Integrated Infrastructure Services

Business Planning and Support

Engineering Services

Anti-icing Pilot Project Environmental Monitoring and Metrics Report 2018-2019

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EXECUTIVE SUMMARY

This Environmental Monitoring and Metrics Report presents the 2018/2019 environmental review of the Anti-icing Pilot Project, along with a comparison to the results of last year's pilot season (2017/2018).

This evaluation includes:

- the 2018/2019 winter maintenance material inventories compared to historic usage (sand, sodium chloride salt, and calcium chloride brine),
- water sample data at major outfalls to the North Saskatchewan River, and
- loadings discharged to the stormwater system from the city snow storage sites.

The winter 2018/2019 data was compared to historic data with similar snowfall years, which provides the necessary information to understand the environmental implications of changes to the City's winter road safety program.

The materials inventory records show that:

- of the total chloride applied to Edmonton roads for road safety in 2018/2019, 0.5% was due to the application of calcium chloride brine. During the previous winter season (2017/2018), 4.3% of the total chloride was from calcium chloride brine application.
- over the winter of 2018/2019, approximately twice the amount of sodium chloride salt was applied to winter roads compared to previous years with similar snowfall.
- over the winter of 2018/2019, approximately 60% less sand was applied to winter roads compared to previous years with similar snowfall.

Significantly less calcium chloride brine was used in the winter of 2018/2019 as compared to the previous pilot year because the winter temperature and precipitation conditions were not conducive to anti-icing practices.

Compared to previous years with similar snowfall volumes, approximately twice the amount of sodium chloride salt was applied in 2018/2019 while less than half of the amount of sand was applied last winter.

Based on the data available at the time of reporting, the anti-icing pilot has produced no discernable impact on the quality of the City's stormwater that discharges to the North Saskatchewan River. The increased sodium chloride salt application by the City in 2017/2018 and 2018/2019 was not apparent in the environmental outfall data. There are numerous sources of chloride related to winter safety, including the use of deicers by private business and citizens, which may partially explain why the City's maintenance practices are not apparent chloride loadings measured at major outfalls to the river.

A compilation and analysis of monitoring data showed that there were no discernible impacts on biological oxygen demand, phosphorus, or ammonia loadings to the North Saskatchewan River related to the Anti-icing Pilot Project.

1.0 Introduction

This report documents the environmental monitoring and metrics for the Anti-icing Pilot Project undertaken by Infrastructure Operations, Parks and Roads Services, City Operations in the winters of 2017/2018 and 2018/2019. This evaluation was conducted by Engineering Services, Business Planning & Support, Integrated Infrastructure Services. The evaluation includes historical winter road maintenance materials usage, water sample data at major outfalls to the North Saskatchewan River (NSR), and environmental monitoring at City of Edmonton snow storage sites. Consideration was given to historic data with similar snowfall years and an evaluation of chloride, phosphorus, ammonia, and biological oxygen demand (BOD), which are constituents of environmental concern.

In 2018/2019, the winter temperatures and precipitation conditions were not conducive to effective anti-icing, so fewer anti-icing applications were carried out than during the previous winter pilot year.

1.1 Background

Each year the City of Edmonton Parks and Roads Services Branch applies a combination of sand and salt to winter roads to improve road safety. Two types of salt are applied:

- Granular sodium chloride salt: “sodium chloride salt”
- Calcium chloride dissolved in water: “calcium chloride brine”

“Salt” is the common name for dry sodium chloride (table salt). However, the chemical definition for “salt” is any substance composed of positively and negatively charged ions. There are many kinds of salt including sodium chloride and calcium chloride.

Brine is water with high concentrations of dissolved salt. We commonly refer to a saturated solution of calcium chloride salt as “brine” but technically, brine is a high concentration solution of any type of salt.

For clarity, this report uses the following terms: ‘sodium chloride salt’ and ‘calcium chloride brine’.

Sodium chloride salt is blended with road sand to keep the stockpiles from freezing during the winter. Additional sodium chloride salt may be added to maintenance trucks depending on the ambient temperature. Historically, the City used calcium chloride brine to pre-wet sand as it was spread, to help the sand adhere to the road and improve longevity of the application in trafficked areas.

In the winter of 2017/2018, the City of Edmonton Parks and Roads Services Branch undertook an Anti-icing Pilot Project on selected routes using calcium chloride brine, a naturally occurring liquid pumped from saline geologic formations with corrosion inhibitor additives. Calcium chloride brine for anti-icing was applied to roads in a thin layer before or during a snowfall in an effort to reduce the amount of snow that adhered to the road, making snow removal easier and more efficient. The anti-icing pilot program was extended to include the 2018/2019 winter season.

1.2 Objective and Scope

The objective of this Environmental Monitoring and Metrics Report is to establish whether there are significant environmental implications associated with the calcium chloride brine used during the Anti-icing Pilot Project. The environmental data review includes all materials used for winter road maintenance in the City of Edmonton. The scope of this report includes:

- Winter road maintenance material usage:
  - historic annual sodium chloride salt, calcium chloride brine, and sand quantities applied to City streets,
- Water sampling data from outfalls to North Saskatchewan River
  - Biweekly data reports for water samples collected at North Saskatchewan River outfalls were compiled. The current and historic monitoring data for these outfalls were used in this evaluation.[1]
  - The total mass of chloride, BOD, phosphorus, and ammonia-N discharged by stormwater outfalls over the last decade were compared to the 2017/2018 and 2018/2019 winter seasons.[2]
- City of Edmonton Snow Storage Sites
  - Historic snow meltwater monitoring data and loadings from City of Edmonton snow storage sites were typically evaluated from October one year to October the next to capture full winter seasons of snow meltwater quality. The chloride loadings in 2017/2018 and 2018/2019 were compared to chloride loadings during similar snowfall years.

Calcium chloride and sodium chloride dissociates into calcium or sodium ions and chloride ions when dissolved in water. Chloride is readily soluble and mobile in the environment; therefore, it is a key indicator of potential environmental impacts to water due to the use of road safety products.

The following constituents of concern related to the anti-icing program were selected for evaluation:

[1] EPCOR Outfall Sampling Data for 2017 to 2019. EPCOR shared this data with the City of Edmonton.
[2] EPCOR provided outfall compliance monitoring data for storm sewer outfalls, which included the concentrations of key environmental indicators. The loadings for BOD, phosphorus, and ammonia were compiled for each winter season over the last decade.

- Chloride was evaluated because it is mobile in the environment and may adversely affect aquatic habitats and the soil environment.
- BOD, phosphorus, and ammonia were evaluated to establish any measurable impacts related to organic corrosion inhibitors added to the calcium chloride brine.

Current and historical data provides the necessary information to clearly understand the environmental implications for the 2017 to 2019 Anti-icing Pilot Project and other changes related to the winter road program.

