street drains, and maintenance covers. The purpose of this system is rapid removal of storm water from the streets to a nearby waterway. In Saskatoon the minor system deposits directly into the South Saskatchewan River. Directing stormwater to the river raises water quality concerns and dependence on a minor system poses the risk of flooding. There are several types of flooding to which Saskatoon is vulnerable. Pluvial flooding occurs when there are "inadequate hydraulic access pathways to the underground sewer system or…the pipes in the system have a hydraulic capacity that is less than the flows that are generated by the rainfall runoff process"[3]. Urban flooding may also occur as a result of flooding in the surrounding catchment area. If the adjacent flooding follows flowpaths into the urban area, the result is urban flooding. Another flooding contributor is deteriorization or failure of infrastructure in the minor stormwater system. This is primarily caused by blockages in the sewer either from collapses or excess sediments.[4] As Saskatoon continues to grow, impervious surface area will increase, creating more stormwater runoff as a by-product. The minor system design criteria is small (two year event) and likely insufficient to handle increased run-off.

The major system is best described as the runoff in excess of the capacity of the minor system. "This network of planned or unplanned ponding areas and overland flow routes is the 'major system'."[5] Successful storm water management systems employ both major and minor system components. This report will recommend that Saskatoon focus on major system strategies to conserve the life of the minor system infrastructure.

Storm water management aims to reduce flood risk. However, there are other considerations related to water quality and environmental protection. "There are a number of ways to manage storm water from a site. This includes conveyance, storage, treatment, re-use, infiltration, and evaporation."[6] The objective of this appendix is to assess the strengths and weaknesses of the current approach to storm water management in Saskatoon. It will include a comparison to best management practices elsewhere, and evaluation of their applicability in Saskatoon. Ultimately, this report seeks to provide recommendations to improve storm water management in Saskatoon.

2. Stormwater Management in Saskatoon

Currently the Saskatoon system follows the conventional approach to stormwater management and deposits effluent directly into the river. In some circumstances the water is directed to stormwater basins prior to reaching the main water course. The basins are designed to slow peak flows, and sometimes employ filtration and vegetation to improve water quality. This serves to protect the minor system from overwhelm and can contain or remove some of the pollutants carried by the stormwater. Saskatoon currently utilizes nine dry ponds and eighteen wet ponds as a part of the overall stormwater management system.

Dry ponds act as holding basins for water in excess of the stormwater sewer system. Rather than having excess water ponding in low intersections or on low-lying property, the water flows into the pond where it slowly drains into the minor system. To prevent overloading the stormwater sewers, dry detention ponds are designed to hold excess water for about 24 hours. During that time the water is slowly released into the system. While dry detention ponds prevent flooding and surcharges, they have very little environmental benefit. They may allow for minimal sediment removal, and also filter some of the suspended solids; however, they are merely intended to slow the overland flow of the water. For this reason, wet ponds are preferable in Saskatoon.[7] Wet ponds are also implemented for the purpose of stormwater retention. However, they are constructed in a manner that allows for some filtration of the water before it enters the stormwater sewer system. In this way they serve to prevent some pollutants from entering the river; effectively improving the water quality of effluent released into the watershed. Saskatoon currently has 18 wet ponds, which remove pollutants and store the water on the surface.

Table 1 - Comparison of Canadian Cities Use of Stormwater BMPs

City	Ponds	WQ monitor	1:5 pipes	Int. Model	Continuous Modelling	Rain Harvest	Rain Garden	Green Roofs	Pollution Prevention	Educate	Swales	Perm Paving	Down-spout
Saskatoon	♦	♦			♦	♦					♦		
Winnipeg	♦		♦		♦	♦	♦	♦	♦	♦	♦	♦	♦
Calgary	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦		♦
Edmonton	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	
Toronto	♦	♦		♦	♦	♦	♦	♦	♦	♦	♦	♦	♦
Victoria		♦				♦	♦	♦	♦	♦	♦	♦	
Kelowna	♦	♦	♦	♦		♦							
Red Deer	♦	♦	♦		♦	♦					♦		♦

♦ Denotes use of BMP

Table 2 - Comparison of Saskatoon to American Cities Use of Stormwater BMPs

City	Ponds	WQ monitor	1:5 pipes	Int Model	Continuous Modelling	Rain Harvest	Rain Garden	Green Roofs	Pollution Prevention	Educate	Swales	Perm Paving	Down-spout
Saskatoon	♦	♦			♦	♦					♦		
Seattle	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦
Minneapolis	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦
Philadelphia	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦
Chicago	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦
Portland	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦

♦ Denotes use of BMP

Table 3 - Comparison of Saskatoon to International Cities Use of Stormwater BMPs

City	Ponds	WQ monitor	1:5 pipes	Int Model	Continuous Modelling	Rain Harvest	Rain Garden	Green Roofs	Pollution Prevention	Educate	Swales	Perm Paving	Down-spout
Saskatoon	♦				♦	♦					♦		
Berlin	♦	*	*	*	*	♦	♦	♦	♦	♦	♦		
London		♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	
Auckland	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	
Melbourne	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦

♦ Denotes use of BMP

Ponds = wetland retention ponds
1:5 Pipes = at least a 5-year return period storm design criteria (or 1-in-5 year event)
Int. Model = Integrated Design Modelling
Perm Pave = Permeable Pavement
Downspout = Downspout disconnection program.
*Not Ascertainable due to Language Barrier.

3. The Law: Obligations Regarding Quantity and Quality, Federally and Locally, and Liability

Stormwater can impact the overall quality of water frequented by fish, and of water that is received by property owners and communities downstream. To ensure adequate consideration is given to the legal ramifications of stormwater systems, one must first look at the jurisdictions of water management. It is then important to consider the ramifications of legislative breach, and also the potential liability resulting from flooding.

In order to assess the jurisdiction of stormwater management, one must look to a general division of powers. Powers in Canada are divided between the Federal government and the Provincial government, with some powers trickling through to municipalities. The division of powers is based on the *Constitution Act of 1867*[8], which assigns various areas to the heads of power. Section 91 of the Act lists matters of federal jurisdiction[9], and section 92 lists matters falling under the provincial jurisdiction[10]. Section 91 includes inland fisheries as a matter under the power of the federal parliament. Local works and undertakings are generally matters of provincial jurisdiction, except when deemed of national importance.[11]

1) Federal Legislation

The federal legislation relevant to stormwater management is the *Fisheries Act*[12]. This *Act* applies to stormwater management through its protection of fish. In spite of the presumed jurisdiction of the province over the river as a local resource, The *Fisheries Act* engages federal jurisdiction should there be a deposit of a deleterious substance into water frequented by fish. Section 34 defines 'water frequented by fish', as Canadian fisheries waters[13]. Water frequented by fish is water inhabited by fish, not unlike the water in the South Saskatchewan River which flows through Saskatoon. This river is the final recipient of all stormwater sewers in the city. Section 34 (1)(a) and (b) of the *Fisheries Act* define deleterious substances as anything specified as harmful which is deposited into the water frequented by fish[14]. Section 34 (1) (c) and (d) explain that deleterious substances are so defined by the Governor Council, who is given authority to regulate substances[15].

The *Fisheries Act* underwent some changes with the passing of the new omnibus budget bill, passed by Senate on June 30, 2012. Bill C-38 made significant alterations to Section 35 of the Fisheries Act. Section 35 previously prohibited unauthorized work or undertakings resulting in "harmful alteration, disruption or destruction of fish habitat"[16]. The revised prohibition is not engaged by an impact on fish habitat, rather it requires actual and serious harm to fish[17]. Under the revisions, deposition of deleterious substances would only engage the federal power if there is actual death to fish utilized in fisheries. The Bill has the effect of passing the jurisdiction of fisheries largely to the provinces.

The omnibus Budget Bill also increased fines for offences under the *Fisheries Act*. Previously, section 40 set out the fines for breaching the *Act* at maximums of three hundred thousand.[18] The

new provisions assign minimums at one million, and maximums at twelve million[19] - unprecedented amounts. Although offences will be rare with the more stringent revisions to the *Fisheries Act*, they will be punished much more severely - to a degree where they can no longer be absorbed as a cost of business. The *Act* provides for exclusion of liability, including circumstances where there is an unforeseeable natural event.[20]

To summarize federal provisions as they relate to stormwater management, the new provisions will place jurisdiction more firmly into the provincial head of power. However, "it should be noted that there are significant legal questions about the ability of the federal government to delegate legal responsibility for fisheries to the provinces, which may result in litigation if a delegation occurs under the provisions enacted through Bill C-38."[21] Time will tell whether the delegation of powers is legal, and in the meantime the provinces are free to regulate water and the effluent entering waterways. Under the recent revisions, it is unlikely that the city of Saskatoon would engage the *Fisheries Act* for storm water effluent deposited into the river.

2) Provincial Legislation

One of the most significant regulations regarding storm water management in Saskatchewan is the *Water Regulations*[22]. The *Regulations* set out the management practices for water in Saskatchewan. Significantly, there is a prohibition against combined sewer systems in this province[23]. Historically, combined sewers were the cause of much concern because raw sewage overflows could result from storm events that over filled the combined system. Treating combined sewage is also problematic due to the volume of sewage entering the system. Saskatoon complies with this regulation by having a separate system for raw sewage and storm water. The raw sewage is piped to the water treatment plant, while storm water is piped to the river.

