Storm Water Flood Resiliency

Recommendation
That the Standing Policy Committee on Environment, Utilities and Corporate Services recommend to City Council:

1. That a Home Flood Protection Program pilot project be developed for high flood risk areas in 2018;
2. That $200,000 be allocated in 2018 from the Storm Water Capital Reserve to fund the pilot Home Flood Protection Program; and
3. That the Administration refine infrastructure options with funding strategies and report back by mid-2018.

Topic and Purpose

The purpose of this report is to outline options to increase flood resiliency to reduce the risk of flooding in high-risk flood areas.

Report Highlights

1. Thirty high-risk flood areas in Saskatoon were prioritized, and concept level options and costs for increasing service levels for the top three flood risk areas were evaluated.
2. A Home Flood Protection Program pilot is recommended to offer subsidized home inspections for citizens in the top 30 high-risk flood areas.
3. Based on the concept level costs and service level, funding options to increase storm water infrastructure capacity are included for consideration.
4. Incentives to increase on-site storm water management will be reviewed in 2018.

Strategic Goals

This report supports the Strategic Goal of Quality of Life through reduced flood damage risk to properties, and diminished stress and anxiety associated with intense rainfalls. This report also supports the Strategic Goal of Environmental Leadership through adaptation to climate change.

Background

At its meeting held on August 28, 2017, City Council approved four recommendations regarding the Storm Water Utility Business Plan, as presented by the Administration, and made four additional directives to address surface flooding in high-risk flood areas:

> "1. That the Storm Water Utility focus resources on maintenance and preservation of existing storm water assets;
> 2. That $3 million be maintained in the Storm Water Utility's capital reserve to protect strategic public infrastructure from damage caused by riverbank slumping and other emergency storm water repairs;

3. That the Equivalent Runoff Unit used for Storm Water Management charges be increased by $13.50 annually from 2019 to 2022, and utilized for projects to maintain and preserve storm water infrastructure;
4. That the temporary Flood Protection Program be extended and phased out by $13.50 annually from 2019 to 2022;
5. That the Administration report prior to 2018 budget consideration on the impact of an increase to the ERU to generate funds for flood mitigation;
6. That the City identify this situation as a further request for Federal Funding;
7. That the Administration report on a funding and infrastructure strategy to systematically deal with the top risk priority areas.
8. That the Administration report back outlining possible incentives to residential and/or commercial/industrial property owners to promote demonstrated onsite storm water management not only for new development/infill development, but for retrofit with possible emphasis on established and flood-prone areas."

Report

Intense rainfalls on July 10, 2017, and August 8, 2017, caused surface flooding in 11 of the prioritized 30 surface flood risk areas in south-central Saskatoon. According to the storm water model, both rain events were rated as "1-in-25 year" in localized areas and up to "1-in-2 year" rainfall in most other areas of the city. A survey of property owners in the highest impact areas was conducted to verify the model results (Attachment 1). The survey results of actual flooding in 2017 provided valuable information that will assist in recalibrating the storm water model and reassessing the cost of infrastructure options for different rain events.

Surface Flood Control Strategy

In 2014, 30 areas at risk of flooding were evaluated and rated. The Surface Flooding Control Strategy Report – Storm Water Management (Attachment 2) provides more information about the prioritization.

Conceptual options to reduce the risk of surface flooding and estimated costs for different service levels were assessed for the following three highest ranked areas:

- Ruth Street/Cairns Avenue
- First Street/Dufferin Avenue
- Cascade Street/Dufferin Avenue

The following options were evaluated:

- Flood walls
- Up-size pipes
- Storm water ponds and underground storage
- Redevelop flood-prone areas
- Combination of ponds/underground storage and redeveloping flood-prone areas

The infrastructure solutions are complex because of the capital intensive work required to retrofit the storm water management systems in areas with existing development. As a result, options for residents to make improvements to their properties to increase flood resiliency were assessed.

Home Flood Protection Program

Homeowners can increase flood resiliency by understanding flood risks and taking preventative actions. The Home Flood Protection Program developed by the University of Waterloo's Intact Centre for Climate Adaptation (ICCA) was introduced in 2017 to southern Ontario municipalities, which experienced severe basement flooding. The program offers free online self-help resources and a Home Flood Protection Assessment. Citizens pay $125 (approximately one-third of the cost) for an inspection and report with ways they can reduce sewer backup and overland flood risks, reduce moisture content, minimize damage to valuables, wisely manage water on site, and understand insurance coverage. The ICCA has indicated that a similar pilot program could be offered in Saskatoon in 2018.

The Administration is recommending that a Home Flood Protection Program, in cooperation with ICCA, be implemented in high-risk flood areas in Saskatoon. Information from the assessments will provide the City with valuable information to develop further programs that may include subsidization of recommendations from the assessments.

A review of other municipal programs found three cities that offer a credit program to residential properties for on-site storage of storm water runoff. Some municipalities offer cost-shared programs to reduce the risk of sewer back-ups but not surface flooding. Increasing Flood Resiliency through Private Property Improvements (Attachment 3) provides more details.

Infrastructure Options to Enhance Storm Water Capacity

The flooding impacts of each rain event are different. A "1-in-10 year" storm water retention solution likely would have prevented most of the basement flooding in 2017; however, infrastructure solutions to reduce surface flooding will not prevent the foundation seepage or sanitary sewer back-ups that occurred. Continued actions will also be needed by individual property owners to make their properties more flood resilient as rainfall events greater than "1-in-10 year" are expected in the future.

Based on modelling, the most effective infrastructure option is to direct runoff from intense rain events to a new retention system, which could include dry storm water ponds and possibly underground storage.

Two service level options for infrastructure to enhance storm capacity are summarized as follows:

1. Implement a "1-in-10 year" storm water capacity expansion service level. The $19.0 million high-level concept cost to implement the expansion in three areas could be funded through one of three options:

- A dedicated 0.6% annual mill rate increase for five years (3.04% compounded);
- Make the Flood Protection Program (FPP) permanent and increase the fee to $66 per meter; or
- Increase the Storm Water Utility Equivalent Runoff Unit (ERU) by 30%, in addition to previously approved ERU increases.

These options would generate approximately $154 million over 25 years to increase capacity for 30 areas.

The following table summarizes potential funding strategies for a "1-in-10 year" service level of storm water capacity expansion for three flood risk areas. Further details for infrastructure options are shown in High Level Conceptual Remediation Options and Costs by Service Level (Attachment 4).