1.3 Limitations

There are 225 major and minor storm sewer outfalls that discharge to the North Saskatchewan River and its tributaries within the City of Edmonton. Biweekly water samples were collected at the four largest storm sewer outfalls, each of which collects stormwater from the City of Edmonton's major drainage basins. The monitored outfalls are critical indicators of City stormwater quality and are used herein to compare the anti-icing pilot years to prior winter seasons.

Private businesses and residents apply snow melt products to sidewalks, driveways, and parking lots. Most commercially available snow melt products are chloride-based and often comprised of sodium chloride, calcium chloride, or a blend of calcium chloride and sodium chloride but may contain other chloride salts. Other widely available anti-icing products include urea, calcium/potassium/sodium acetate, and formates (used at airports and other more specialized applications). Beet juice anti-icers are another available product which is usually a blend of sodium or calcium chloride brine with byproducts from the beet sugar industry added for corrosion inhibition. The amount of chloride applied by citizens and private business is not known but is potentially significant to overall river loadings. Transport by overland flow or infiltration of salt or brine from streets, parking lots, sidewalks, and driveways are also not considered.

2.0 Methodology

The following inventory records and environmental monitoring data were used to establish whether the anti-icing pilot program produced any measurable environmental impacts to the North Saskatchewan River:

1. City of Edmonton Parks and Roads Services winter road maintenance material usage inventories.
2. Outfall sampling data.[3]
3. City of Edmonton Snow Storage Site environmental sampling data.

[3] EPCOR Outfall Sampling Data. The City funded an increased frequency of outfall sample collection for the duration of the Anti-icing Pilot Project, and EPCOR agreed to provide current and historical data for the City's use in this evaluation.

The data between the first snowfall in one year (typically October to the last snowfall of the following spring) were used to compare one winter season to the next. Data and calculations were verified by the Engineering Services Environmental Compliance Team. This report has been peer reviewed.

2.1 Material Inventories

Infrastructure Operations' historic seasonal roadway maintenance materials usage inventories from 2001/2002 to 2018/2019 were compiled. The sodium chloride salt and calcium chloride brine inventories were used to calculate the total amount of chloride applied by the City to roads in each winter season.

Minor modifications to the material inventory were made in the preliminary report as a result of a technical review and records update, and accordingly some changes were made to the historical inventory data. The inventory corrections did not have an impact on the results and interpretations made in the 2017/2018 pilot project environmental report

2.2 Snow Storage Sites

A portion of the calcium chloride brine, sodium chloride salt, and sand used for road safety is removed with snow during plowing and transported to snow storage sites where meltwater is directed to settling ponds before discharge to the stormwater system. Engineering Services collects regular water samples from City snow storage sites. Water flow volume data is collected from the snow site discharge point[4], which Engineering Services uses to calculate environmental loadings and to advise Infrastructure Operations of emerging issues. Analytical results for the environmental monitoring samples taken at the snow storage sites were used to compare chloride loadings from the anti-icing pilot years to historical years.

2.3 Outfall Data

Semi-monthly stormwater baseflow samples, flow event samples, and regular monthly water samples were collected from four major outfalls: 30th Avenue, Groat Road, Kennedale, and Quesnell. Additional data was collected from a few selected minor outfalls.

[4] EPCOR monitors the water flow volume at the City snow storage sites and provides the City with this data.

Loadings are reported in kilograms or tonnes. Historic outfall chloride loadings from the beginning of October to the end of September of each year were used for an overall assessment of sodium chloride salt and calcium chloride brine impacts due to the Anti-icing Pilot Project on a “per winter” basis. It is common for BOD and phosphorus loadings to be elevated in summer due to the abundance of organic matter and fertilizer in regional runoff; therefore, only winter and spring loadings were used to evaluate potential impacts due to the use of organic corrosion inhibitors added to the calcium chloride brine. The historic chloride, BOD, phosphorus, and ammonia-N loadings at all stormwater outfalls[5] were evaluated to establish any observable changes to loadings potentially associated with the 2017 to 2019 Anti-icing Pilot Project.

2.4 City of Edmonton Snow and Ice Control Policy

The City of Edmonton Parks and Road Services, City Operations applied road maintenance products for winter safety in accordance with the City of Edmonton Snow and Ice Control Policy 2018-2019. The purpose of the policy is to set snow and ice control standards to provide a safe and reliable transportation network while protecting the environment and providing excellent customer/citizen service. Driver safety is the highest priority of the City’s approach to winter road maintenance.

3.0 Historic Cumulative Snowfall

Historic cumulative snowfall at the Edmonton International Airport was retrieved from Environment Canada’s Monthly Climate Summaries web page. Snowfall data between the first snowfall in the autumn season and the last snowfall in the following spring was analyzed to compare historical annual winter maintenance practices.

Missing snowfall data between 2006 and 2008 was estimated by averaging snowfall data from several Edmonton weather stations. Historical cumulative snowfall data are presented in Table 1. Previous years with similar snowfall[6] to 2017/2018 and 2018/2019 were used for comparison purposes.

[5] The stormwater outfall data is defined by EPCOR as “comprised of monitored and unmonitored storm sewer outfalls” as per the spreadsheet provided by Andrew Liu, date August 8, 2018.

[6] Years with similar snowfall was defined as +/-15 cm compared to 2017/2018 and 2018/2019 snowfall measured at the Edmonton International Airport. There is considerable variability in the snowfall measured at different monitoring stations. Within this report, all of the available historical material use, loadings, and snow data is presented to facilitate additional interpretation.

Table 1
Historical Cumulative Snowfall

Winter Season	Cumulative Snowfall (cm)	Year with Similar Snowfall to 2017/2018	Year with Similar Snowfall to 2018/2019
2001/2002	123	✔	
2002/2003	140		✔
2003/2004	111	✔	
2004/2005	64		
2005/2006	61		
2006/2007	140		✔
2007/2008	96		
2008/2009	106	✔	
2009/2010	82		
2010/2011	160		✔
2011/2012	101		
2012/2013	138		✔
2013/2014	151		✔
2014/2015	106	✔	
2015/2016	53		
2016/2017	138		✔
2017/2018	117	--	
2018/2019	145		--

4.0 Historic Roadway Materials Usage

The Infrastructure Operations section of Parks and Roads Services in City Operations uses calcium chloride brine, sodium chloride salt, and sand for traffic safety during the winter. Table 2 presents the material inventory records since the 2001/2002 winter season. The mass of chloride associated with the salt and brine inventory records was calculated and included in Table 2.

The original historical data in Table 2 was updated to reflect minor quantity adjustments based on an internal review of material usage quantities. The adjustments include the addition of sand placed in community sandboxes to the sand quantities and a few minor data corrections to the sand and salt inventory. These corrections did not influence the data interpretation made in the previous year.