The *Environmental Management and Protection Act* (EMPA) of Saskatchewan does not currently regulate storm water quality or management, but reserves the right to do so[24] and prohibits the discharge of effluent harmful to the environment.[25] The province has the authority and jurisdiction to regulate storm water discharge, and may do so in the future. Alternatively, the province of Alberta *Environmental Protection and Enhancement Act*[26] and other pursuant regulations require municipal stormwater discharge to operate under a permit, and the American *Clean Water Act*[27] requires municipalities across America to comply with permit requirements, including monitoring stormwater quality.

3) Municipal Liability

The province of Saskatchewan added a clause to *The Cities Act* in 2006, which seeks to limit the liability of the cities within the province[28]. The clause is similar to other provincial legislation on municipal liability.[29] Municipalities are not liable if acting in accordance with statutory authority, [30] and cannot be found liable for an action that is does not require a finding of intention or negligence.[31] A municipality also cannot be found liable for decisions made with discretion and in good faith.[32] This stems from a principle established by the Supreme Court of

Canada in 1989:[33] municipalities do not owe each resident a private duty of care in exercising bona fide discretion in decision making. In that same year, the court also distinguished between policy decisions and their operational implementation – determining that policy decisions are excluded from liability (so long as they are made in good faith), while operational implementation can be vulnerable to liability.[34] "The operational aspect of a governmental activity includes that manner and quality of an inspection system, and the standard of care applied to a particular operation is assessed in light of all surrounding circumstances, including budgetary restraints, and the availability of trained staff and the appropriate equipment."[35]

Municipalities can be found liable for flooding resulting from overloading the sewer system with new development and subsequent impervious surfaces.[36] It was found that flooding resulting in part from the city failing to enforce bylaws to disconnect downspouts and that extensive paving and that development contributed to the backups. Therefore, municipalities should continue to enforce bylaws, especially as they relate to downspout disconnection. They could be found liable for negligence if there is a backup resulting from failing to enforce bylaws. Bylaws do not apply to connections made prior to the law, as those are 'grandfathered' in. Furthermore, municipalities must be mindful of the distinction between policy and operational decisions, as liability may be imposed upon decisions considered operational in nature.

4. Beneficial Management Practices

1) Designing a Stormwater System

London, UK is a city which has been forced to employ a number of innovative approaches to managing stormwater. The vast degree of urbanisation in the area has created a mostly impervious catchment. They have a combined sewer system, and "around 39 million tonnes of untreated sewage is discharged annually through the 57 overflows, and as little as 2 mm of rainfall can trigger a discharge. Currently, the overflows occur more than once a week on average".[37] Although Londoners face challenges that are not present in Saskatoon, we can utilize a number of the innovations that they demonstrate.

Stormwater design analysis benefits from overland flow technologies based on accurate, high definition 3-dimentional LiDar (Light Detection and Ranging) data.[38] LiDar provides detailed ground topography of urban and rural settings. LiDar is a technology that uses near infrared light to produce high definition, three dimension topography data. Highly accurate topography data enables sophisticated design and accurate results from modelling software. "Catchment and overland pathway delineation is an essential and important step for both stormwater and sewer system modelling studies."[39] In spite of new advances in accurate overland flow estimations, there are limitations to hydrological models that are currently employed.[40] Event-based models fail to consider climate change, or "represent processes efficiently at a range of scales"[41].

Saskatoon currently employs sophisticated modelling techniques. XP-SWMM is the modelling software used for existing system analysis and for new design verification. XP-SWMM is dynamic rainfall runoff simulation modelling software, first developed by the American Environmental Protection Agency. Analytical modelling is based on LiDar 3-D flow routing. Accurate hydraulic models require 3-D data because the floodplain in 2-D leads to computational constraints and subsequent "mass balance errors",[42] which Saskatoon has reconciled by adopting 3-D flow routing. In the design stage, proposed designs are inputted into the model rather than LiDar, because the design is not yet built. The city uses continuous simulation models which largely overcome the limitations of event-based models.[43] They also assess current system components using continuous simulation based on LiDar flow routing. This technology enables the corporation to accurately predict and reconcile problems that will arise in a storm event or events over a continuous simulation range.

Municipalities benefit from utilizing integrated watershed management in the stormwater management process. A report compiling the opinions of Canadian stormwater experts cited that "the recommended approach emphasizes the use of a wide range of combinations of innovative measures, rather than focusing on single innovations, in order to hedge against uncertainties and to integrate individual efforts between the site, neighbourhood, and watershed levels".[44] Experts claim that the greatest challenges of stormwater management "are associated with hydrological, rather than hydraulic, elements of simulation"[45]. Hence, an integrated approach is vital to overcoming these challenges because it includes several variables,[46] enabling cities to plan for climate change, and design capacities that deliver a consistent level of service.

a. Design and Climate Change

Climate change poses unique challenges to the design process of stormwater systems[47]. The Traditionally, historic rainfall data is the common input factor to designing. However, climate change is predicted to impact the intensity, duration and frequency of rainfall. Global climate models (GCMs) are the primary tool for predicting climate change.[48] However, GCMs are unreliable at small scales. New developments seek to reconcile this by "focusing on capturing intensities, especially extremes, and the representation of spatial-temporal variability".[49] These uncertainties can largely be addressed by downscaling the data.[50]

The United Kingdom has advanced technology for climate change design modelling. Traditionally, stormwater design used historic rainfall data, but these are not accurate predictions as climate change impacts rainfall. The UK employs rainfall generators such as "Stormpac" and "TSRSim", which simulate design storms that exceed historic rainfall intensity, duration and frequency. TSRSim is preferable because it generates stochastic rainfall time series data which has proven "more representative of higher return periods than Stormpac".[51] The generated weather information is then plugged into a simulation model to retrieve hourly data.[52] Cities

benefit from using an integrated watershed management approach to stormwater design, and generated storm modeling to predict storm intensity that exceeds historic data.

b. Design Criteria for Major and Minor Components

The guidelines for design in Saskatoon are set out in the *City of Saskatoon New Neighbourhood Design and Development Standards Manual*.[53] In Saskatoon the major system components[54] are designed to accommodate a one hundred year, twenty-four hour design storm event.[55] Saskatoon's minor system components are designed to accommodate two year event.[56] These storm descriptors are more accurately described in annual probability. A one hundred year storm has a one percent likelihood of occurring in any given year, whereas a two year storm has a fifty percent chance of occurring. Design storms events are created using historic rainfall data that is representative of the severity of storms of each probability level.

The *City of Edmonton's Design and Construction Standards, Volume 3: Drainage*[57] sets out guidelines for storm water management for the city. The guide is comprehensive, and Edmonton, like Saskatoon, does not allow for combined sewer systems.[58] The Edmonton guidelines, however, mandate a larger capacity for storm water systems, thus enabling the infrastructure to carry greater volumes of storm water. Compared to Saskatoon's mandated two year return period event, Edmonton minor systems must accommodate a five year return period event. Edmonton's system is mandated to increase the capacity of the infrastructure serving a large catchment area. For example, a minor system serving 30 ha or less requires a five year system[59], whereas an area greater than 30ha must have a system that supports 1.25 times the rate of volume needed for a five year event.[60] This approach accounts for the fact that a greater impervious area creates greater runoff, and that the rational method of calculation is less accurate in a greater catchment area.

The rational method is an equation for estimating volume of peak flow run-off. It is widely used for determining the size of pipe needed to convey run-off from an area. The rational method for storm run-off formula is expressed as:

$$Q = \frac{CIA}{360}$$

Where:
Q = discharge in cubic metres per second (design flow rate)
C = a dimensionless runoff coefficient
I = the average intensity of rainfall in millimetres per hour
A = the drainage area in hectares [61]

The city of Edmonton mandates that the major storm water system be designed to accommodate runoff rates and flow characteristic of a one hundred year return period event. It also has provisions regarding depths relevant to landscape gradients. The guideline mandate that a system design be computer tested against four event criteria, all of which are one hundred year events. The management practices they employ allow for some flexibility, accommodating the likely volume increases that will accompany climate change. There is little doubt that climate

change will impact the historic rainfall and infiltration rates, and Edmonton mandates reflect these predictions.

Calgary mandates that minor systems accommodate a one in five year event[62]. The five year event design criterion has been required since 1952.[63] Prior to that, the city allowed for construction of minor systems with a design criteria of a two year event.[64] Major systems must accommodate a one hundred year return period event[65]. These practices align with Edmonton, but are unique in that they employ the unit area release rate method, rather than the rational method for the sizing of storm trunks.[66] Calgary abandoned use of the rational method because "when the drainage area exceeds 30 ha, there is a marked inequity in trunk capacity (expressed as capacity per hectare drained) in the downstream direction."[67] The unit area release method seeks to avoid this inequity in trunk capacity by uniformly distributing the trunk capacity across the trunk tributary. The formula recommends higher area release rates based on the slope of the area.[68] This method considers more factors, thus is more accurate in designing for large drainage areas.

2) Water Quality Monitoring

Saskatoon is not mandated to monitor stormwater quality. According to *The Environmental Management and Protection Act*[69], the jurisdiction for ordering collection of data is with the minister of the environment. The minister may, in fact adopt additional measures deemed necessary for obtaining data on water quality in Saskatchewan[70]. Furthermore, the Act mandates a permit for deposition of harmful effluent into water,[71] and future amendments may require an operating permit similar to others used in North America.