Funding Options for "1-in-10 Year" Storm Water Capacity Expansion (Revenue In Millions)						
Funding Options	2018	2019	2020	2021	2022	Total (2018 to 2022)
Mill Rate (0.6% Annual Increase)	$ 1.3	$ 2.7	$ 4.0	$ 5.3	$ 6.7	$ 20.0
Flood Protection Program (FPP) ($66/meter)	$ 0.6	$ 5.0	$ 5.1	$ 5.1	$ 5.2	$ 21.0
ERU Increase (30%) & FPP Re-allocation	$ 1.9	$ 5.2	$ 5.0	$ 4.6	$ 4.1	$ 20.8

2. Implement a "1-in-25 year" storm water capacity expansion service level. The $36.6 million high-level concept cost to implement the expansion in three areas could be funded through one of three options:
   - A dedicated 1.2% annual mill rate increase for five years (6.12% compounded);
   - Make the FPP permanent and increase the fee to $114 per meter; or
   - Increase the Storm Water Utility ERU by 67%, in addition to previously approved ERU increases.

   These options would generate approximately $311 million over 25 years to increase capacity for 30 areas.

Conceptual Storm Water Capacity Expansion and Funding Options (Attachment 5) provides more details on the funding strategy options for different service level options and a high-level implementation plan, if one of these options is desired in the future.

Although solutions and costs have not been developed for the other 27 flood risk areas, if costs for each area are a similar order of magnitude (average of $6.3 million per area), in some areas, the infrastructure solution will exceed the total value of the houses protected and the most cost-effective option may be to redevelop flood-prone areas. The solution complexity, cost, number of properties, and cost to protect each property will vary significantly for each area. Each zone needs to be looked at on a case-by-case basis to determine the most cost-effective solution for the unique circumstances.

If a new retention system is constructed, efforts will be made to maintain recreation usage of parks after reconstruction. However, current recreation activities in these parks are expected to be impacted and park maintenance costs may increase.

Incentives to Promote On-site Storm Water Management

Commercial and industrial property owners in Saskatoon can reduce their Storm Water Utility Bill by reducing permeability. The program will be further assessed in 2018 to determine possible changes to increase uptake and encourage on-site storm water runoff storage, particularly in flood risk areas.

Options to the Recommendation

An option is to purchase the houses in the high-risk areas. This option is generally more expensive than the infrastructure options in more intensive rainfall scenarios; therefore, not recommended for the top three risk areas. This option may be the most cost-effective option in some of the 30 high-risk flood areas but will require further analysis.

Public and/or Stakeholder Involvement

Extensive consultations were undertaken in 2014 with residents in the top flood risk areas about the impacts of property flooding and options to reduce flood risks. Citizens' preferred solutions were storm water retention and upsizing pipes.

Many citizens who were impacted by the July and August 2017 flooding contacted City Council members and the Administration about concerns with flooding in their area. Citizens who presented to the August 15, 2017, Standing Policy Committee on Environment, Utilities and Corporate Services and the August 28, 2017, City Council meeting provided personal accounts of the impact of flooding and requested timely action.

Communication Plan

Flyers were delivered to 480 properties at risk of flooding to provide information about the Provincial Disaster Assistance Program funding, to invite feedback on the extent of the 2017 flooding through an online survey, and to acquire email addresses from citizens for future engagement. The flyers were followed up with phone calls and e-mails to residents in the highest risk areas. Information about flood mitigation is available at saskatoon.ca/flooding.

When a decision about flood resiliency is made, a more detailed communication plan will be developed to inform residents in areas at risk of flooding.

Communication about increases to property taxes or other charges will focus on the importance of enhancing capacity to reduce the risk of property damage, in light of climate change and the likelihood of more frequent intense storms. The communication will also focus on the importance of asset maintenance and preservation to prevent future higher costs.

Financial Implications

The cost to subsidize up to 600 Home Flood Protection Assessments to eligible properties in the 30 high-risk flood areas by $250 each, would be $150,000 and approximately $50,000 to set up, communicate, and administer the assessment program for a total cost of $200,000. The Storm Water Capital Reserve has sufficient funding available in 2018 to support this program.

Estimated resources of $500,000 will be required from the Storm Water Capital Reserve for community engagement and internal engineering design work to support the infrastructure options. A reallocation from the Storm Water Capital Reserve will reduce funding available for emergency remediation of storm water assets and slope stability funding.

If the detailed engineering shows that costs for capacity expansion are more than the concept level costs, adjustments to the Asset Preservation Plan, construction schedule extension, and further mill rate or fee increase will be evaluated and presented.

Environmental Implications

The proposed program supports climate adaptation measures to mitigate flood damage associated with longer-term climate change impacts (e.g. more frequent and intense rainfall events). Storm water infrastructure options would generate greenhouse gas emissions resulting from construction-related activities; however, the overall impact on greenhouse gas emissions has not been quantified.

Other Considerations/Implications

There are no policy, privacy, or CPTED implications or considerations.

Due Date for Follow-up and/or Project Completion

A report summarizing the details and eligibility of the Home Flood Protection Program will be presented in early 2018.

Public Notice

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

Attachments

1. 2017 Rain Events
2. Surface Flooding Control Strategy Report – Storm Water Management
3. Increasing Flood Resiliency Through Private Property Improvements
4. High Level Conceptual Remediation Options and Costs by Service Level
5. Conceptual Storm Water Capacity Expansion and Funding Options

Report Approval

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Approved by: Angela Gardiner, Acting General Manager, Transportation & Utilities Department

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"Approved by Angela Gardiner, Acting/GM of T & U Department, October 31, 2017"

2017 Rain Events

In 2017, severe rainfall events on July 10 and August 8 resulted in localized flooding in south-central Saskatoon. On July 10, accumulated rainfall of 45 mm was recorded at the Saskatoon Light & Power rain gauge. On August 8, Environment Canada reported 57 mm of rainfall at an unofficial rain gauge in the Nutana area, while the closest Saskatoon Water rain gauge at the Acadia Reservoir recorded 26 mm of rainfall. Eleven of the 30 prioritized flood risk areas are located in south-central Saskatoon where flooding was primarily concentrated. Both rain events were rated as a "1-in-25 year" in the areas with the highest official and unofficial accumulated rainfall, and up to a "1-in-2 year" rainfall in most other areas of the city.

In September 2017, 480 flyers inviting residents to complete an on-line questionnaire were delivered in the 11 areas that had been identified to be at highest risk of flooding. The flyers were followed up with phone calls and e-mails to the residents in the top five flood risk areas. As of October 26, 2017, 114 citizens in the 11 areas completed the survey.