Table 2
Historic Roadway Materials Usage

Year	Sand (tonnes)	Sodium Chloride Salt (tonnes)	**Chloride from Salt (tonnes)**	Calcium Chloride Brine (m^3)	**Chloride from Brine (tonnes)**	**Total Chloride* (tonnes)**	Similar Snowfall Year as 2017/2018 (✔)	Similar Snowfall Year as 2018/2019 (✔)
2001/2002	114,858	17,280	**10,482**	1	**0**	**10,483**	✔	
2002/2003	148,537	30,252	**18,352**	74	**16**	**18,367**		✔
2003/2004	133,806	17,400	**10,555**	245	**53**	**10,608**	✔	
2004/2005	155,421	13,041	**7,911**	201	**43**	**7,954**		
2005/2006	73,695	9,719	**5,896**	230	**49**	**5,945**		
2006/2007	159,635	16,599	**10,069**	406	**87**	**10,156**		✔
2007/2008	146,270	13,688	**8,303**	394	**84**	**8,388**		
2008/2009	152,511	20,284	**12,305**	235	**50**	**12,355**	✔	
2009/2010	89,806	16,030	**9,724**	141	**30**	**9,754**		
2010/2011	118,520	22,743	**13,796**	141	**30**	**13,827**		✔
2011/2012	66,123	19,886	**12,063**	139	**30**	**12,093**		
2012/2013	125,412	25,275	**15,332**	285	**61**	**15,394**		✔
2013/2014	97,691	18,806	**11,408**	144	**31**	**11,439**		✔
2014/2015	92,913	21,194	**12,857**	185	**40**	**12,897**	✔	
2015/2016	56,374	10,260	**6,224**	72	**15**	**6,239**		
2016/2017	109,085	19,309	**11,713**	206	**44**	**11,757**		✔
2017/2018	38,949	36,789	**22,317**	4,673	**1000**	**23,317**	--	
2018/2019	48,840	42,082	**25,528**	617	**132**	**25,660**		--

* Total chloride is the sum of chloride from sodium chloride salt and calcium chloride brine.

4.1 Applied Chloride due to Calcium Chloride Brine from 2017 to 2019

Historically, calcium chloride brine was used to pre-wet sand as it was applied to improve longevity on the roads by making it adhere to the road surface. The historic volumes of calcium chloride brine applied are presented in Table 2. In the 2017/2018 and 2018/2019 winter seasons, calcium chloride brine was used for anti-icing purposes. The chloride contribution from calcium chloride brine is a key environmental performance indicator for the Anti-icing Pilot Project.

According to the roadway maintenance inventory records, sodium chloride salt is the primary source of chloride applied to roads by the City of Edmonton (Table 2). The material usage records show that the application of thin layers of calcium chloride brine as an anti-icer did not contribute significant amounts of chloride compared to sodium chloride salt.

Table 3 shows the contribution of calcium chloride brine compared to the total chloride applied by the City for road safety during the 2017/2018 and 2018/2019 winter seasons.

Table 3
Chloride Applied by the City in 2017/2018 and 2018/2019

Source of Chloride	Chloride Applied 2017/2018 (tonnes)	Chloride Applied 2018/2019 (tonnes)
Total chloride applied (sodium chloride salt + calcium chloride brine)	23,317	25,660
Chloride from calcium chloride brine	1000	132
% of total chloride from calcium chloride brine	4.3%	0.5%

Of the total chloride applied to Edmonton roads for road safety in 2018/2019, 0.5% was due to the application of calcium chloride brine.

The contribution of calcium chloride brine to environmental chloride loadings during the 2018/2019 season of the pilot was negligible. The weather conditions in 2018/2019 were not conducive to the use of calcium chloride. During the previous winter season (2017/2018), 4.3% of the total chloride was from calcium chloride brine application.[7]

4.2 Sodium Chloride Salt

The amount of sodium chloride salt applied in 2017/2018 and 2018/2019 compared to sodium chloride salt application during other years presented in Table 4. Similar snow years were previously identified in Table 1.

[7] The historic materials inventory data was updated to reflect minor quantity adjustments based on an internal review of material usage quantities. The calculated percent of chloride due to anti-icing during the 2017/2018 changed by 0.2% as a result.

Table 4
Sodium Chloride Salt applied by the City in 2017/2018 and 2018/2019

Year	NaCl Salt (tonnes)	Snowfall (cm)	2017/2018		2018/2019	
			Salt Applied in 2017/2018 Compared to Salt Applied in Other Years	Similar Snowfall Year	Salt Applied in 2018/2019 Compared to Salt Applied in Other Years	Similar Snowfall Year
2001/2002	17,280	123	2.1X	✔	2.4X	
2002/2003	30,252	140	1.2X		1.4X	✔
2003/2004	17,400	111	2.1X	✔	2.4X	
2004/2005	13,041	64	2.8X		3.2X	
2005/2006	9,719	61	3.8X		4.3X	
2006/2007	16,599	140	2.2X		2.5X	✔
2007/2008	13,688	96	2.7X		3.1X	
2008/2009	20,284	106	1.8X	✔	2.1X	
2009/2010	16,030	82	2.3X		2.6X	
2010/2011	22,743	160	1.6X		1.9X	✔
2011/2012	19,886	101	1.8X		2.1X	
2012/2013	25,275	138	1.5X		1.7X	✔
2013/2014	18,806	151	2.0X		2.2X	✔
2014/2015	21,194	106	1.7X	✔	2.0X	
2015/2016	10,260	53	3.6X		4.1X	
2016/2017	19,309	138	1.9X		2.2X	✔
2017/2018	36,789	117	--	--	1.1X	
2018/2019	42,082	145	0.9X		--	--

Over the winter of 2018/2019, about twice the amount of sodium chloride salt was applied to winter roads compared to previous years with similar snowfall amounts (1.4X to 2.5X, with an average of 2.0X)

In 2017/2018, sodium chloride salt application to winter roads was greater by a factor of 1.7X to 2.1X compared to other similar snowfall years, approximately twice the previous amounts. Similar quantities of sodium chloride salt was applied in both pilot years.

4.3 Sand for Winter Traction

The amount of sand applied in 2017/2018 and 2018/2019 compared to sand applications during similar snowfall years is presented in Table 5. Similar snow years were previously identified in Table 1.