Water quality in Alberta is governed more strictly than in Saskatchewan. "Pursuant to the *EPEA (*Alberta's *Environmental Protection and Enhancement Act*[72]*)*, the *Wastewater and Storm Drainage Regulation*, and the *Activities Designation Regulation*, a written authorization is required from Alberta Environment for the construction, operation, or reclamation of a storm drainage system..."[73] Operation of such systems require a permit to operate in Alberta, which mandates water quality monitoring.

The city of Edmonton monitors their four largest outfalls, which carry roughly 60% of the storm water from the city.[74] The sampling is automatic, and engaged when the water volume reaches a certain point.[75] Outfalls are monitored for TSS, BOD5, TP, TKN, (NO-2+NO-3)-N, NH3-N, Cl-, and *E. coli*.[76] As a portion of the approval to operate, the city of Edmonton is also required to monitor the quality of the river water. Sampling includes upstream of the city, at intakes throughout the city, and downstream of the city at Fort Saskatchewan. Samplings at all locations occur 12 times per year. They also sample up and down stream of the city bi-weekly to ensure river quality standards are met. They sample nutrient levels as well as biological properties of the river. They are required to monitor the total loading of the river, and have established total loading goals for the quality of the river upon receipt of all effluent from the city of Edmonton.

3) Low Impact Development

Low impact development (LID) is innovative management that controls rainwater at its source. The goal is to mimic the predevelopment state of the locations and micromanage and contain the water that falls on the site. Municipalities of all climates across North America and Europe are implementing techniques for keeping water on lots, utilizing several landscaping and development strategies aimed at source control of run-off and pollution. These lot level techniques, the building blocks of LID, employ integrated management practices. This portion of the report examines effective integration of practices, showcasing successful implementation by municipalities.

Calgary

The city of Calgary has identified the seven source control management most suitable for the climate, including vegetated swales, absorbent landscaping, porous pavement, rainwater harvesting, and green roofs.[77] Calgary copes with similar climate challenges to those in Saskatoon, and have developed source control practices that work in a cold climate.

Toronto

Toronto, like Calgary, has developed a long term plan to mitigate stormwater pollution[78]. Their plan employs educating residents and utilizes innovative source controls. As with any plan, monitoring is essential to assess success and impact. Toronto is employing monitoring to ensure that the correct modifications are implemented over their 25-year Wet Weather Flow Master Plan.

Philadelphia

In 2011, the watershed authorities in Philadelphia agreed to a $2 billion, 25 year plan to reduce the city's water pollution. The agreement, beginning in 2011, includes plans to "replace as much as one-third of the city's existing impervious cover – about 4,000 acres – with natural or porous surfaces that can intercept stormwater, store it, and then release it at a controlled rate".[79] "Philadelphia is not alone in rethinking water management – although the scale of this project is unprecedented. "There's increasing acceptance by politicians that water cannot be taken for granted."[80]

Philadelphia employs several LID techniques. They have a comprehensive implementation guide available online for residents and developers. They are overhauling their system to prevent combined system overflows, and are exemplary in their implementation of current management practices. "The Philadelphia Water Department is committed to a balanced "land-water-infrastructure" approach to achieve its watershed management goals".[81] Their encompassing approach makes them a leader in stormwater management.

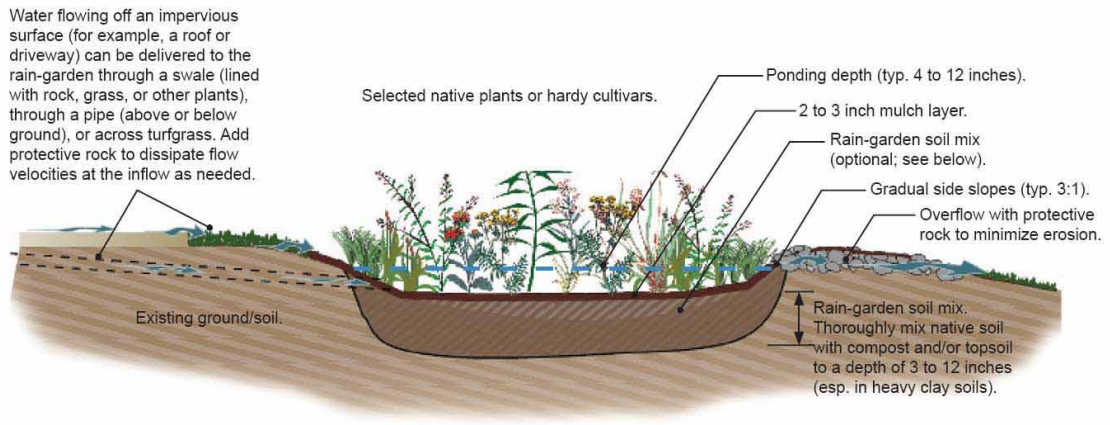
a. Rain Gardens

Rain gardens provide storage for runoff and enhance the aesthetics of a yard. They are designed to hold water for up to 72 hours, while it infiltrates into the ground. Homeowners can be assured

that they are not a breeding ground for mosquitoes, because the standing water drains quickly enough to prevent eggs from hatching.

Rain gardens are used in many cities, promoted as way to reduce runoff, and improve the aesthetics of a property. They are fairly simple to install, and instructions are provided on a number of municipal websites, and by the Canadian Mortgage and Housing Corporation.[82] These gardens are designed as a depression from surrounding landscape. Runoff flows into the depression, waters the native plants in the garden, and slowly infiltrates into the aquifer.

Figure 1.0 Rain garden design cross section – City of Minneapolis



b. Green Roofs

Green roofs facilitate storage and filtration of stormwater, ultimately reducing the runoff generated by an urban property. According to research conducted in Calgary, Alberta: "in summer, depending on the plants and depth of growing medium, green roofs retain 70-90% of the precipitation that falls on them; in winter they retain between 25-40%. For example, a grass roof with a 4-20 cm (1.6 - 7.9 inches) layer of growing medium can hold 10-15 cm (3.9 - 5.9 inches) of water."[83] While they are more expensive to install than a conventional roof, the lifespan of a green roof can be double that of a conventional roof.[84] Furthermore, the energy savings resulting from the green roof exceed the difference in installation prices. As an example, Canadian research indicates that green roofs reduce energy expended on air conditioning in the summer by over 75%.[85] It was found that even a shallow green roof membrane "reduced the heat flow through the roof by 70% to 90% in the summer and 10% to 30% in the winter, lowering the energy demand for space conditioning in the building".[86]

Toronto

Toronto was the first North American city to pass a bylaw[87] requiring green roofs on some new developments. "Any new construction with floor space of more than 2,000 square meters must devote between 20 and 60 percent of its roof to vegetation".[88] Toronto's approach to mandatory green roofs on large surfaces is an innovative way to reduce the amount of runoff generated by a city. They are cutting back the impervious surface which will reduce peak flows in comparison

to those generated by impervious roof material. Low impact development reduces the peak flow, ultimately preserving the older minor stormwater infrastructure. [89]

Table 1: Toronto's Green Roof Requirement Scale

Gross Floor Area * (Size of Building)	Coverage of Available Roof Space (Size of Green Roof)
2,000 - 4,999 m^2	20%
5,000-9,999 m^2	30%
10,000-14,999 m^2	40%
15,000-19,999 m^2	50%
20,000 m^2 or greater	60%

* Note: Residential buildings less than 6 storeys or 20m in height are exempt from being required to have a green roof. *City of Toronto Green Roof Requirement Scale*[90]

Chicago

Chicago has identified a number of consequences stemming from poor stormwater management in the municipality. They include backflows into Lake Michigan, flooding, and combined sewer overflow (CSO).[91] Integration of stormwater best management practices is identified as the most effective way to prevent flooding and CSOs. "In 2001, a 20,300 square-foot green roof was installed atop Chicago's City Hall as part of Mayor Daley's Urban Heat Island Initiative."[92] See figure 1.1 for Chigago's city hall green roof. Their green roof initiative was not limited to municipal roofs; "between 2005 and 2007, Chicago...had a Green Roof Grants Program that assisted with the costs of more than 70 green roof projects"[93] As a result, Chicago now "boasts about 500 green roofs that are either finished or underway, according to Department of Environment spokesman Larry Merritt, and they cover 7 million square feet"[94]. While this may seem like a lot, it is only 1% of the rooftops in Chicago, while Germany has green roofs on 15 to 20 % of the flat roofs in their country.

Figure 1.1 Chicago's Green Roof on City Hall

Portland

The city of Portland implemented a "Grey to Green"[95] initiative in 2008. The initiative utilizes green roofs (ecoroofs) and green streets[96], but also emphasizes revegetation with native plants in

natural areas. This provides better water filtration, and will "better able to adapt to climate changes"[97]. Stormwater is managed through restoration projects having the effect of improving water quality, reducing storm water pollution, and erosion control; ultimately enhancing fish and wildlife habitat.[98] Additionally, the city encourages Portlanders to plant trees. This is facilitated by cost-reducing opportunities, offering utility bill rebates or the purchase of trees at discounted rates.[99] Portland's new design policy requires design and construction of all new city-owned facilities to include an ecoroof (green roof)."[100] They classify the roofs into several categories, one of which is a roof garden and designed for pedestrian use and enjoyments[101]. Roof gardens enhance properties by creating recreation space on the roof of a building. Like a typical green roof, they have double the life expectancy of a conventional roof, and mitigate some of the heat island effects. The components of green roofs are demonstrated in figure 1.2.