The following are survey highlights based on the responses:

- During the July 10 rain event, surface water entered 16 houses and reached the base of an additional 19 houses but did not penetrate the house.
- During the August 8 rain event, surface water entered 41 houses and reached the base of an additional 12 houses.
- Over half of the houses with flooding had less than 2.5 cm of water depth in their house. Fifteen houses had water depth between 2.5 cm and 30 cm (one inch to one foot) and five houses experienced water depth of more than 30 cm (one foot). Three of these houses with more than 30 cm of water were in the First Street/Dufferin Avenue area.
- Of the houses that flooded, fourteen had less than $1,000 in damage, eight had between $1,000 and $10,000, eleven had between $10,000 and $50,000, and seven experienced more than $50,000 in damage.
- Of the houses that experienced flooding, water entered the majority through basement windows. Water also entered via doors, the garage, seepage through the foundation, air conditioning lines, and crawl spaces. Eight properties experienced sewer back-up.

The questionnaire responses confirming flooding were mapped and compared to debris lines and models to determine the estimated number of houses in the top five risk areas that experienced flooding on August 8. The table below shows that based on an extrapolation of the surveys, the maximum number of houses and businesses with water in or at the building in the top five areas on August 8 was 81, with 63 of those being in the top three areas. These numbers based on actual reported flooding indicate that the impact was closer to a "1-in-5 year" modelled rain event, in which 118 properties would be expected to experience water at the base or in their buildings (204 buildings in a "1-in-10 Year" rain event).

Top Five Flood-Risk Areas	Number of survey respondents indicating water reached or entered the building	Maximum houses or businesses with water to the base or in the building extrapolated from surveys and maps	Maximum houses or businesses with expected flooding based only on modelling for a "1-in-10 Year" rain event
1. Ruth Street/Cairns Ave.	17	21	54
2. First Street/Dufferin Ave.	11	19	39
3. Cascade Street/Dufferin Ave.	12	23	41
4. Early Drive/Tucker Ave.	3	9	47
5. Seventh Street/Cairns Ave	7	9	23
Total for five areas	**50**	**81**	**204**

Climate change could result in more frequent, high-intensity rain events in the future. If a "1-in-10 year" design standard is implemented, properties will still be at risk of flooding when intense rains exceed the "1-in-10 year" modelled rain event. Each rain event is different and the impacts are influenced by many factors, including:

- Amount of rainfall
- Intensity
- Duration
- Soil saturation from previous rainfall or snowmelt
- Topography
- Measures taken by homeowners to make their properties more flood resilient.

Municipalities and homeowners can invest in measures to increase flood resiliency. However, there will always be a chance of basement flooding, no matter what municipalities or private homeowners do to reduce the risk.[1]

[1] Dan Sandink, *Handbook for Reducing Basement Flooding*, Institute for Catastrophic Loss, June 2009, pg 4.

Attachment 2

Surface Flooding Control Strategy Report

Storm Water Management

Saskatoon Water
Transportation & Utilities Department

City of Saskatoon

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

BACKGROUND

The storm sewer in Saskatoon is designed to fill and flood onto the street during major rain events. In neighbourhoods constructed after 1989, the water in the street was accounted for as part of the design to try and limit property damage. However, many areas in Saskatoon constructed before 1989 were not designed with the same provision. Therefore, many residents are concerned about property damage as a result of a major rain event.

To add to the problem, Saskatoon has recently received more precipitation than any other similar period, dating back to 1900. This precipitation has led to an increase in ground water elevation which has caused a higher level of saturation in the soil. As well, the rainfall intensity and frequency has increased the risk of property damage in many areas of Saskatoon.

In response, the Storm Water Management Group within Saskatoon Water has developed a surface flooding control strategy. The strategy is to prioritize all the known flooding locations and investigate possible remedial options. Thirty flood zones have been assessed and the top five have been identified to address first.

INTRODUCTION

The 2007 city-wide model produced flood contours for four different storms with the following return periods: 2 year, 5 year, 10 year, and 100 year.

METHODOLOGY

Site Risk

Site Risk is an indicator of the probability that any given site will flood within a specific flood zone. For each of the flood zones, the number of residential flooded sites and the number of commercial flooded sites were counted for each of the four storms. A site was assumed to be flooded if any amount of water touched or surpassed its boundaries. As well, it should be noted that residential sites are those sites with a subclass of RES (residential), MRES (multi-residential), or COND (condominium), while commercial sites are those sites with a subclass of COMM (commercial). For this analysis, residential property is considered to be more important that commercial property. Therefore, the following formula was used to determine the total number of flooded sites within a flood zone:

$$\text{Number of Flooded Sites} = 2 \times \left(\text{Number of Residential Flooded Sites}\right) + \left(\text{Number of Commercial Flooded Sites}\right) \quad (1)$$

The above formula resulted in four values for each flood zone, one for every storm event. These values were then used in the following formula to determine the Site Risk for each storm within each flood zone:

$$\text{Site Risk} = \frac{\text{Number of Flooded Sites}}{\text{Return Period of Storm}} \quad (2)$$

This resulted in four Site Risk values for each flood zone, one for each storm event. Finally, the Site Risk for each flood zone was determined to be the largest of the four resulting values.

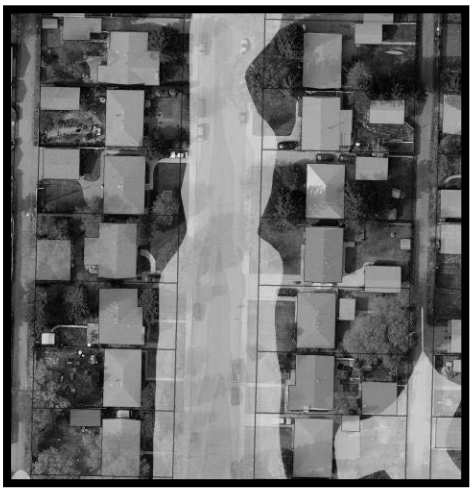

Figure 1: An example of flooded sites during a 5 year storm.