Table 5
Historic Sand Tonnages Applied for Roadway Maintenance Purposes during Years with Similar Snowfall as 2017/2018 or 2018/2019

Year	Sand (tonnes)	Snowfall (cm)	2017/2018		2018/2019	
			Sand Applied in 2017/2018 Compared to Sand Applied in Other Years	Similar Snowfall Year	Sand Applied in 2018/2019 Compared to Sand Applied in Other Years	Similar Snowfall Year
2001/2002	114,858	123	0.3 X	✔	0.4 X	
2002/2003	148,537	140	0.3 X		0.3 X	✔
2003/2004	133,806	111	0.3 X	✔	0.4 X	
2004/2005	155,421	64	0.3 X		0.3 X	
2005/2006	73,695	61	0.5 X		0.7 X	
2006/2007	159,635	140	0.2 X		0.3 X	✔
2007/2008	146,270	96	0.3 X		0.3 X	
2008/2009	152,511	106	0.3 X	✔	0.3 X	
2009/2010	89,806	82	0.4 X		0.5 X	
2010/2011	118,520	160	0.3 X		0.4 X	✔
2011/2012	66,123	101	0.6 X		0.7 X	
2012/2013	125,412	138	0.3 X		0.4 X	✔
2013/2014	97,691	151	0.4 X		0.5 X	✔
2014/2015	92,913	106	0.4 X	✔	0.5 X	
2015/2016	56,374	53	0.7 X		0.9 X	
2016/2017	109,085	138	0.4 X		0.4 X	✔
2017/2018	38,949	117	--	--	1.3 X	
2018/2019	48,840	145	0.8 X		--	--

Over the winter of 2018/2019, about 60% less sand was applied to winter roads compared to previous years with similar snowfall amounts.

The reduction in sand application is generally consistent with the 2017/2018 data, where the quantity of sand applied to winter roads was approximately a third of the amount of sand applied during previous years with similar snowfall.

5.0 Chloride Loadings to the North Saskatchewan River

5.1 Chloride Loadings at Major Outfalls to the NSR

Water sample analyses for key environmental parameters and flow volumes at storm sewer outfalls to the North Saskatchewan River were collected to determine loadings. The major outfalls collect water from major drainage basins across the City and the chloride measured in the outfall water is mainly from municipal, residential, and commercial anti-icing and de-icing activities. Chloride loadings (total mass of chloride discharged each year) were calculated from the flow volume and chloride concentrations measured in the water samples. Four of the major monitored outfalls are: 30th Avenue, Kennedale, Groat Road, and Quesnell. The historic chloride loading data from these major drainage basins are presented in Table 6. Figure 1 shows the City's major drainage basins.

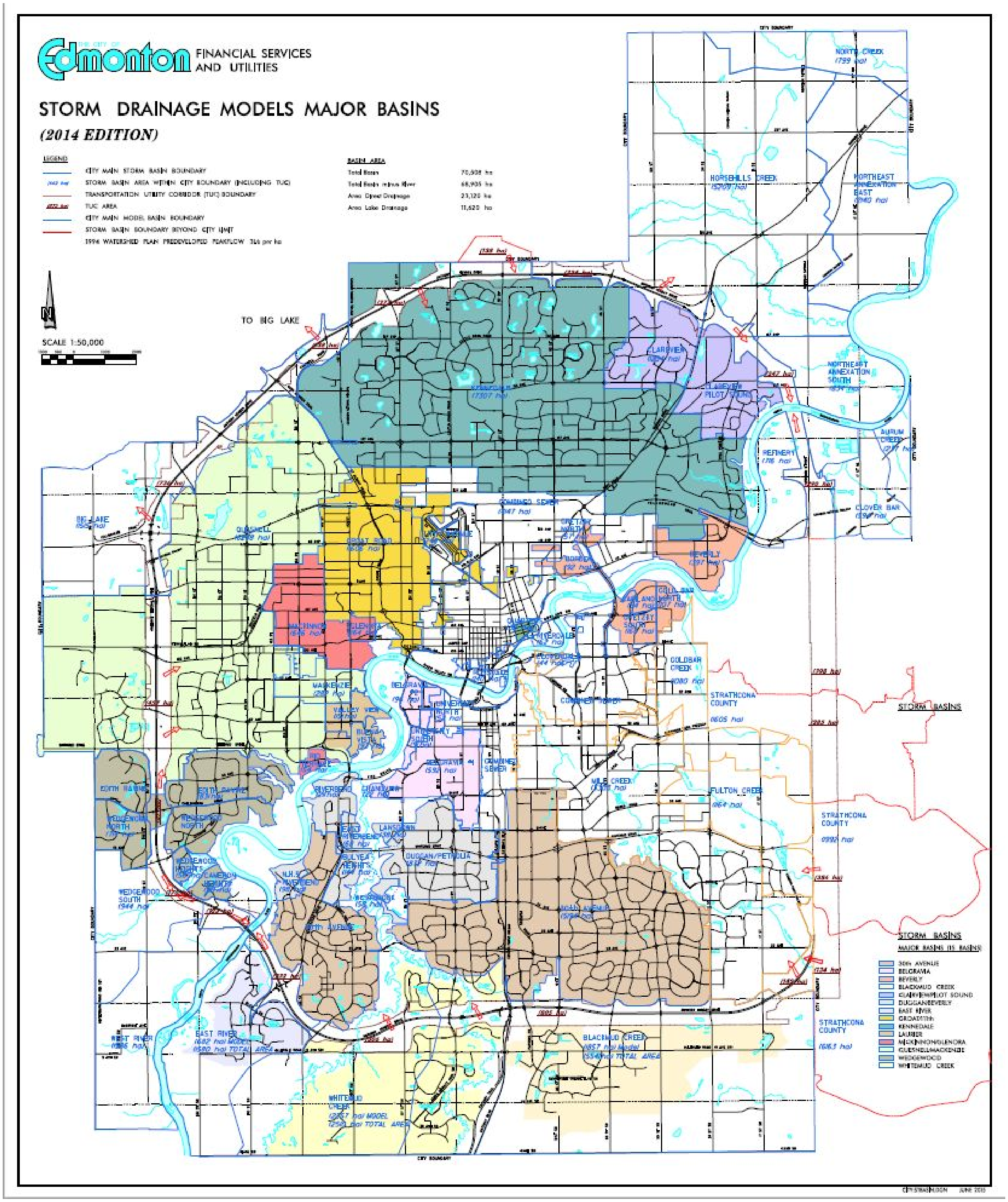

Figure 1: The City's major stormwater drainage basins.

5.2 Influence of Snowfall on Chloride Loadings at Outfalls

The outfall chloride data during the last two pilot years was compared to years with similar snowfall over the last decade (Table 6 and Figure 2) .