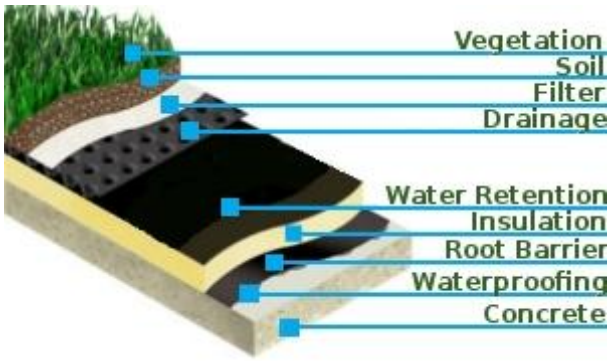


Figure 1.2: The Components of a Green Roof [1]

While green roofs are more expensive than a conventional roof, they are reported have at least double the life expectancy of a typical roof. In addition to the longer life of the roof, green roofs save money on energy because they provide insulation for the roof. Studies by Environment Canada indicate that a green roof conserves 30% of the energy used in cooling the building.[102] "An energy study undertaken by the City of Chicago estimated that, with whole scale greening of the cities rooftops, energy to the value of $100M could be saved each year due to the reduced demand for air conditioning".[103] Research indicates that green roofs reduce winter heating energy consumption by 10%.[104] "Studies in Berlin show that green roofs absorb up to 75% of precipitation that falls on them. A study from Portland confirms similar results, with greenroofs mitigating from 65% to 94% of runoff".[105] Furthermore, they reduce the heat island effect and contribute to the pervious area on a development. All things considered, there is little doubt that a green roof saves money in the long run. See figure 1.3 for an example of a green roof.


Figure 1.3: Example of a residential green roof.

c. Downspout Disconnection

The city of Toronto has a mandatory downspout disconnection program which comes into effect over five years, and will be complete in 2016.[106] The downspout disconnection strategy is comprehensive, offering financial assistance for some residents, exemptions for some types of

connections, and fines for noncompliance.[107] The city reimburses costs for disconnection for seniors, those with a disability, or low-income residents. The reimbursement is up to five hundred dollars. Toronto's city website offers a "do it yourself" guide that educates residents on disconnecting downspouts.[108] Time will tell if Toronto's disconnection program is successful.

d. Swales

Seattle employs many of the techniques demonstrated in other North American cities, but have excelled with the use of swales. "A sloped base to facilitate this water movement distinguishes bioswales from rain gardens".[109] Swales are shown to reduce runoff volume – "even where soils have very poor hydraulic conductivity (around 1 mm/h), a 4 m swale/trench can reduce the volume of runoff from a typical local road to about 25% of total rainfall".[110] Seattle's Street Edge Alternative (SEA) project is the famous retrofit of 2nd Avenue NW, employing natural drainage systems to replace old impervious surfaces. Other cities are modeling their retrofits after the Seattle project, with the goal of minimizing the amount of stormwater flowing off the site. SEA has experienced outstanding results. "The first three years of project monitoring has shown that 98% of wet-season and 100% of dry-season stormwater runoff has been eliminated by the project."[111]

Figure 1.3: Seattle's SEA Street Design Transformation. Credit of SEA Street Design

The project took a typical street and increased pervious surface by narrowing the street and creating swales along the edges. The gutters have sections where the run-off funnels into the grassy swale edges and thus the stormwater is managed along the street and not away from the source. The result is a green street that manages virtually all of the stormwater runoff at its source. Seattle demonstrates an innovative way for municipalities to incorporate low impact development to keep stormwater on site and out of the pipes underground.

e. Retention Ponds

Winnipeg uses constructed wetlands extensively for stormwater management. They have a similar climate to Saskatoon. Subsequently the runoff, vegetation and stormwater management challenges are similar. Winnipeg employs Natural Plant Solutions to construct their wetlands. Native Plant Solutions conducted an educational seminar in Saskatoon in June. The city of Saskatoon is developing a wetlands policy, and looking to incorporate more wetlands into new stormwater management systems.

Winnipeg boasts of 48 naturalized stormwater systems.[112] Saskatoon has some naturalized systems as well. Of note is the constructed wetland system at Lakewood. The water channels through three ponds of nutrient removal before entering the river. Winnipeg systems are designed to maximize nutrient removal by increasing the ratio of vegetation to water.[113] Total phosphorus is one of the main nutrients, and it is removed by vegetation. There does not seem to be any indication of biomass loading in the vegetation, and maintenance requirements are low on the ponds. Saskatoon and Winnepeg report never harvesting the vegetation on their stormwater ponds. See figure 1.4 for a stormwater retention pond.

f. Permeable Pavement

Minneapolis is a city featuring all stormwater best management practices in a climate similar to Saskatoon. Minneapolis provides simple ways for homeowners to decrease stormwater runoff, including the use of porous or pervious pavement[114]. Permeable pavement is advantageous because it allows for water to filter through to the aquifer, hence recharging groundwater.[115] It also reduces the amount of runoff entering the stormwater management infrastructure. There are also claims that permeable pavement lasts longer than conventional asphalt.[116]

g. Education

Education is a vital component to improving source control and subsequent reduction of pollution. The city of Calgary employs excellent techniques for educating their community about the importance of storm water and protecting the Bow River. To improve river water quality, the city of Calgary launched an educational video titled "The Bow is Below"[117]. It teaches residents about the watershed and how humans impact the river. Calgary developed a stormwater management strategy,[118] which is another accessible tool informing residents of how they can make a difference. Tools included on the city website are 'how to' manuals on rain gardens,[119] and brochures on rain barrels.[120] They claim that 30% of Calgarians already use rain barrels to harvest water from their properties. The city of Calgary is also dedicated to 'going green' in development, and promotes green roofs and rainwater harvesting in cisterns and storm water retention for property use.[121]

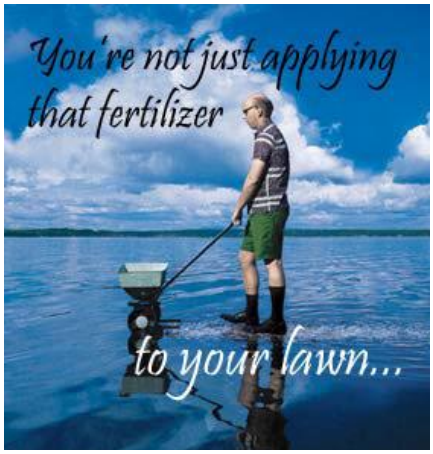


Figure 1.6: Courtesy of Allegan County

h. Pollution Prevention

The city of Calgary employs several pollution prevention strategies, including good housekeeping, cleaning catch basins, and frequent street cleaning[122]. Saskatoon also employs these pollution prevention strategies. A significant component of Calgary's stormwater management strategy has included retrofit stormwater management programs[123]. These have helped reduce the suspended solid loading in the Bow River. The Bow feeds into the South Saskatchewan, so initiatives in Calgary improve the quality of water in Saskatoon. Due to

similar climate, Saskatoon can implement many of the initiatives that Calgary has demonstrated.

Some American cities and states have taken their dedication to pollution prevention further, by prohibiting the use of phosphorus fertilizers.[124] Typically these states allow exceptions for golf courses establishing turf.[125] Ann Arbour, Michigan curtailed the use of phosphorus fertilizers in 2006, and three years later a study showed phosphorus levels in the adjacent Huron River decreased by 28 percent.[126] The use of phosphorus fertilizers is also prohibited in the state of Minnesota, which reduces the overall pollutant loading in stormwater effluent.

i. Rainwater Capture and Use

Rainwater capture is a simple and cost effective way to not only reduce runoff, but conserve water usage. Most cities have a rain barrel incentive and educational program.[127] The city of Edmonton includes the details of greenhouse gas emission reduction, and cost savings created by using harvested water:

Greenhouse Gas Savings April to October – 7 months 35.8 m^3 x 1.7534 kg/m^3 (water and sewer factor) = **62.771.72 kg** of GHG emission reductions

Cost Savings April to October – 7 months 35.8 m^3 of water x $2.6392* (water and sewer charges) = **$94.48**

**As of April 1st, 2009 the water rate for residential homes (up to 60 m^3) = $1.5625 per cubic metre plus sewer charges of $1.0767 per cubic metre for a total of $2.6392 per cubic metre.*

One household within the City of Edmonton, having a 102 m^2 (1,100 ft^2) roof surface, can save $94.48 on their water bill during these 7 months by using rain water to water their lawn and garden. They would also reduce their share of GHG emissions by 62.7717 kg per year.[128]

Figure 1.7: Functioning Rainbarrel - City of Minnesota

Edmonton's water prices are higher than Saskatoon's. Saskatoon has lower water prices than any other municipality in this report. Increases to water prices in Belgium have led to an increase in rainwater harvesting.[129] It fits with the polluter pays concept that Canada shares. Municipalities provide incentives for the construction of rainwater cisterns that enable residents to harvest runoff,[130]and some regions "prescribe the installation of the rainwater tanks as a condition for the issue of a building permit".[131] The discharge tax is based upon the volume of drinking water supplied, and thus provides incentive to conserve water. While use may decrease, the water supply must remain constant, so a price increase is the only way to simultaneously decrease consumption and avoid a deficit for water companies. Ultimately this strategy serves to both keep some runoff out of the infrastructure and reduce potable water consumption. See table 2 for costs and benefits of low impact development strategies.