METHODOLOGY

Building Risk

Similar to Site Risk, Building Risk is an indicator of the probability that a building will flood within a specific flood zone. For each of the flood zones, the number of residential flooded buildings and the number of commercial flooded buildings were counted for each of the four storms. A building was assumed to flood if any amount of water touched or surpassed the boundaries of the building. It was also assumed that a building was residential if it was located on a site with a subclass of RES, MRES, or COND. Commercial buildings were those buildings located on sites with a subclass of COMM. Once again, this analysis assumed that residential property was more important than commercial property. Therefore, the following formula was used to determine the total number of flooded buildings within a flood zone:

$$\text{Number of Flooded Buildings} = 2 \times \left(\text{Number of Residential Flooded Building}\right) + \left(\text{Number of Commercial Flooded Buildings}\right) \quad (3)$$

The above formula resulted in four values for each flood zone, one for every storm event. These values were then used in the following formula to determine the Building Risk for each storm within each flood zone:

$$\text{Building Risk} = \frac{\text{Number of Flooded Buildings}}{\text{Return Period of Storm}} \quad (4)$$

This resulted in four Building Risk values for each flood zone, one for each storm event. Finally, the Building Risk for each flood zone was determined to be the largest of the four resulting values.

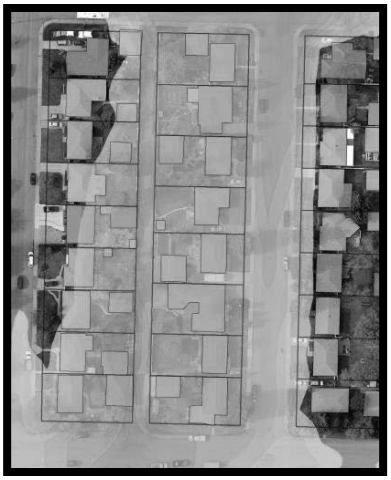

Figure 2: An example of flooded buildings during a 5 year storm.

METHODOLOGY

Road Risk

Throughout Saskatoon, there are eight different road types, each classified based on their importance to and impact on the public. For this analysis, each road type was assigned a value between one and eight to indicate how the public would be affected if the road was flooded. An eight indicates that the majority of the public would be affected if the road was flooded, while a one indicates that very few people would be affected if the road was flooded. This value is referred to as Road Criticality. It should be noted that a road was considered to be flooded if any amount of water was on the road. A summary of the different road types, and their corresponding Road Criticality values, can be seen below in Table 1.

Table 1: Road Type Summary

Road Type	Road Criticality
Highway	8
Expressway	7
Expressway Ramp	6
Arterial Major	5
Arterial Minor	4
Collector	3
Local	2
Grid Road	1

For each storm event, the total number of roads that experienced flooding were counted for each unique road type within each flood zone. Once this information was collected, the following formula was used to determine the Road Risk for each storm within each flood zone:

$$\text{Road Risk} = \frac{\sum (\text{Road Criticality} \times \text{Number of Flooded Roads})}{\text{Return Period of Storm}} \quad (5)$$

This resulted in four Road Risk values for each flood zone, one for each storm event. Finally, the Road Risk for each flood zone was determined to be the largest of the four resulting values.

METHODOLOGY

Combined Risk

Finally, a Combined Risk was calculated for each of the flood zones by taking into account Building Risk, Site Risk, and Road Risk. For this analysis, each of the three risk factors were given different levels of importance. Building Risk was considered the most important since damage to a building due to flooding can be costly to fix and has a large impact on the well-being of the public. Road Risk was considered the least important since roadways constructed after 1989 are designed to convey overland flow. The following formula was used to determine the Combined Risk for each flood zone:

$$\text{Combined Risk} = (3 \times \text{Building Risk}) + (2 \times \text{Site Risk}) + \text{Road Risk} \quad (6)$$

The following Table provides the Combined Risk for each of the thirty flood zones, as well as the resulting priority for each zone.

METHODOLOGY

Table 2: Flood Zone Risk Analysis Results

Priority	Flood Zone	Neighbourhood(s)	Combined Risk
1	Ruth - Cairns	Adelaide / Churchill	103.4
2	1st Street - Dufferin	Haultain / Buena Vista / Queen Elizabeth	80.4
3	Cascade - Dufferin	Avalon	78.4
4	Early - Tucker	Brevoort Park	64.2
5	7th Street - Cairns	Haultain / Holliston	60.4
6	24th Street - 3rd Avenue	City Park / Central Business District	56.6
7	Centennial - Dickey	Pacific Heights	53.6
8	Main - Cumberland	Varsity View / Grosvenor Park / Holliston / Haultain	49.4
9	John A MacDonald - McCully	Confederation Park	47.9
10	Junor - Makaroff	Dundonald / Westview	41.0
11	Louise - Taylor	Holliston	38.6
12	21st Street - Avenue W	Pleasant Hill / Meadowgreen / Mount Royal	38.6
13	King - 5th Avenue	City Park	38.2
14	Confederation - Laurier	Massey Place / Confed Suburban Centre / Confed Park	38.2
15	Meighen Crescent	Confederation Park	36.0
16	East - Louise	Eastview / Nutana Suburban Centre	32.2
17	Kingsmere - Brightsand	Lakeridge	32.0
18	14th Street - Cumberland	U of S South Area / Varsity View / Grosvenor Park	30.9
19	Eastview Streets	Eastview	30.2
20	Grosvenor - Taylor	Holliston	28.3
21	Eastlake - Willow	Queen Elizabeth	26.6
22	1st Avenue - 46th Street	North Industrial	22.0
23	Byers - Selkirk	Westview / Hampton Village	21.2
24	Ruth - York	Avalon / Queen Elizabeth	19.4
25	Albert - Bute	Avalon / Adelaide / Churchill	17.6
26	Idylwyld - Circle	North Industrial / Airport Business Area	17.3
27	Kingsmere - Wakaw	Lakeview	14.6
28	Smith - McCormack	Parkridge	11.0
29	1st Avenue - 50th Street	North Industrial	9.5
30	Northumberland - Mackie	Massey Place	6.6

Increasing Flood Resiliency Through Private Property Improvements

Property owners can take various actions to manage rainwater on their properties and increase flood resiliency. The following summarizes a review of municipal programs, measures that property owners can take to increase flood resiliency, and advantages and disadvantages of cost-shared programs for private properties.

Municipal Programs to Increase Flood Resiliency

Programs to Reduce Basement Flood Risk

After flooding occurred in 2005, the City of Saskatoon implemented a grant program to fund 100% of the installation of sumps and backflow devices, up to $2,500, in designated areas that experienced sewer backup. In 2007, the program was expanded to properties that did not flood but were in high-risk zones, and in 2010, the maximum grant was increased to $3,000. In 2008, a new program funded 100% of the cost to install winter weather bypass systems to direct sump flow into floor drains for previous Flood Protection Program participants who were experiencing winter weather flow.