Table 6
Historic Chloride Loadings from Major Outfalls to North Saskatchewan River (tonnes)

Year Oct - Oct	30th Ave (tonnes of Cl^-)	Groat (tonnes of Cl^-)	Kennedale (tonnes of Cl^-)	Quesnell (tonnes of Cl^-)	Sum of Loadings (tonnes of Cl^-)	Annual Snowfall (mm)	Similar Snowfall Years as 2017/2018	Similar Snowfall Years as 2018/2019
2001/2002	-	-	-	-	-	123	✔	
2002/2003	1068.7	-	-	-	-	140		✔
2003/2004	1056.3	-	-	-	-	111	✔	
2004/2005	936.2	-	-	-	-	64		
2005/2006	838.9	-	-	-	-	61		
2006/2007	967.7	-	-	-	-	140		✔
2007/2008	584.0	384.8	1327.6	2431.0	4727.4	96		
2008/2009	994.5	2024.8	1007.5	2684.6	6711.4	106	✔	
2009/2010	964.9	1082.5	609.5	2259.5	4916.3	82		
2010/2011	1270.5	2242.9	1405.4	2410.3	7329.1	160		✔
2011/2012	1572.2	901.3	649.7	1735.7	4859.0	101		
2012/2013	1492.9	1035.4	714.5	2584.2	5827.0	138		✔
2013/2014	1460.2	735.5	596.4	2605.7	5397.7	151		✔
2014/2015	1163.6	910.3	471.4	1943.3	4488.6	106	✔	
2015/2016	892.6	384.7	306.4	1463.8	3047.5	53		
2016/2017	1167.9	1053.1	646.5	1785.7	4653.2	138		✔
2017/2018	1533.4	850.1	616.1	2011.8	5011.4	117	--	
2018/2019	1740.1	1232.7	1034.6	2863.2	6870.6	145		--

To summarize, data from the four major drainage outfalls shows that:

- during unusually high snowfall years, total chloride loadings are noticeably higher;
- during unusually low snowfall years, total chloride loadings are noticeably lower;
- during typical snow years the chloride loadings are variable, but the data over the last decade prior to the Anti-icing Pilot Project may be reasonably described as 5,196 tonnes +/- 1,207 tonnes of chloride discharged from four major drainage outfalls in Edmonton;

- this data is used as a benchmark for comparison to evaluate the 2017/2018 to 2018/2019 anti-icing impacts to outfalls.

The following was observed during the snow years of the Anti-icing Pilot Project:

- the Edmonton area received an average of 131 cm +/- 20 cm of snow annually during the two-year pilot project;
- the average chloride loading discharged from the major outfalls to the North Saskatchewan River over the winter years of the Anti-icing Pilot Project was 5,941 tonnes +/- 1,315 tonnes.

The average chloride loading to the North Saskatchewan River during the pilot winter years was higher than the historical average; however, so is the average snowfall. There is a coarse data trend of increased City-wide chloride loadings at monitored outfalls with increasing annual snowfall (Figure 2). The average chloride contribution during the anti-icing pilot years was relatively typical for the annual snowfall.

The chloride contributions due to winter road maintenance during the two-year anti-icing pilot has produced no discernable impact on the quality of the City's stormwater that is discharged to the North Saskatchewan River compared to the available historical data.

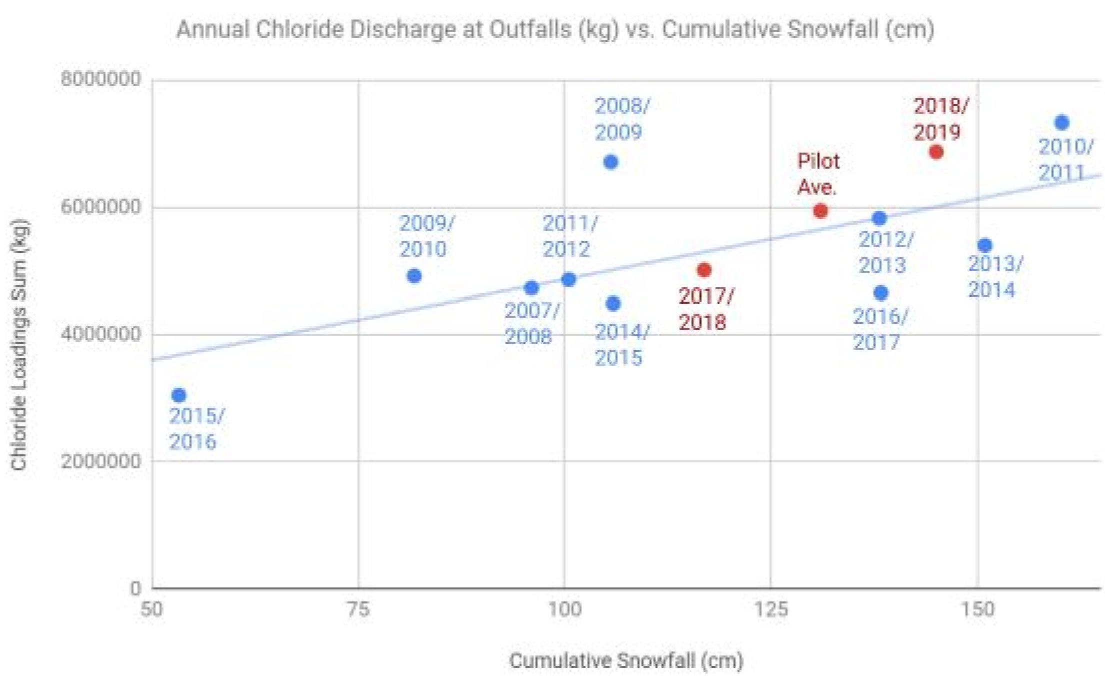

Figure 2: Chloride loadings at the four major outfalls compared to snowfall, 2007/2008 to 2018/2019.

The significant scatter in the historic snow and chloride data is likely a reflection of variability in winter weather patterns and temperatures; for example, winter rain, or icy conditions often require higher than usual chloride applications by the City, as well as private industry and residents for safety reasons. Regardless of the snowfall received, snow containing salt will melt at temperatures below zero degrees Celsius; therefore, the City storm sewer system might contain water and measurable chloride concentrations at any time during the winter.

5.2 City of Edmonton Contributions to Major Storm Outfalls

There is a general historic trend for higher city-wide chloride loadings at major outfalls with increased snowfall. The loadings during the pilot year were divided by the loadings calculated for other years to produce a multiplier factor (Table 7). The multiplier factors were compared to factors generated in a similar fashion for chloride application by the City of Edmonton (Table 8). If the City were the primary contributor to chloride loadings to major outfalls, then the increased sodium chloride salt application during the two pilot years should be apparent in the factors and of similar magnitude.

If the City of Edmonton were the sole or primary contributor of chloride to the storm sewer, then it would be expected that any increase or decrease in City salt application would produce a similar factor in outfall loadings. There appears to be an appreciable difference between the calculated factors for salt applied by the City of Edmonton and the outfall chloride loadings. This lack of relationship suggests that chlorides applied to streets by the City of Edmonton may not be the primary source of chloride loadings.