Table 2: BMPs, Costs and Benefits

BMP	Typical Initial Cost	% Reduction in Water Volume or Pollutants
Green Roof: **Extensive** **Intensive**	 $8-10 per sq ft. $15-25 per sq ft.	Cadmium, copper & lead: 95% reduction. Zinc 16% reduction, Captures/stores runoff: small to moderate storms
Rain Barrel	$20-150 each	Captures/stores runoff: small to moderate storms
Permeable Paving	2-3 times conventional costs	Reduces quantity of runoff
Natural Landscaping	Similar to conventional costs	Suspended solids & heavy metals (such as cadmium and lead): 80% Nutrients:(phosphorus, nitrogen)70% Reduces residential runoff by 65%
Rain Garden	$3-4 per sq ft	Removes runoff and pollution from small storms
Swales	Less than conventional landscaping costs	Suspended solids 30-70% removal, nutrients 10-30%, retains runoff from small storms
Detention Basin	Similar to conventional costs	Reduces stormwater runoff rates and pollution Suspended sediments & pollutants: 60-90% Nutrients & suspended matter: 40-80%

4) LEED Certification and Stormwater Management

The city of Calgary also has a sustainable development policy and twelve LEED certified Calgary owned/funded buildings.[132] Most of these buildings achieved a LEED Gold certification. One component of LEED is storm water management for the property.[133] LEED points are earned based on the percentile of rainfall retained on the property during a rainfall event. Stormwater retention points are assigned based on the percentile of rainwater that is retained on a property following a rainfall event.

5. Climate Change and Stormwater Management

The city of Saskatoon recently partnered with the University of Saskatchewan to conduct a study on stormwater management and climate change. The results of that study are anticipated in 2014, and will be relevant to future stormwater planning.

Climate change has already impacted the average temperatures and the precipitation in the Berlin region,[134] and it is forecast that the area will experience an increase in the frequency and intensity of droughts and extreme weather events.[135] According to the predictions by local climate impact researchers, "by 2055 climate change will have led to a significant rise in average temperatures, milder winters and an increase in hours of sunshine and decreasing amounts of precipitation in Berlin-Brandenburg."[136] A tangible impact is the pollution resulting from extreme rainfall events. The article concludes that increasing the capacities of sewerage networks was required to prevent the discharge of highly polluted 'first flush' effluent into the watercourse.[137]

Parts of Germany use innovative methods for mitigating climate change. A recent study employed the use of rainwater and evapotranspiration to cool urban areas. They found that

"rainwater harvesting measures can play a key role in further mitigation strategies against increased surface temperatures and drought. This new approach means to focus rainwater management on evaporation rather than infiltration".[138] Deforestation leads to reduced evaporation and subsequent higher temperatures.[139] The premise for his work is that rainwater management should focus on evaporation rather than the common infiltration approach. This thinking attempts to revert the mindset that evaporation is a loss of precipitation; rather that it is the source of precipitation.

The rainwater system at UFA-Fabrik is an example of integrating best management practices aiming to mitigate climate change. This location employs green roofs integrated with a rainwater harvesting system. Covering the building with plants reduces the heat island effect. The system captures the first flush of rainwater, which is typically the most contaminated with pollutants and nutrients. The polluted runoff is directed to a constructed wetland, where it is treated with vegetation. Ultimately, the collected rainwater is used for toilets and irrigation on the property. This system could easily be employed in Saskatoon, since clear water (rainwater) is not regulated.

The Institute of Physics in Berlin-Adlershof is of note because it utilizes façade greening systems, demonstrating the effect of shading and evapotranspiration on the energy performance of the building. One of the unique features of the building is that it is not connected to stormwater sewers[140]. Stormwater is infiltrated into the groundwater only in areas that are vegetated to improve the quality of the water entering the watershed.[141] The building also utilizes air conditioning through "evaporative cooling units...(that) use rainwater to cool air by the process of evaporation".[142] Research indicates that compared to a conventional cooling system, the evaporative cooling units decrease energy consumption for cooling by 80 to 90% annually.[143] The study notes that rainwater is superior to tap water for use in cooling systems, because it has no salt/lime and is therefore low in electrical conductivity, and also reduces the amount of wastewater by half.[144]

Whereas Canadian uses for rainwater are limited to irrigation and toilet flushing, these European management practices utilize rainwater and green architecture in a way that promotes sustainability on a large scale. Furthermore, green approaches seem to impact the effects of a changing climate. European studies show that evaporation is vital to maintaining a stable climate. Furthermore, green roofs and facades decrease the impact on the infrastructure as a whole, by utilizing rainwater, purification and slowing the flow that reaches the pipes. Ultimately "rainwater harvesting measures which focus on evaporation rather than infiltration have tremendous potential to decrease the environmental impacts of urbanization"[145]. This approach serves several goals and is one that Saskatoon would benefit from employing.

Germany subsidizes information campaigns in favour of innovative equipments for water conservation. Second, some communities prescribe the installation of the rainwater tanks as a condition for the issuance of a building permit, and give a grant that partly covers the investment.[146] Third and above all, households with tanks indirectly benefit from a reduction on the tax on wastewater discharges. Like Belgium, the wastewater tax is calculated on the basis of the volume of drinking water supplied.[147]

6. Recommendations for Saskatoon

- The city should adopt a larger design criterion for the city's stormwater infrastructure. The minor system components designed for two year storm events should be scaled to accommodate a five year storm.
- The city should mandate developers install retention ponds for the purpose of storing and improving the quality of stormwater.
- Saskatoon should enforce water bylaws that mandate disconnection of downspouts. The city should also mandate disconnection of downspouts existing previous to the bylaw.
- Saskatoon should implement a stormwater quality monitoring program.
- The city of Saskatoon should provide education and incentives for low impact development and rainwater harvesting. This should be coupled with an increase to water prices, which will provide financial incentive to harvest runoff for use in yards and gardens.
- Saskatoon should adopt a pollution prevention program, which includes a prohibition on the use of phosphorus fertilizers in the city.
- The city of Saskatoon should mandate low impact development and rainwater harvesting in all new developments. They should follow Toronto's example and mandate green roofs on all commercial buildings over a specified size.
- Saskatoon should use integrated watershed management to address the uncertainties in hydrological elements of simulation. Simulations would benefit from the use of storm generation models and downscaling data from global climate models. This will ensure that designs are the most technically accurate in predicting future precipitation.

Step 1: Basic Recommendations

Saskatoon would benefit from adopting a larger design capacity. Saskatoon's minor stormwater systems are likely insufficient to convey the increased run-off that will accompany climate change. All but two of the municipalities examined in this report require at least a five year design storm criteria for minor components. Saskatoon still employs the two year event design

criteria for new storm water sewer systems and should mandate the use of larger pipes in all new developments. While this is complicated by the small size of stormwater mains that lead to outfalls, it may be necessary to twin some of those routes to accommodate for larger capacities of stormwater. Saskatoon already integrates stormwater retention ponds in a number of new developments, and should continure this practice. Each location should have a few ponds serving as a filtration system. This will achieve water purification before it enters the river.

The city must diligently enforce water bylaws and the provincial *Water Act* which prohibit combining stormwater with sanitary waste. Sump pumps from homes must be disconnected from the sanitary sewage system, and fines must be enforced for non-compliance. Stormwater levels will increase with climate change, and stormwater effluent in sanitary sewers must be removed. The city could be found liable for negligence if there is a backup resulting from failing to enforce bylaws. Furthermore, municipalities must be mindful of the distinction between policy and operational decisions, as liability may be imposed upon decisions considered operational in nature. The city should employ a technique similar to Toronto; mandating and inspecting compliance by quadrant of the city. In this manner, the connections made prior to the bylaw could be disconnected wherever possible.

The final component to the basic improvements needed in Saskatoon is a water quality monitoring program. Stormwater effluent may eventually be provincially regulated for quality, but in the meantime the city of Saskatoon would benefit from a monitoring program that alerts them of pollution spills and the quality of effluent flowing into the river. Furthermore, it would enable the city to monitor the results of low impact development programs and the success of pollution prevention strategies.

Step 2: Low Impact Development

In addition to the approaches above, Saskatoon should install rain gardens, swales and permeable paving. These low impact development techniques are inexpensive, improve aesthetics, and hold rainwater on the surface for several hours as it infiltrates into groundwater tables. Ultimately, low impact development keeps water out of the underground stormwater infrastructure, and reduces the peak flows that can overwhelm the system. The city should empower residents to install low impact development on personal property. This can be achieved through basic educational days and an educational section on the city's website.

The city should also implement the use of rain barrels for harvesting rain. These should be mandated on all new public and private developments. This can be achieved in a similar manner to the rain gardens; educate and equip Saskatoon to implement rainwater harvesting. It keeps water out of the sewers, and reduces water consumption.

Increasing the price of potable water delivery serves as an incentive for rain water harvesting. Not only does the increase serve as incentive to conserve water and use the rain barrels for watering yards, but it ensure that waterworks does not experience a deficit. They require

constant revenue to ensure that constant water is supplied, and the correct increase should be determined through application of formulas that account for a percentage decrease in potable water consumption.

Saskatoon should employ a pollution prevention strategy that prohibits the use of phosphorus fertilizers and other stormwater contaminants. Phosphorus is a common pollutant in stormwater, and prohibition of its use would reduce the total pollutant load in stormwater.