Several other Canadian municipalities offer subsidies or grants for sump pits, sump pumps, backwater devices, and disconnecting downspouts and weeping tiles from sanitary sewers. A typical maximum municipal subsidy for these programs is $3,000, with maximum amounts ranging from $1,500 (Humboldt, SK) to $11,000 (London, ON). London's program is higher because a subsidy is provided for a drain connection from the city sewer in the road allowance to the dwelling unit.

Programs to Encourage On-site Runoff Storage for Commercial Properties

Commercial, industrial, and institutional property owners in Saskatoon can reduce their Storm Water Utility Bill by installing private storage ponds, green roofs, permeable pavement, rain gardens, or other "soft" landscaping that reduces runoff. Few companies have made these type of changes, likely because of the relatively high upfront capital cost.

Programs to Encourage On-site Runoff Storage for Residential Properties

Three municipal programs to encourage rainwater management on residential properties were identified. The City of Victoria offers residential "Rainwater Rewards" which are rebates for on-site storage, ranging from $100 for a rain barrel to $1,500 for permeable pavement with a rock reservoir, in addition to ongoing credits. The Cities of Kitchener and Waterloo offer up to a 45% credit applied to storm water charges, depending on the amount of water diverted from the storm water system. Although these are best practices for storm water management, they would have little impact in preventing surface flooding during intense rain events similar to those experienced in Saskatoon in 2017.

Programs to Encourage Retrofitting Properties to Reduce Surface Flooding

In 2017, Burlington, Ontario, launched the Home Flood Protection Program in collaboration with the University of Waterloo's Intact Centre on Climate Adaptation. The pilot program provides free online self-help resources and for $125, residents can get a

home flood protection assessment with tips to reduce sewer backup and overland flood risks, reduce moisture content, reduce damage to valuables, and wisely manage water on site. All residents are eligible and approximately 100 had booked by mid-October. Although no other Canadian municipal subsidy program for property improvements to increase surface flooding resiliency was identified, the United Kingdom implemented "The Property Level Flood Resilience Grant Scheme" which provided a grant of up to £5,000 (~$9,000 CAD) to homeowners and businesses that were flooded in December 2015. [1]

Flood Resiliency and Resistent Measures

The most effective way for property owners to minimize flooding varies and requires an assessment of the unique characteristics of each individual property. The following are examples of measures that homewowners can take to increase flood resiliency:[2]

1. Install weeping tiles, sump pits, sump pumps, and backwater valves
2. Seal cracks and gaps in walls
3. Install water-resisting external doors and windows
4. Construct flood defense walls and gates
5. Acquire temporary free standing barriers, such as self-inflating flood protection or water absorbing bags
6. Acquire water sensor and alarm
7. Enhance lot grading, backfilling, and swales
8. Raise porches

The cost of options to reduce flooding range from under $100 for water alarms or a basic rain barrel, to over $10,000 for lot regrading and other property improvements.

Program Advantages and Disadvantages

A main benefit to subsidizing a program for property owners as an alternative to investing in a large infrastructure program is the significantly lower cost. Infrastructure projects that would protect up to 130 houses in three areas for a "1-in-10 year" storm, are estimated to cost $19.0 million. A grant of up to $4,000 for up to 130 homeowners to make improvements would be a maximum of $0.52 million and about $0.1 million to communicate and administer for a total of about $0.62 million. Expanding a program to up to 600 properties in the top 30 assessed risk areas would cost up to $2.8 million,

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[1] The grant was available until March 31, 2017
http://www.flood-products.co.uk/government-flood-grant-explained/
http://www.nationalfloodforum.org.uk/government-grants-for-property-level-flood-resilience/

[2] *Handbook for Reducing Basement Flooding* published by Institute for Catastrophic Loss Reduction (2009). Author: Dan Sandink.
http://www.basementfloodreduction.com/forhomeowners/20tipsforhomeowners.html
Homeowners Guide to Flood Resilience: A Living Document published through the "Know Your Flood Risk" Campaign in conjunction with RAB Consultants Ltd. and MDA. (2016). Authors: Mary Dhonau et al. http://www.knowyourfloodrisk.co.uk/sites/default/files/FloodGuide_ForHomeowners.pdf

including about $0.4 million to administer. Not all property owners would be expected to access the program so the cost is likely to be lower.

A decision to fund improvements to private properties must consider various advantages and disadvantages:

Advantages

- Reduces impacts of flooding of eligible properties that benefit from the program.
- Increases quality of life for residents of eligible properties by reducing risk of flooding.
- Lower cost than large capital solution.
- Increases property values for eligible properties that are upgraded.

Disadvantages

- Fairness: Determining criteria for eligibility will be partly subjective. Current modelling is not based on individual situations and includes a three meter buffer zone around each property. A more comprehensive evaluation of properties may be needed to determine eligibility. Properties in other areas also may also be prone to flooding.
- Fairness: Many homeowners at risk of flooding have already been proactive in investing at their own cost to minimize the impacts of flooding, and those costs would be ineligible.
- Another precedent for covering costs of private property improvements: The City may receive additional requests from property owners to cover costs to minimize the impacts of flood damage to personal property.
- Could encourage rent-seeking: Evidence indicates that costs often increase when government funded programs are implemented.
- Administrative costs for the program may be higher than expected, depending on the criteria that are put in place, to determine eligibility and to audit eligible expenses.
- Effective flood prevention solutions may be unaffordable to some property owners, even with cost-sharing.
- Won’t eliminate flood risk: Flood damage could still occur in intense storms.
- Transfers more costs of flooding from the Federal and Provincial Governments to the City. The Provincial Disaster Assistance Program currently provides funding of up to $240,000 per property for damage incurred from surface flooding during intense storms. However, this program is currently under review and could be eliminated because surface flood insurance became available in Saskatchewan in 2016.

High Level Conceptual Remediation Options and Costs by Service Level

The first three of five risk level one flood zones were analyzed to determine the feasibility and relative cost of remediation. These three zones include:

- Ruth Street/Cairns Avenue
- First Street/Dufferin Avenue
- Cascade Street/Dufferin Avenue

The following five remediation solutions were considered:

- Up-size pipes
- Storm water ponds and underground storage
- Flood walls
- Redevelop flood-prone areas
- Combination of ponds/underground storage and redevelop flood-prone areas

The necessary conceptual design for each method was evaluated against five different design storms: 2, 5, 10, 25, and 100 years.

The following tables and graphs below outline the estimated cost in millions of dollars for the five options and five design storms. The 2014 costs have been inflated at 3.2% annually for three years to 2017 dollars. The pipe up-size option is the most expensive option and is not included in the individual flood zone tables and graphs as this solution would be a coordinated cost sharing amongst the three zones. Flood walls are the least expensive but not recommended because they may not be effective and consultations indicated a low acceptance among residents.