Table 7
Outfall Chloride Loadings in 2017/2018 and 2018/2019 Compared to Chloride Loadings in Other Years

Year Oct - Oct	Annual Snowfall (mm)	Outfall* Chloride Loadings (tonnes)	2017/2018		2018/2019	
			Outfall Chloride Loadings* in 2017/2018 Compared to Chloride Loading in Other Years	Similar Snowfall Year	Outfall Chloride Loadings* in 2018/2019 Compared to Chloride Loading in Other Years	Similar Snowfall Year
2007/2008	96	4727.4	1.1X		1.5X	
2008/2009	106	6711.4	0.7X	✔	1.0X	
2009/2010	82	4916.3	1.0X		1.4X	
2010/2011	160	7329.1	0.7X		0.9X	✔
2011/2012	101	4859.0	1.0X		1.4X	
2012/2013	138	5827.0	0.9X		1.2X	✔
2013/2014	151	5397.7	0.9X		1.3X	✔
2014/2015	106	4488.6	1.1X	✔	1.5X	
2015/2016	53	3047.5	1.6X		2.3X	
2016/2017	138	4653.2	1.1X		1.5X	✔
2017/2018	117	5011.4	--	--	1.4X	
2018/2019	145	6870.6	0.7X		--	--

*Outfall Chloride Loadings - sum of the four major storm outfalls (30 Ave, Groat, Kennedale, Quesnell).

Table 8
Comparison of City Applied Salt Factor to Outfall Chloride Loading Factor

Year Oct - Oct	Annual Snowfall (mm)	2017/2018			2018/2019		
		Salt Applied in 2017/2018 Compared to Salt Applied in Other Years	Outfall Chloride Loadings* in 2017/2018 Compared to Chloride Loading in Other Years	Similar Snowfall Year	Salt Applied in 2018/2019 Compared to Salt Applied in Other Years	Outfall Chloride Loadings* in 2018/2019 Compared to Chloride Loading in Other Years	Similar Snowfall Year
2007/2008	96	2.7X	1.1X		3.1X	1.5X	
2008/2009	106	1.8X	0.7X	✔	2.1X	1.0X	
2009/2010	82	2.3X	1.0X		2.6X	1.4X	
2010/2011	160	1.6X	0.7X		1.9X	0.9X	✔
2011/2012	101	1.8X	1.0X		2.1X	1.4X	
2012/2013	138	1.5X	0.9X		1.7X	1.2X	✔
2013/2014	151	2.0X	0.9X		2.2X	1.3X	✔
2014/2015	106	1.7X	1.1X	✔	2.0X	1.5X	
2015/2016	53	3.6X	1.6X		4.1X	2.3X	
2016/2017	138	1.9X	1.1X		2.2X	1.5X	✔
2017/2018	117	--	--	--	1.1X	1.4X	
2018/2019	145	0.9X	0.7X		--	--	--

*Outfall Chloride Loadings - sum of the four major storm outfalls (30 Ave, Groat, Kennedale, Quesnell).

5.3 Spring Freshet

The major outfalls discharge water from major drainage basins across the City and the chloride measured in the outfall water is mainly from municipal, residential, and commercial anti-icing and de-icing activities. The majority of chloride loadings to the North Saskatchewan River from storm sewer outfalls occur during the spring thaw (March, April, May, and June). Table 9 compares the percentage of chloride loadings that occur during the spring melt season compared to the total annual chloride loadings. Based on data provided to the City for major outfalls, spring melt is responsible for most of the total chloride that discharges to the North Saskatchewan River each year (approximately 80% of the time, over half of the total chloride discharge occurs from the beginning of March to the end of June).

Table 9
Major Outfalls: Historic Spring Freshet Chloride Contribution
(spring loading compared to entire season loading, %)

Year March, April May & June	30th Ave Outfall (%)	Groat Road Outfall (%)	Kennedale Outfall (%)	Quesnell Outfall (%)	Years With Similar Snowfall to 2017/2018	Years With Similar Snowfall to 2018/2019
2002/2003	61	-	-	-		✔
2003/2004	44	-	-	-	✔	
2004/2005	43	-	-	-		
2005/2006	50	-	-	-		
2006/2007	55	-	-	-		✔
2007/2008	61	78	68	70		
2008/2009	63	37	81	72	✔	
2009/2010	52	15	87	72		
2010/2011	56	91	73	64		✔
2011/2012	46	82	73	55		
2012/2013	63	79	81	66		✔
2013/2014	66	55	71	58		✔
2014/2015	41	36	57	53	✔	
2015/2016	40	33	63	51		
2016/2017	55	59	68	59		✔
2017/2018	61	82	85	71	--	
2018/2019	46	50	74	58		--

5.4 Snow Storage Sites

The City's five snow storage sites accumulate snow that is plowed from City roads and stockpiled until the snow melts and ultimately drains into their respective outfalls. Two of the five snow sites, Poundmaker and Kennedale, discharge to major outfalls where water sampling data were collected. Figure 4 shows the location of snow storage sites and their respective outfalls. Table 10 presents the annual loadings calculated from meltwater samples and flow rates. In general, higher chloride loadings are observed with higher annual snow volumes.