Step 3: The Innovative Option

The city of Saskatoon should ultimately utilize stormwater as a resource rather than sending it downstream. The city should therefore mandate the rainwater harvesting practices set out above. It is recommended that Saskatoon require all new developments include an efficient rainwater harvesting system. Public buildings should be equipped with cooling systems that employ the harvested rainwater, and utilize the clear water for toilets and watering yards. Unlike grey water, clear water from runoff use is not prohibited by legislation. Bylaws that require water harvesting will ultimately extend the lifespan of the aging infrastructure in parts of Saskatoon.

The city should mandate green roofs. Saskatoon should mimic Toronto's bylaw requiring new construction with a floor space of over 2,000 square meters to devote 20-60% of its roof to vegetation.[148] See the appendix at table 1 for details. Saskatoon should educate property owners of the benefits of green roofs. Green roofs are a vital component of low impact development. They reduce run-off, and will also reduce the heat island effect. Green roofs serve to purify the rainwater on the roof, and to capture some of the flow. Green roofs can be designed for cold climates, and like other green developments, they decrease the city's reliance on aging underground stormwater infrastructure.[149] Furthermore, the temperature stability of green roofs reduces the amount of energy consumed by heating and air conditioning the building. Green roofs are used in Calgary and Minneapolis and are therefore suitable for cold climates.

Saskatoon should also employ integrated watershed management that accounts the uncertainties of hydrological elements of simulation. This integrated approach is used widely by other municipalities in light of the variables that accompany climate change. Integrated management is achieved by utilizing software that generates stochastic rainfall data that exceeds historic rainfall data for the region. Furthermore, the city would benefit from preparing for climate change by downscaling data from global climate models. This innovative approach would ensure that Saskatoon's stormwater system was prepared for climate change and the excessive runoff predicted.

7. Conclusion

The city of Saskatoon employs sophisticated planning and design technology for its stormwater system. Sustainability in the water sector requires a better understanding of watershed and ecosystem dynamics and interactions between human activities and nature. Designs that integrate the watershed would improve overall performance of the system, and help mitigate impacts of climate change. Saskatoon is growing, and will need to increase its minor system capacity to accommodate increased runoff.

Retrofitting the entire stormwater is not an option, due to cost and time constraints. Furthermore it is more efficient and much less expensive to use innovative stormwater management and low impact development to keep the run-off out of the underground infrastructure altogether. In this case, the more innovative options are less expensive than the conventional methods for stormwater management. Saskatoon provides rainwater harvesting and natural landscaping design education. However, it would benefit from implementing cost-based incentives that promote low impact development, managing stormwater at its source and preventing pollution. Water quality monitoring would provide a way to quantify success, and ensure protection of natural waterways. Low impact development can be outsourced to residents, who are supplemented with an incentive. Source management of stormwater is more efficient for the city, prevents flooding, and even prevents some pollutants from entering the river. Saskatoon should develop a long term plan that utilizes innovative means to keep water out of the infrastructure.

8. Endnotes

[1] Marsalek, Jiri, and Hans Schreier, "Innovation in Stormwater Management in Canada: The Way Forward", *Water Quality Research Journal of Canada* at page 1 (Innovation in Canada) citing U.S. EPA**.** 2000. Low Impact Development (LID): A literature review. Report EPA-841-B-00-005, Office of Water,Washington, D.C.
[2] Heritage Park: Treating Stormwater Differently page 1 Online: http://www.minneapolismn.gov/www/groups /public/@publicworks/documents/webcontent/convert_263624.pdf
[3]Pender, Gareth and Hazel Faulkner (Eds) *Flooding Risk Science and Management,* Wiley-Blackwell: 2011 at page 260
[4] Ibid.
[5] The City of Edmonton's Design and Construction Standards Volume 3: Drainage at 12.2.3 Online: http://www. edmonton.ca/city_government/urban_planning_and_design/city-design-construction-standards.aspx (Edmonton Design Manual)
[6]The City of Calgary Water Resources – Stormwater Management and Design Manual 2011. Online: http://www. calgary.ca/PDA/DBA/Pages/Urban-Development/Urban-Development.aspx (Calgary Design Manual)
[7] City of Saskatoon, New Neighbourhood Design and Development Standards Manual – Section Six: Storm Water Drainage System at 6.5. (Saskatoon Design Manual).
[8] *The Constitution Act, 1867* (UK), 30 & 31 Victoria, c 3
[9] Section 91 includes (inter alia) matters such as criminal law, navigation and shipping, banking, postal service and matters significant on a national scale. As a general rule, matters of national concern fall under the federal head of power.
[10] Section 92 enumerates the subjects that are matters within provincial jurisdiction including matters of property and civil rights, provincial incorporation, local works and undertaking. Section 92 (16) reads that (provincial jurisdiction includes) "generally all Matters of a merely local or private Nature in the Province".
[11] Section 92 (10) c. Reads that some works, "although wholly situate within the Province, are before or after their Execution declared by the Parliament of Canada to be for the general Advantage of Canada or for the Advantage of Two or more of the Provinces". For this reason those particular works are enumerated as matters of federal jurisdiction.
[12] *Fisheries Act* R.S.C., 1985, c. F-14
[13] The text of section 34 (1)(e) reads: ""water frequented by fish" means Canadian fisheries waters".
[14] "deleterious substance" means
(*a*) any substance that, if added to any water, would degrade or alter or form part of a process of degradation or alteration of the quality of that water so that it is rendered or is likely to be rendered deleterious to fish or fish habitat or to the use by man of fish that frequent that water, or
(*b*) any water that contains a substance in such quantity or concentration, or that has been so treated, processed or changed, by heat or other means, from a natural state that it would, if added to any other water, degrade or alter or form part of a process of degradation or alteration of the quality of that water so that it is rendered or is likely to be rendered deleterious to fish or fish habitat or to the use by man of fish that frequent that water.
[15] *Fisheries Act*, *supra* note 12, at Section 34 (2).
[16] The full text of Section 35 reads: "No person shall carry on any work or undertaking that results in the harmful alteration, disruption or destruction of fish habitat.
Alteration, etc., authorized
(2) No person contravenes subsection (1) by causing the alteration, disruption or destruction of fish habitat by any means or under any conditions authorized by the Minister or under regulations made by the Governor in Council under this Act".
[17] Denstedt, Shawn QC and Sander Duncanson, Osler, Hoskin & Harcourt LLP, *Bill C-38 /2012 Budget Bill : Legal Perspective on Env. Changes to Federal Regulatory System*. Online: http://www.sierraclub.ca/en/main-page/bill-c-38-2012-budget-bill-legal-perspective-env-changes-federal-regulatory-system (Changes to Federal Regulations)
[18] *Fisheries Act*, *supra* note 12 at section 40
[19] Changes to Federal Regulations, supra note 17.
[20] *Fisheries Act*, *supra* note 12 Defences to liability

(4) The liability of any person described in paragraph (1)(*a*) is absolute and does not depend on proof of fault or negligence but no such person is liable for any costs and expenses pursuant to subsection (1) or loss of income pursuant to subsection (3) if he establishes that the occurrence giving rise to the liability was wholly caused by
(*a*) an act of war, hostilities, civil war, insurrection or a natural phenomenon of an exceptional, inevitable and irresistible character; or
(*b*) an act or omission with intent to cause damage by a person other than a person for whose wrongful act or omission he is by law responsible.

[21] *Bill C-38 and offloading Fisheries onto the Provinces*, West Coast Environmental Law, Vancouver BC http://wcel.org/sites/default/files/publications/OffloadingFisheriesFinal.pdf accessed on July 17, 2012 at page 1 citing *Alexandra Morton v. BC*, 2009 BCSC 136.

[22] *Water Regulations*, 2002, RRS c E-10.21 Reg 1, http://canlii.ca/t/1ssx

[23] *Ibid* at Section 14: **No interconnection between sanitary sewers and storm sewers**
14 No permittee shall cause any sanitary sewers and storm sewers to be interconnected in a manner that permits sewage in the sanitary sewer to be discharged through the storm sewer.

[24] *Environmental Management and Protection Act* of Saskatchewan 2002, SS 2002, c E-10.21, at section 81 (1)(bbb) Online: http://canlii.ca/t/h7gj (EMPA)

[25] *Ibid* at section 4(1).

[26] *Environmental Protection and Enhancement Act,* RSA 2000, c E-12 (AB EPEA)

[27] *Clean Water Act* Compliance Monitoring. Online http://www.epa.gov/compliance/monitoring/programs/cwa/index.html

[28] *The Cities Act* being Chapter C-11.1* of The Statutes of Saskatchewan, 2002 Online: Queen's Printer.
Immunity against certain nuisance actions
303(1) A city is not liable in an action based on nuisance, or on any other tort that does not require a finding of intention or negligence, for any loss or damage arising, directly or indirectly, from any public works, including streets, or from the operation or non-operation of a public utility.

[29] *The Municipalities Act* being Chapter M-36.1 of The Statutes of Saskatchewan, 2005 see sections 339 - 341

[30] *Ibid* at s. 339. **Non-liability if acting in accordance with statutory authority**
339 Subject to this and any other Act, a municipality is not liable for damage caused by anything done or not done by the municipality in accordance with the authority of this or any other Act unless the cause of action is negligence or any other tort.

2005, c.M-36.1, s.339.