Total Solution Concept Costs for All Three Zones Cost in Millions of Dollars ($2017)					
Modelled Solution/ Rain Event Risk	**2 YR**	**5 YR**	**10 YR**	**25 YR**	**100 YR**
Up-size pipes	$ 31.3	$ 48.8	$ 61.0	$ 70.0	$ 79.2
Pond/Underground storage	$ 12.8	$ 16.6	$ 19.0	$ 42.7	$ 57.7
Flood walls	$ 0.7	$ 5.8	$ 10.1	$ 16.8	$ 28.0
Redevelop flood-prone areas	$ 7.9	$ 29.0	$ 48.2	$ 73.3	$ 105.9
Combinations	$ 10.1	$ 17.9	$ 29.2	$ 41.2	$ 68.1

The optimal concept solutions in the following table are generally based on a storm water retention system (ponds/ underground storage) and/or redevelop flood-prone areas. The optimal type of solution can depend on the rain risk event.

Top 3 Modelled Flood Zones Optimal Concept Solution by Risk Zone and Rain Risk Event Cost in Millions of Dollars ($2017)					
Flood Zone/ Rain Event Risk	**2 YR**	**5 YR**	**10 YR**	**25 YR**	**100 YR**
Ruth-Cairns	$ 0.4	$ 3.7	$ 4.3	$ 6.4	$ 6.6
1st - Dufferin	$ 3.8	$ 3.8	$ 3.8	$ 16.0	$ 27.2
Cascade-Dufferin	$ 3.0	$ 5.3	$ 10.9	$ 14.2	$ 23.9
Total Cost	**$ 7.2**	**$ 12.7**	**$ 19.0**	**$ 36.6**	**$ 57.7**
Average Cost Per Area	**$ 2.4**	**$ 4.2**	**$ 6.3**	**$ 12.2**	**$ 19.2**
# of Properties Affected	22	79	130	197	286

Flood Zone 1: Ruth - Cairns Concept Solutions and Rain Risk Events Cost in Millions of Dollars ($2017)					
Modelled Solution/ Rain Event Risk	**2 YR**	**5 YR**	**10 YR**	**25 YR**	**100 YR**
Pond/Underground storage	$ 4.2	$ 3.7	$ 4.3	$ 6.4	$ 6.6
Flood walls	$ 0.1	$ 1.9	$ 3.3	$ 6.9	$ 10.7
Redevelop flood-prone areas	$ 0.4	$ 7.6	$ 20.1	$ 33.7	$ 46.6
Combinations	$ 2.7	$ 5.5	$ 8.2	$ 11.0	$ 16.1
# of Properties Affected	1	20	53	89	123

Flood Zone 2: 1st - Dufferin Concept Solutions and Rain Risk Events Cost in Millions of Dollars ($2017)					
Modelled Solution/ Rain Event Risk	**2 YR**	**5 YR**	**10 YR**	**25 YR**	**100 YR**
Pond/Underground storage	$ 3.7	$ 3.8	$ 3.8	$ 19.8	$ 27.2
Flood walls	$ 0.2	$ 1.8	$ 3.4	$ 4.9	$ 7.5
Redevelop flood-prone areas	$ 3.8	$ 8.7	$ 12.8	$ 20.9	$ 37.3
Combinations	$ 4.4	$ 7.2	$ 10.3	$ 16.0	$ 27.2
# of Properties Affected	11	25	36	58	104

Flood Zone 3: Cascade - Dufferin Concept Solutions and Rain Risk Events Cost in Millions of Dollars ($2017)					
Modelled Solution/ Rain Event Risk	**2 YR**	**5 YR**	**10 YR**	**25 YR**	**100 YR**
Pond/Underground storage	$ 4.6	$ 8.6	$ 10.9	$ 16.5	$ 23.9
Flood walls	$ 0.4	$ 2.2	$ 3.4	$ 4.9	$ 9.8
Redevelop flood-prone areas	$ 3.7	$ 12.7	$ 15.3	$ 18.7	$ 22.0
Combinations	$ 3.0	$ 5.3	$ 10.7	$ 14.2	$ 24.8
# of Properties Affected	10	34	41	50	59

The cost per property based on the optimal storm water solution varies by area and the number of properties impacted for each modelled rain risk event. The cost per property impacted for a "1-in-10 year" rain event averages $146,000 per property for the three areas, and ranges from $80,255 for Ruth-Cairns up to $265,394 for Cascade-Dufferin. The table below summarizes the costs per property impacted for each of the three areas for the five design storms.

Top 3 Modelled Flood Zones Cost Per Property Affected ($2017)					
Flood Zone/ Rain Event Risk	**2 YR**	**5 YR**	**10 YR**	**25 YR**	**100 YR**
Ruth-Cairns	$ 373,696	$ 185,749	$ 80,255	$ 72,245	$ 53,347
1st - Dufferin	$ 345,718	$ 150,358	$ 106,857	$ 276,671	$ 261,671
Cascade-Dufferin	$ 300,056	$ 154,844	$ 265,394	$ 283,349	$ 405,551
Average Cost Per Property (Not in Millions)	$ 326,234	$ 161,248	$ 146,012	$ 186,011	$ 201,759

All numbers may change based on more detailed designs and costs, and refined modelling assumptions based on the survey results clarifying the number of houses impacted by rain events.

Conceptual Storm Water Capacity Expansion and Funding Options

Funding Option Overview

Three options are summarized in the tables below to generate funding for storm water retention infrastructure for three of the top risk areas over five years for different levels of service: "1-in-10 Year" and "1-in-25 Year". In addition, community engagement and detailed engineering design work could be started in 2018 by re-allocating existing staff resources. If the costs for capacity expansion are more than the estimated concept level costs, adjustments to the asset preservation plan, an extension of the construction schedule, and other increases will be evaluated and reported.