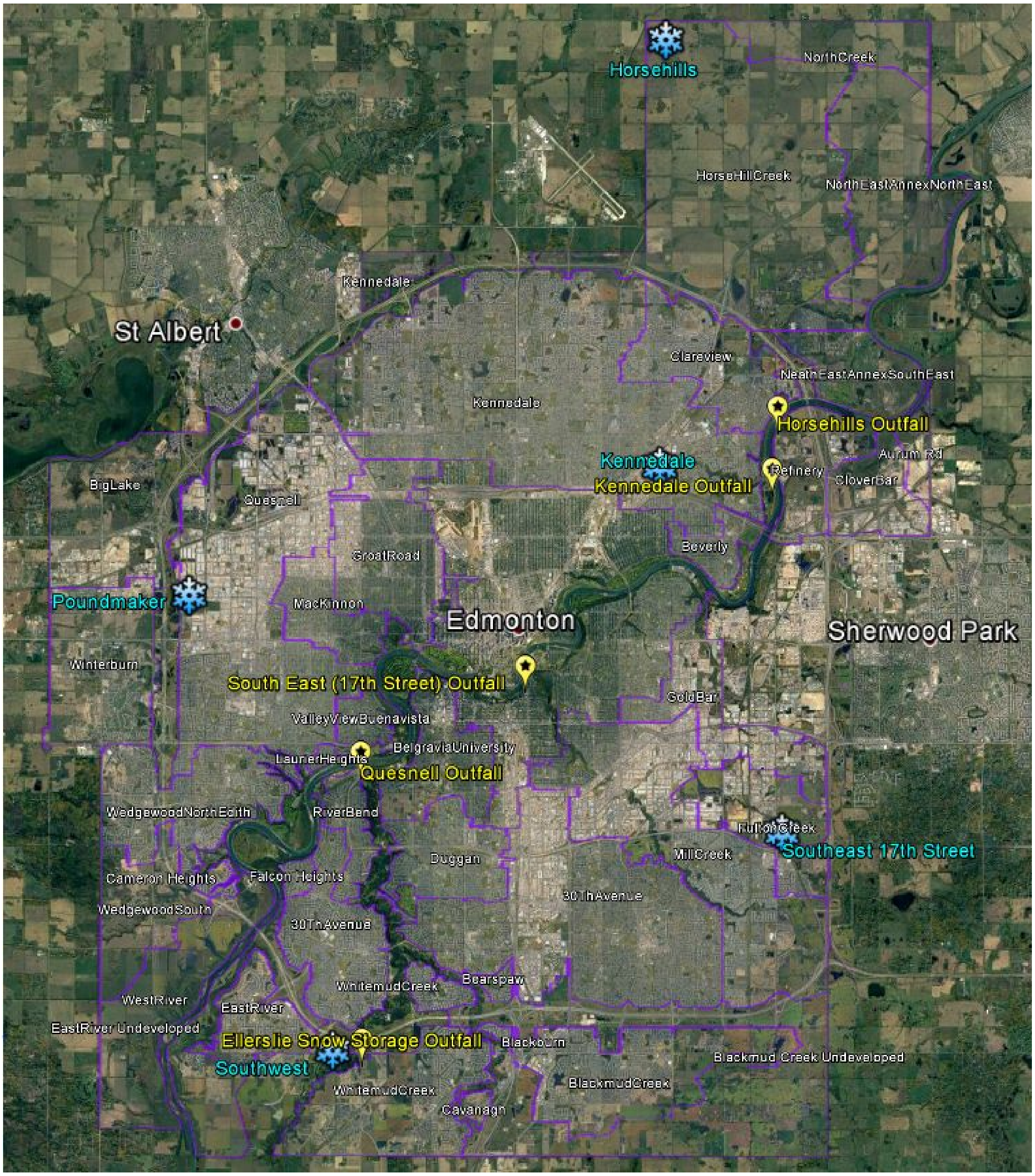

Figure 4: Location of City snow storage sites (❄), major outfalls and snow storage site outfalls.

Table 10
Annual Chloride Loadings per Snow Storage Site (kg)

Year	17 Street Snowsite (kg)	Poundmaker Snowsite (kg)	Kennedale Snowsite (kg)	Horsehills Snowsite (kg)	Ellerslie Snowsite (kg)	Years With Similar Snowfall to 2017/2018	Years With Similar Snowfall to 2018/2019
2007/2008	263,200	--	137,000	--	--		
2008/2009	--	--	--	--	--	✔	
2009/2010	--	--	--	--	--		
2010/2011	529,639	264,681	463,057	--	422,389		✔
2011/2012	7,765	1,533	--	--	2,587		
2012/2013	268,866	170,043	86,304	--	66,426		✔
2013/2014	324,410	125,985	--	214,900	103,387		✔
2014/2015	152,784	112,410	61,867	76,803	75,170	✔	
2015/2016	44,375	7,768	--	27,125	13,178		
2016/2017	79,111	179,115	19,127*	7,339	22,792		✔
2017/2018	242,822	188,170	107,846	69,268	204,272	--	
2018/2019	131,765	238,354	123,858	116,027	155,867		--

Absent Data (--):

- AEP first requested chloride loadings data from snow sites in 2007/2008. An estimate was made based on a small data set using simple methodology. **Low quality data.**
- During 2008/2009 the flow monitoring equipment was not functional due to equipment failure. Data was sporadic and not considered defensible. 2011/2012, Kennedale, flow rate instrumentation failure. **Poor data.**
- The first year of operation for Ellerslie snow storage site was 2010/2011.
- The first year of meltwater flow monitoring for the Horsehills snow storage site was 2013/2014.
- Kennedale Snowsite was not operational in 2013/2014 and 2015/2016.

*Kennedale Snowsite was used minimally in 2016/2017.

The Kennedale and Poundmaker snow storage sites discharge to the storm sewer system that connects to the Kennedale and Quesnell outfalls, respectively. These two snow sites were examined more closely in Tables 11 and 12 to evaluate the chloride contribution of snowmelt water from snow storage sites to the total chloride loadings measured at the monitored outfalls.

Table 11
Kennedale Outfall:
Chloride Contribution from Kennedale Snow Storage Site

Year Oct - Oct	Kennedale Snowsite Chloride Loadings (kg)	Kennedale Outfall Chloride Loadings (kg)	Kennedale Snowsite Contribution to Outfall (Kennedale Snowsite ÷ Kennedale Outfall) (%)
2007/2008	137,000	1,327,591	10.3
2008/2009	--	1,007,498	--
2009/2010	--	609,459	--
2010/2011	463,057	1,405,376	32.9
2011/2012	--	649,712	--
2012/2013	86,304	714,539	12.1
2013/2014	--	596,414	--
2014/2015	61,867	471,408	13.1
2015/2016	--	306,384	--
2016/2017	19,127*	646,513	3.0
2017/2018	107,846	616,110	17.5
2018/2019	123,858	1,034,634	12.0

Absent Data (--):

- AEP first requested chloride loadings data from snow sites in 2007/2008. An estimate was made based on a small data set using simple methodology. **Low quality data.**
- During 2008/2009 the flow monitoring equipment was not functional due to equipment failure. Data was sporadic and not considered defensible. 2011/2012, Kennedale, flow rate instrumentation failure. **Poor data.**
- N/A Kennedale Snowsite was not operational in 2013/2014 and 2015/2016.

*Kennedale Snowsite was used minimally in 2016/2017.

Between 10 and 33 percent of chloride loadings measured at the Kennedale outfall over the last decade might be reasonably attributable to snow removed from City streets and stored at the Kennedale Snow Storage Site.

Less than 1% to 11% of the chloride loadings measured at the Quesnell outfall over the last decade might be reasonably attributable to snow removed from City streets and stored at the Poundmaker Snow Storage Site. The unusually low chloride loadings in 2011/2012 and 2015/2016 were verified using the monitoring data and likely reflects the inherent variations in the nature of winter snow clearing (routes, snow event volume, temperature).

Table 12
Quesnell Outfall:
Chloride Contribution from Poundmaker Snow Storage Site

Year Oct - Oct	Poundmaker Snowsite Chloride Loadings (kg)	Quesnell Chloride Loadings (kg)	Poundmaker Snowsite Contribution to Outfall (Poundmaker Snowsite ÷ Quesnell Outfall) (%)
2007/2008	--	2,430,951	N/A
2008/2009	--	2,684,582	N/A
2009/2010	--	2,259,479	N/A
2010/2011	264,681	2,410,289	11.0
2011/2012	1,533	1,735,728	0.1
2012/2013	170,043	2,584,155	6.6
2013/2014	125,985	2,605,668	4.8
2014/2015	112,410	1,943,328	5.8
2015/2016	7,768	1,463,779	0.5
2016/2017	179,115	1,785,688	10.0
2017/2018	188,170	2,011,763	9.4
2018/2019	238,354*	2,863,220	8.3

Absent Data (--)
N/A denotes value cannot be calculated due to missing data
*Missing partial flow data. Missing flow data was extrapolated.