[31] *Ibid* at 340. **Immunity against certain nuisance actions**
340(1) A municipality is not liable in an action based on nuisance, or on any other tort that does not require a finding of intention or negligence, for any loss or damage arising, directly or indirectly, from any public works, including streets, or from the operation or non-operation of a public utility.
(2) A municipality is not liable for damages resulting from:

(a) any interference with the supply of a public utility service if:

(i) the interference is necessary for the repair and proper maintenance of the public utility service; and

(ii) a reasonable attempt is made to notify the owners or occupants of land or buildings affected by the intended interference; or

(b) the breaking or severing of a service pipe, service line or attachment.

2005, c.M-36.1, s.340; 2007, c.32, s.15.

[32] *Ibid* at s. 341 **Non-liability for discretion**
341 A municipality that has the discretion to do something is not liable for, in good faith, deciding not to do the thing.

[33] *Laurentide Motels Ltd. C. Beauport (Ville)* [1989] 1 S.C.R. 705 (S.C.C.).

[34] *Just v. British Columbia,* [1989] 2 S.C.R. 1228 at para 15. (Just)

[35] *Municipal Liability for Sewer and Water Pipe Failures…Despite Statutory Authority and Immunity,* Ontario Sewer and Watermain Construction Association at page 10-11 citing *Just,* supra note 34 at para 30.

[36] *Oosthoek v. Thunder Bay (City)* 30 O.R. (3rd) 323 (Ontario Court of Appeal).
[37] *City of London Strategic Flood Risk Assessment.* Document: 1 Version: 12 Main Report, City Corporation May 2012 at page 44. Online: http://www.cityoflondon.gov.uk/services/environment-and-planning/planning/heritage-and-design/Documents/strategic-flood-risk-assessment-2012.pdf
[38] LiDar – UK. Online: http://lidar-uk.com/
[39] Joseph, Thomas. *Catchment and Overland Flow Pathway Delineation Using Lidar and GIS Grid Based Approach in Urban Stormwater and Sewer Network Models* at page 1**.** Online: http://www.waternz.org.nz/documents/sigs/modelling/technical_articles_2007/joseph_t_catchment_and_overflow.pdf
[40] Wheater, H.S. *Progress in and prospects for fluvial flood modeling* Philisophical Transactions. Royal Society. 15 August 2006 vol. 364 no. 1845. 2135-2145 at page 2140
[41] *Ibid* at page 2142. Accuracy could be achieved through a fully integrated model if the representation of component processes is carefully designed to be at an appropriate level of complexity to support the computational requirements of catchment-scale application.
[42] *Ibid* at page 2143.
[43] *Ibid*.
[44] Innovation in Canada*, supra* note 1 at page 10.
[45] Wheater *supra* note 40 at page 2143.
[46] Wilby R.L. et al. *Integrated modelling of climate change impacts on water resources and quality in a lowland catchment: River Kennet,* UK Journal of Hydrology (2006) 330, 204– 220. Early studies (2006) in the UK linked "established models of regional climate (SDSM), water resources (CATCHMOD) and water quality (INCA) within a single framework". Trial experiments "illustrate how the system can be used to explore aspects of climate change uncertainty, reliability of water resources, and water quality dynamics in upper and lower reaches of the drainage network".
[47] Hüesker, Frank, et. al. *Managing Water Infrastructures in the Berlin-Brandenburg Region between Climate Change, Economic Restructuring and Commercialisation* DIE ERDE **142** 2011 (1-2) Global Change: Challenges for Regional Water Resources pages 187-208, at page 188.
[48] *Precipitation Downscaling Under Climate Change, Recent Developments to Bridge the Gap Between Dynamical Models and the End Use* at page 1. Online*:* http://www2.meteo.unibonn.de/mitarbeiter/venema/articles/2010/2010_downscaling_precipitation_review.pdf (Precipitation)
[49] *ibid* at page 28.
[50] *Ibid*
[51] *Innovyze – Innovating for Sustainable Infrastructure.* Martin Spiers, Senior Engineer, MWH "Frequency of Failure of Existing and Proposed Systems" Online: http://www.innovyze.com/news/fullarticle.aspx?id=667
[52] Onof, C., Arnbjerg-Nielsen, "Quantification of climate change impacts on high resolution design rainfall for urban areas", (2009), *Atmospheric Research*, 92, 360-363.
[53] Saskatoon Design Manual, *supra* note 7.
[54] Overland flows and above ground storage basins comprise the major component of stormwater systems.
[55] Saskatoon Design Manual, *supra* note 7. Section Six, Storm Water Drainage System at 3.2, Major System.
[56] *Ibid* at 3.1 Minor System.
[57] Edmonton Design Manual, *supra* note 5. Volume 3: Drainage
[58] *Ibid,* at 12.6.3
[59] *Ibid*, at 12.3.1
[60] *Ibid* at 12.4.2
[61] *Ibid* at page 43
[62] Calgary Design Manual, *supra* note 6 at page 72.
[63] *Ibid.*
[64] *Ibid.*
[65] *Ibid.*at page 73.
[66] *Ibid* at pg 72..
[67] *Ibid*.
[68] *Ibid* at page 73.

[69] EMPA, *supra* note 24 at section 17 on the collection of data respecting water.
[70] *Ibid* at section 17(2)(b)
[71] *Ibid* at section 35(1)(a)
[72]AB EPEA, *supra* note 26.
[73] Calgary Design Manual, *supra* note 6 at page 57.
[74] Interview with Ross Bulat, City of Edmonton Stormwater Manager, July 17, 2012.
[75] *Ibid.* Edmonton samples outfalls (bi-weekly and when triggered by a storm event). Testing for: TSS, BOD5, TP, TKN, (NO-2+NO-3)-N, NH3-N, Cl-, and *E. coli*.
Additional: volatile fraction of suspended solids (VSS); dissolved phosphorus, i.e. orthophosphate (PO4-); particle size analysis of the suspended solids; SSC using U.S. Geological Survey published protocols; and Total and free chlorine tested in field using portable colorimeter. Hardness, metals Turbidity, *Cryptosporidium, Giardia*, VOC's; Pesticides. Water Quality Monitoring City of Edmonton Online: http://www.edmonton.ca/environmental/ wastewater_sewers/north-saskatchewan-river-water-quality.aspx
[76] City of Edmonton, Water Quality Monitoring Locations Presentation.
[77] Calgary Design Manual, *supra* note 6, at page 310.
[78] City of Toronto, Wet Weather Flow Master Plan, 25-year Plan. Online http://www.toronto.ca/water/protecting _quality/wwfmmp/25year_plan.htm
[79] de Lange, Catherine. *Philadelphia Takes a Revolutionary Approach to Stormwater*. This Big City. Online: http://thisbigcity.net/ philadelphia-revolutionaryapproachstormwater/?utm_source=twitterfeed &utm_medium=twitter&utm_ campaign=Feed%3A+thisbigcity%2FFMhB+%28This+Big+City%29
[80] *Ibid*.
[81] Philadelphia Water Department. Online: http://www.phillywatersheds.org/what_were_doing
[82] Canadian Mortgage and Housing Corporation. Rain Gardens. Online: http://www.cmhc-schl.gc.ca/en/co/maho/la/la_005.cfm
[83] Green Roofs for Healthy Cities. Green Roof Benefits. Online: http://www.greenroofs.org/index.php/about-green-roofs/green-roof-benefits
[84]Land Stewardship Centre – Green Roofs. Online: http://www.landstewardship.org/green-roofs/
[85] http://www.nrc-cnrc.gc.ca/obj/irc/doc/pubs/nrcc47705/nrcc47705.pdf
[86]Liu, K. Bass, B. Performance of Green Roof Systems. National Research Centre of Canada. Online: http://www.nrc-cnrc.gc.ca/obj/irc/doc/pubs/nrcc47705/nrcc47705.pdf
[87] Green Roof Bylaw (Toronto Municipal Code Chapter 492, Green Roof) Online: http://www.toronto.ca/legdocs/municode/1184_492.pdf
[88] *Toronto's new green roof law a first for North America* Online: http://www.mnn.com/earth-matters/politics /stories/torontos-new-green-roof-law-a-first-for-north-america.
[89] *Green City, Clean Waters. The City of Philadelphia's Program for Combined Sewer Overflow Control – A Long Term Control Plan Update*. The Philadelphia Water Department September 1, 2009 at page 3. Online: http://www.phillywatersheds. org/ltcpu/LTCPU_Summary_LoRes.pdf (*Green City, Clean Waters*)
[90] City of Toronto, Green Roofs Bylaw. Online: http://www.toronto.ca/greenroofs/overview.htm
[91]*A Guide to Stormwater Best Management Practices* City of Chicago, at page 6.Online: http://www.cityofchicago .org/dam/city/depts/doe/general/NaturalResourcesAndWaterConservation_PDFs/Water/guideToStormwaterBMP .pdf
[92] http://www.explorechicago.org/city/en/about_the_city/green_chicago/Green_Roofs_.html
[93] City of Chicago. "Green Roof Grants Programs," accessed at www. cityofchicago.org /city/en/depts/doe/supp_info/green_roof_grantsprograms. html.
[94]Explore Chicago; The City of Chicago's Tourism Site. *Green Roofs in Chicago.* Online: http://featuresblogs. chicagotribune.com/theskyline/2010/04/theres-been-so-much-hype-about-green-roofs-in-chicago-that-i-went-to-the-willis-tower-sky-deck-last-week-expecting-to-see.html
[95] *City of Portland Bureau of Environmental Services* – Grey to Green. Online: http://www.portlandonline.com/ bes/index.cfm?c=47203