Funding Options for for 1-in-10 Year Storm Water Capacity Expansion (Revenue In Millions)						
Funding Options	**2018**	**2019**	**2020**	**2021**	**2022**	**Total (2018 to 2022)**
Mill Rate (0.6% Annual Increase)	$ 1.3	$ 2.7	$ 4.0	$ 5.3	$ 6.7	**$ 20.0**
Flood Protection Program (FPP) ($66/meter)	$ 0.6	$ 5.0	$ 5.1	$ 5.1	$ 5.2	**$ 21.0**
ERU Increase (30%) & FPP Re-allocation	$ 1.9	$ 5.2	$ 5.0	$ 4.6	$ 4.1	**$ 20.8**

Funding Options for 1-in-25 Year Storm Water Capacity Expansion (Revenue In Millions)						
Funding Options	**2018**	**2019**	**2020**	**2021**	**2022**	**Total (2018 to 2022)**
Mill Rate (1.2% Annual Increase)	$ 2.6	$ 5.3	$ 8.0	$ 10.8	$ 13.5	**$ 40.3**
Flood Protection Program ($114)	$ 4.2	$ 8.6	$ 8.7	$ 8.9	$ 9.0	**$ 39.4**
ERU Increase (67%) & FPP Re-allocation	$ 4.3	$ 8.2	$ 8.7	$ 8.9	$ 9.1	**$ 39.2**

A borrowing strategy could be implemented in conjunction with any of the funding options to complete the design and construction more quickly but costs would increase due to interest costs and the higher cost of using consultants instead of available in-house design engineers.

Option 1: Mill Rate Increase

A 0.6% annual mill rate increase over five years (3.04% compounded increase) will generate $20.0 million over five years with a base budget of approximately $6.7 million by 2022. This could be a dedicated increase for increasing storm water capacity similar to the dedicated increase for sound walls. Over 25 years, approximately $154 million (excluding assessment growth) would be generated to increase storm water capacity in 30 flood risk areas.

A mill rate increase is appropriate to fund the storm water expansion because the improvement increases the level of service for storm water infrastructure in at risk areas to a level that is more consistent with the service level in other areas of the city. An option is to delay the mill rate increase until 2019 when construction costs start to be incurred.

Option 2: Flood Protection Program

A second funding option is to expand the scope of the temporary Flood Protection Program (FPP), increase the fee to $66.00 per water meter in 2018, and make the FPP permanent. The FPP increase and permanent extension would supersede City Council's recommendation on August 28, 2017, to extend and phase-out the FPP by December 31, 2021.

After intense rain events caused sewer backups in 2005, the temporary FPP was established with a $3.00 monthly charge on all water meters. The charge was increased to $4.50 per month ($54.00 annual) in 2009. The program was extended to sunset December 31, 2018, after generating about $44 million in revenues to fund damage from the 2005 sewer backups, a program for sewer backup valve installation, and superpipes to reduce sewer backups during severe rain events.

On August 28, 2017, City Council approved an extension and gradual phase-out of the FPP by December 31, 2021, to fund the current projected program deficit of $0.3 million and additional superpipes in areas at risk of sewer backups. Option 2 proposes that the scope of the FPP be expanded to include surface flooding, that the annual charge be increased, and that it be made permanent.

The following tables summarize the amount that single family residential, and small and large commercial properties would pay in total for storm water Equivalent Runoff Unit (ERU) and FPP charges for two service levels using the option to fund capacity expansion through the FPP. The maximum commercial charge assumes one water meter per property but many commercial properties have more than one meter.

Option 2: Fee Structure for "1-in-10 Year" Storm Water Capacity Expansion Annual Charges for Residential and Commercial Properties

	2017	2018	2019	2020	2021	2022	2017-2022 % Increase
Annual ERU Rate	$ 52.80	$ 52.80	$ 66.30	$ 79.80	$ 93.30	$ 106.80	102%
Annual FPP Rate	$ 54.00	$ 66.00	$ 66.00	$ 66.00	$ 66.00	$ 66.00	22%
Total Single Family Res	$ 106.80	$ 118.80	$ 132.30	$ 145.80	$ 159.30	$ 172.80	62%
Total Commercial Min	$ 159.60	$ 171.60	$ 198.60	$ 225.60	$ 252.60	$ 279.60	75%
Total Commercial Max	$ 4,542.00	$ 5,346.00	$ 6,696.00	$ 8,046.00	$ 9,396.00	$ 10,746.00	137%

Option 2: Fee Structure for "1-in-25 Year" Storm Water Capacity Expansion Annual Charges for Residential and Commercial Properties

	2017	2018	2019	2020	2021	2022	2017-2022 % Increase
Annual ERU Rate	$ 52.80	$ 52.80	$ 66.30	$ 79.80	$ 93.30	$ 106.80	102%
Annual FPP Rate	$ 54.00	$ 114.00	$ 114.00	$ 114.00	$ 114.00	$ 114.00	111%
Total Single Family Res	$ 106.80	$ 166.80	$ 180.30	$ 193.80	$ 207.30	$ 220.80	107%
Total Commercial Min	$ 159.60	$ 219.60	$ 246.60	$ 273.60	$ 300.60	$ 327.60	105%
Total Commercial Max	$ 4,542.00	$ 5,394.00	$ 6,744.00	$ 8,094.00	$ 9,444.00	$ 10,794.00	138%

The projected revenues for the FPP funding strategy are based on a 1.0% increase in the number of water meters in 2018 and a 1.5% annual increase from 2019 to 2022. An

FPP rate of $66.00 per water meter will generate approximately $5.2 million a year by 2022, and $155 million over 30 years.

Option 3: Equivalent Runoff Unit

The Storm Water Management Charge is based on a unit of measure known as an ERU, which many municipalities use for storm water utility billing. A single family residential (residential) dwelling is deemed to produce one ERU of storm water based on an average of 265.3 m^2 of impervious surface, such as roofs, driveways, and sidewalks.

One ERU valued at $52.80 per year ($4.40 per month) is the amount charged to residential properties. Commercial, industrial, and institutional (commercial) can generate significantly more storm water than residential properties generate; therefore, they are charged multiple ERUs ranging from an annual minimum of two ERUs ($105.60) to a maximum of 100 ERUs ($5,280) in 2018.

The seven-year phase-in of ERUs charged to commercial sites began in 2012 with increases to the annual caps. City Council approved incremental increases of $13.50 per year to the ERU Rate from 2019 to 2022 to fund storm water infrastructure maintenance and preservation and other business plan components. The following table shows the maximum approved charges for ERUs for commercial properties from 2012 to 2022.

Year	Maximum Commercial ERUs	ERU Rate	Maximum Annual Commercial Charge for ERUs
2012	10	$ 52.80	$ 528
2013	25	$ 52.80	$ 1,320
2014	40	$ 52.80	$ 2,112
2015	55	$ 52.80	$ 2,904
2016	70	$ 52.80	$ 3,696
2017	85	$ 52.80	$ 4,488
2018	100	$ 52.80	$ 5,280
2019	100	$ 66.30	$ 6,630
2020	100	$ 79.80	$ 7,980
2021	100	$ 93.30	$ 9,330
2022	100	$ 106.80	$ 10,680

Approximately one third of the ERU revenue is paid by Commercial customers and about two thirds is paid by residential (including multi-residential) customers.