[96] *City of Portland Bureau of Environmental Services* – Grey to Green Elements: Revegitation. Online: http://www.portlandonline.com/bes/index.cfm?c=47203&a=193188#revegetation
[97] *Ibid.*
[98] *City of Portland Bureau of Environmental Services* – Watershed Revegitation Program. Online: http://www.portlandonline.com/bes/index.cfm?c=44717&a=394076
[99] *City of Portland Bureau of Environmental Services* – Tree Planting Program. Online: http://www.portlandonline.com/bes/index.cfm?c=50795 Portland has a Treebate program; if you plant a tree on your residential property, the city of Portland offers a rebate on your utility bill. Trees planted in streets and yards are offered at a discounted rate through the Friends of Trees Program.
[100] Andrews, Scott et al. Green and Sustainable Building Policy: a Case Studey for Decision Makers. Online: http://www.docstoc.com/docs/73161191/Chicago at page 25 citing the Green Building Policy Update, *Binding City Policy* BCP-ENB-9.02
[101] *When It Falls on the Roof.* Stormwater Solutions Handbook - Environmental Services - City of Portland Oregon. Online: http://www.portlandonline.com/bes/index.cfm?c=43110&a=129056 at page 10.
[102] Bass, Brad. Green Roofs and Green Walls: Potential Energy Savings in the Winter. Adaptation & Impacts Research Division Environment Canada at the University of Toronto Centre for Environment. 2007
[103] Energy Conservation – Improved Thermal Performance. Online: http://livingroofs.org/2010030776/green-roof-benefits/energycons.html
[104] Capital Region District, Green Roofs Online: http://www.crd.bc.ca/watersheds/lid/roofs.htm
[105] *Ibid.*
[106] City of Toronto, Mandatory Downspout Disconnection – Three-Phase Rollout. Online: http://www.toronto.ca/water/protecting_quality/threephase.htm
[107] *Ibid.*
[108] City of Toronto, Mandatory Downspout Disconnection. Online: http://www.toronto.ca/water/protecting_quality/downspout.htm
[109] Capital Region District – Bioswale. Online: http://www.crd.bc.ca/watersheds/lid/swales.htm
[110] *Ibid.*
[111] City of Seattle, SEA Street Tour. Online: http://www2.cityofseattle.net/util/tours/seastreet/slide8.htm
[112] Wetlands workshop, June 19, 2012.
[113] Wetlands workshop, June 19, 2012.
[114] Metropolitan Council, Protecting Waterways Starts in Your Own Yard. Online: http://www.metrocouncil.org/directions/water/water2007/yardcare.htm
[115] Capital Region District – Permeable Pavement. Online: http://www.crd.bc.ca/watersheds/lid/permeable.htm
[116] *Ibid*
[117] City of Calgary – The Bow is Below, Educational Video. Online: http://www.calgary.ca/UEP/Water/Pages/Water-and-wastewater-systems/The-bow-is-below/Only-Rain-Down-the-Storm-Drain.aspx
[118] City of Calgary – Stormwater Management Report. Online: http://www.calgary.ca/UEP/Water/Documents/Water-Documents/stormwater_report.pdf
[119] City of Calgary – Yard Smart, Rain Gardens. Online: http://www.calgary.ca/UEP/Water/Documents/Water-Documents/Yard_Smart_Rain_Garden.pdf (Calgary Rain Gardens)
[120] City of Calgary Rain Barrel Information. Online: http://www.calgary.ca/UEP/Water/Pages/Water-conservation/Lawn-and-garden/Water-wise-gardening-and-plants/RainBarrel.aspx and Rain Barrel Brochure: http://www.calgary.ca/UEP/Water/Documents/ Water-Documents/Yard_Smart_Rain_Barrel.pdf
[121] City of Calgary – Types of Green Technologies. Online: http://www.calgary.ca/PDA/DBA/Pages/Green-building/Types-of-Green-Technologies.aspx#green_roofs
[122] The City of Calgary Water Resources – Stormwater Management and Design Manual 2011 at page 309. Online: http://www.calgary.ca/PDA/DBA/Pages/Urban-Development/Urban-Development.aspx
[123] City of Calgary – Stormwater Retrofit Program. Online: http://www.calgary.ca/UEP/Water/Pages/construction-projects/Stormwater-quality-retrofit-program/Stormwater-Quality-Retrofit-Program.aspx

[124] Miller, Kristen. State Laws Banning Phosphorus Fertilizer Use. Online http://www.cga.ct.gov/2012/rpt/2012-R-0076.htm It is banned in the state of Illinois, Maine, Maryland, Michigan, Minnesota, New Jersey, New York, Vermont, Virginia, Washington, and Wisconsin.
[125] *Ibid.*
[126] Ross-Flanigan, Nancy. "Water quality improves after lawn fertilizer ban, study shows" *University of Michegan News Service.* Online: http://ns.umich.edu/new/releases/7272
[127] City of Edmonton – Rain Barrel Calculations. Online: http://www.edmonton.ca/environmental/programs/rain-barrel-water-collection-calculations.aspx (Edmonton Rain Barrel Calculations), Calgary Rain Gardens, *supra* note 120, Portland Water District
Rain Barrel Installation & Maintenance Instructions, Online: http://www.pwd.org/pdf/water_resources/rain_barrel_instruct.pdf, The Seattle Rain Barrel A service of Seattle Conservation Corps and Seattle Public Utilities**,** Online: https://www.seattle.gov/parks/scc/files/rain_barrels.pdf.
[128] *Ibid.* Edmonton Rain Barrel Calculations
[129] Cornut, Pierre et al. The Case of Domestic Rainwater Tanks in Belgium. International Conference: Enfironmental Economic Geography: State of the Art and Prospects. Koln, Germany: 2004. (Belgium Rainwater)
[130] www.ecoconso.be
[131] Belgium Rainwater, *supra* note 130 on page 6.
[132] City of Calgary – Sustainable Building Policy. Online: http://www.calgary.ca/CS/IIS/Pages/About-land-information/sustainable-building-policy.aspx
[133] LEED Points Guide. US Green Building Council. Online: https://new.usgbc.org/resources/points-retaining-stormwater-site-gibc8 LEED Points for Retaining Stormwater On-site. 80% retention = 1 point, 85% =2 points, 90% = 3 points, 95% = 4 points.
[134] *Ibid.*
[135] *Ibid* citing research on the consequences of climate change in Berlin-Brandenburg conducted by the Potsdam Institute for Climate Impact Research: Gerstengarbe, F.-W., F. Badeck, F. Hattermann, V. Krysanova, W. Lahmer, P. Lasch, M. Stock, F. Suckow, F. Wechsung und P.C. Werner 2003: *Studie zur klimatischen Entwicklung im Land Brandenburg bis 2055 und deren Auswirkungen auf den Wasserhaushalt, die Forst- und Landwirtschaft sowie die Ableitungerster Perspektiven*. – PIK-Report **83**. – Potsdamand and Lotze-Campen, H., L. Claussen, A. Dosch, S. Noleppa, J. Rock, J. Schuler und G. Uckert 2009: *Klimawandelund Kulturlandschaft in Berlin. Bericht im Auftrag für die Senatsverwaltung für Stadtentwicklung*. – Berlin
[136] Hüesker et al. *Supra,* note 47 at page 191.
[137] *Ibid.*
[138] Schmidt, Marco, *Rainwater Harvesting for Mitigating Local and Global Warming*, Technische Universitat: Berlin. Rainwater Harvesting for Evaporation, Fifth Urban Research Symposium 2009 at page 1.
[139] *Ibid.*
[140] *ibid,* at page 9.
[141] *Ibid* at page 10
[142] *Ibid.*
[143] *Ibid*
[144] *Ibid* at page 11
[145] *Ibid* at page 14
[146] *Ibid* at page 6
[147] *Ibid* at page 6-7
[148] *Toronto's new green roof law a first for North America* **Online:** http://www.mnn.com/earth-matters/politics/stories/torontos-new-green-roof-law-a-first-for-north-america.
[149] *Green City, Clean Waters. The City of Philadelphia's Program for Combined Sewer Overflow Control – A Long Term Control Plan Update*. The Philadelphia Water Department September 1, 2009 at page 3. Online: http://www.phillywatersheds. org/ltcpu/LTCPU_Summary_LoRes.pdf

01-5536-103 SASKATOON ENVIRONMENTAL ADVISORY COMMITTEE - Budget - $6,800							
Date	**Number**	**Description**	**Debit**	**Credit**	**Balance**	**Budget Remaining**	**GL**
		Beginning Balance			**0**	**$6,800**	
3/31/2015	R547604	LA PREP - Lunch for Performance Target Facilitation/Stakeholder Consultation Meeting - March 30, 2015	431.55	20.55	411		x
3/31/2015	APV355714	LAINE, MELANIE - Reimbursement for March 30, 2015 Consultation meeting Refreshments	47.17	0.6	46.57		x
		March Total	**478.72**	**21.15**	**457.57**	**$6,342**	
		Ending Balance, July/2015			**457.57**	**$6,342**	
9/22/2015	R547788	Saskatchewan Environmental Society - 2015 Funding for Student Action for a Sustainable Future Program Initiative	1800			**$4,542**	

Total Expenditures		**2257.57**
2015 Budget		
Publications/State of the Environment ReportAnnual Report	100	
Conferences and Workshops	500	
Public Education/Information Gathering	6,000	
Membership Fees	200	
Total	**6800**	