The following tables summarize the amount that residential, and small and large commercial properties would pay in total for ERU and FPP charges for two service levels using the option to fund capacity expansion through an additional increase to the

ERU rate. By 2022, the largest commercial properties would pay up to $17,836 annually.

Option 3: Fee Structure for "1-in-10 Year" Storm Water Capacity Expansion Annual Charges for Residential and Commercial Properties							
	2017	2018	2019	2020	2021	2022	2017-2022 % Increase
Annual ERU Rate	$ 52.80	$ 68.64	$ 86.19	$ 103.74	$ 121.29	$ 138.84	163%
Annual FPP Rate	$ 54.00	$ 54.00	$ 40.50	$ 27.00	$ 13.50	$ -	-100%
Total Single Family Res	$ 106.80	$ 122.64	$ 126.69	$ 130.74	$ 134.79	$ 138.84	30%
Total Commercial Min	$ 159.60	$ 191.28	$ 212.88	$ 234.48	$ 256.08	$ 277.68	74%
Total Commercial Max	$ 4,542.00	$ 6,918.00	$ 8,659.50	$10,401.00	$12,142.50	$13,884.00	206%

Option 3: Fee Structure for "1-in-25 Year" Storm Water Capacity Expansion Annual Charges for Residential and Commercial Properties							
	2017	2018	2019	2020	2021	2022	2017-2022 % Increase
Annual ERU Rate	$ 52.80	$ 88.18	$ 110.72	$ 133.27	$ 155.81	$ 178.36	238%
Annual FPP Rate	$ 54.00	$ 54.00	$ 40.50	$ 27.00	$ 13.50	$ -	-100%
Total Single Family Res	$ 106.80	$ 142.18	$ 151.22	$ 160.27	$ 169.31	$ 178.36	67%
Total Commercial Min	$ 159.60	$ 230.35	$ 261.94	$ 293.53	$ 325.12	$ 356.71	124%
Total Commercial Max	$ 4,542.00	$ 8,871.60	$ 11,112.60	$13,353.60	$15,594.60	$17,835.60	293%

Neighbourhood Improvement Levy

Saskatoon's 1994 Local Improvement Program (Bylaw 5257 *The Local Improvement Procedure* Bylaw) allows for Neighbourhood Improvement Levies to be collected. [1]
A levy to fund the 14th Street storm sewer lining was previously applied to properties in south-central Saskatoon draining to the trunk. However, one resident's response to the 2017 flood impact survey indicated that even though he had paid the levy, he did not believe the improvement reduced the flooding on his street.

If a decision is made to expand the capacity of the storm water network in the three modelled at-risk areas, a $600 annual levy for 130 modelled properties that would benefit from increased storm water capacity would generate $1.9 million over 25 years, which is 10% of the estimated infrastructure cost. Alternative amounts could also be considered.

The main advantage to a levy would be the additional revenue and cost sharing for new infrastructure for those that benefit. Some residents who are at greatest risk of flooding may support the levy because reduced flood risk would improve their quality of life and increase the value of their property. The City's cost of providing higher service levels for storm water infrastructure in new neighbourhoods is passed on to property owners in the form of development levies.

[1] Assessing Owners' Share District Storm Sewers 16) In assessing the owner's share of the cost of construction of a district storm sewer, the said rate shall be specially assessed upon: (a) the land directly abutting upon the work; (b) the land not abutting directly on the work but deemed by Council to be benefitted thereby.

Neighbourhood Improvement Levies require that a majority of impacted property owners support the levies. Residents may not support the levy because of the following:

- A neighbourhood improvement levy was previously paid to fund storm water capacity but properties still flooded.
- Adding a new fixed annual cost may reduce the quality of life for some residents, particularly fixed income residents who may be required to make difficult decisions to adapt to the higher costs.
- Some of the property owners who would be required to pay may have experienced no or minimal flood damage, particularly if they have already made significant investments to make their properties more flood resilient.
- The cost may be considered high relative to the incremental cost of surface flood insurance. While many factors impact the cost of insurance, SGI indicated that the average cost is about $100 per year.
- Neighbourhood Improvement Levies have not been implemented in Saskatoon for many years. Other infrastructure improvements that primarily benefit specific areas have been funded through general revenues.
- Some properties would still be at risk of flooding during rain events that exceed “1-in-10 years”.

Another consideration is the administration cost that would be incurred for managing, billing and collecting the levies.

Federal Funding

An application for storm water capacity expansion will be made to the federal Disaster Mitigation and Adaptation Fund, which is a national, competitive, merit-based program, designed to support investments that will mitigate current and future climate risks, including floods. More information about the program is expected to be released by the Government of Canada in October 2017.

The Storm Water Utility will also leverage federal funding for eligible storm water activities from the National Disaster Mitigation Program, the Municipal Asset Management Program (maximum of $50,000 annually), and any Integrated Bilateral Agreements with the Province of Saskatchewan that provide funding for municipal infrastructure.

Storm Water Capacity Implementation Strategy

If City Council approves proceeding with increased infrastructure capacity, the following implementation is proposed:

One-Year (2018):

- Community engagement about the use of parks for storm water retention will be conducted in high-risk flood areas.

- The storm water model will be further refined based on survey results, and refined details on the infrastructure solution and funding strategy will be presented to City Council.

Five Years: (2018-2022):

- Detailed engineering plans and costs will be prepared for the top two high-risk flood areas: Ruth Street/Cairns Avenue (Area #1) and First Street/Dufferin Avenue (Area #2)
- Cascade Street/Dufferin Avenue (Area #3) will be further assessed, and high-level options and costs for Early Drive/Tucker Crescent (Area #4) and Seventh Street/Cairns Avenue (Area #5) will be completed.
- The next areas for more detailed engineering and construction will be prioritized.
- Constructed infrastructure solutions will be completed for three high-risk areas.
- Automated gates to close two high-risk intersections included in the top 30 ranked areas (Confederation Drive/Laurier Drive and Idylwyld Drive/Circle Drive) will be evaluated.

Twenty-Five Years (2018-2044)

- The funding options provide for implementation of service level infrastructure solutions for up to 30 areas at risk of surface flooding within the next 25 to 30 years. Implementing a borrowing plan will allow for quicker implementation but costs are expected to be higher to contract with engineering firms to supplement in-house resources.