The major outfalls discussed herein do not represent loadings from the entire storm sewer system in Edmonton. The City-wide stormwater system discharges to 225 major and minor outfalls. Stormwater also travels by overland flow and infiltrates into the subsurface. Chloride contributions from private business and citizens due to winter anti-icing and deicing are unknown.

The outfall data trends are critical environmental indicators for the environmental performance of the anti-icing pilot and the key resource used to establish related impacts. These key environmental indicators show that the anti-icing pilot did not have an observable effect on stormwater quality.

6.0 Environmental Impacts of Corrosion Inhibitors

Infrastructure Operations trialled four brine products with various corrosion inhibitor additives during the anti-icing pilot:

- Calcium chloride brine with an organic corrosion inhibitor. The inhibitor is similar in odor and color to molasses (a typical byproduct of the sugar beet industry).
- Calcium chloride brine with magnesium hydroxide additive as a corrosion inhibitor (the common name for magnesium hydroxide is "milk of magnesia").
- Calcium chloride brine with a phosphate based additive as a corrosion inhibitor.
- Sodium chloride brine with beet juice corrosion inhibitor.

Inorganic and organic corrosion inhibitors were used during the 2017/2018 year of the Anti-icing Pilot Project. During the 2018/2019 year of the pilot, an organic corrosion inhibitor was used exclusively.

Organic corrosion inhibited brine has a lower corrosion rate than brine with inorganic inhibitors, brine alone, or salt alone. Organic corrosion inhibitors biodegrade and contain nutrients; therefore, BOD, ammonia, and phosphorus were analyzed to establish whether the controlled application of anti-icing brine had an impact on outfall water quality.

Biological oxygen demand (BOD) is critical to river and surface water ecological health and may be affected by the amount of organic corrosion inhibitor added. Salt and brine have little or no contribution to BOD. Organic substances impact water quality because aquatic microbes use them as food, consuming dissolved oxygen in the process. Oxygen depletion may be harmful to fish, aquatic insects, and plants. The BOD related to corrosion inhibitor additives is an important consideration for product selection. Organic inhibitors have a higher BOD than inorganic inhibitors.

Ammonia may cause nutrient over-enrichment and at elevated concentrations may have adverse effects to aquatic life. ***Phosphorus*** is an essential nutrient and a component of fertilizers but at high concentrations may degrade water quality by overstimulating algal growth (which decreases dissolved oxygen).

Key environmental indicator data are presented in the following tables:

- Table 13 provides historic annual winter season BOD loadings
- Table 14 provides historic annual winter season phosphorus loadings
- Table 15 provides historic annual winter season ammonia loadings
- Table 16 provides the historic average and standard deviation for available data from the last decade.

Table 13
Biological Oxygen Demand (BOD) Loadings Measured at Outfalls

Year (Nov - Apr)*	BOD loading (kg)	Annual Snowfall (cm)	Years with Similar Snowfall to 2017/2018	Years with Similar Snowfall to 2018/2019
2007/2008	269,588	96		
2008/2009	274,045	106	✔	
2009/2010	221,079	82		
2010/2011	558,366	160		✔
2011/2012	320,878	101		
2012/2013	390,247	138		✔
2013/2014	372,012	151		✔
2014/2015	460,675	106	✔	
2015/2016	253,085	53		
2016/2017	270,915	138		✔
2017/2018	302,488	117	--	
2018/2019**	315,504	145		--

*The summer months of monitoring data were excluded from the data in order to capture anti-icing related impacts and eliminate potentially elevated summer BOD levels due to warm weather and summer runoff that contains oxygen consuming waste.
** Loadings were updated using the current, complete information available at the time of reporting.

Table 14
Total Phosphorus Loadings Measured at Outfalls

Year (Nov - Apr)*	Total Phosphorus (kg)	Annual Snowfall (cm)	Years with Similar Snowfall to 2017/2018	Years with Similar Snowfall to 2018/2019
2007/2008	12,304	96		
2008/2009	12,838	106	✔	
2009/2010	9,608	82		
2010/2011	25,902	160		✔
2011/2012	13,128	101		
2012/2013	18,564	138		✔
2013/2014	17,114	151		✔
2014/2015	19,421	106	✔	
2015/2016	8,105	53		
2016/2017	15,974	138		✔
2017/2018	15,680	117	--	
2018/2019**	13,256	145		--

Table 15
Ammonia-N Loadings Measured at Outfalls

Year (Nov - Apr)*	Ammonia - N (kg)	Annual Snowfall (cm)	Years with Similar Snowfall to 2017/2018	Years with Similar Snowfall to 2018/2019
2007/2008	24,422	96		
2008/2009	25,792	106	✔	
2009/2010	25,606	82		
2010/2011	55,439	160		✔
2011/2012	31,323	101		
2012/2013	27,789	138		✔
2013/2014	23,624	151		✔
2014/2015	27,898	106	✔	
2015/2016	24,061	53		
2016/2017	29,652	138		✔
2017/2018	33,828	117	--	
2018/2019**	23,516	145		--

*The summer months of monitoring data were excluded from the data in order to capture anti-icing related impacts and eliminate potentially elevated summer BOD levels due to warm weather and summer runoff that contains oxygen consuming waste.
** Loadings were updated using the current, complete information available at the time of reporting.

Table 16
Average Annual BOD, Phosphorus, and Ammonia-N Loadings at Major Outfalls

Statistics	BOD (kg)	Total Phosphorus (kg)	Ammonia-N (kg)
Average winter and spring loadings, Last ten years (excludes Anti-icing Pilot Project years)	339,089	15,296	29,561
Standard Deviation, Last ten years (excludes Anti-icing Pilot Project years)	+/- 106,422	+/- 5,2464,847	+/- 9,431
2018/2019	315,504	13,256	23,516

BOD, phosphorus, and ammonia-N discharge to the North Saskatchewan River from the major monitored stormwater outfalls are variable; however, there is no discernible impact on the North Saskatchewan River water quality due to the Anti-icing Pilot Project.

7.0 Discussion

In the winter of 2018/2019, the City of Edmonton Parks and Roads Services Branch continued the Anti-icing Pilot Project initiated in 2017/2018. This Environmental Monitoring and Metrics Report presents the 2018/2019 environmental review of the Anti-icing Pilot Project, along with a comparison to the results of last year's pilot season (2017/2018).

The City of Edmonton Parks and Road Services, Infrastructure Operations Section applied road maintenance products for winter safety in accordance with the City of Edmonton Snow and Ice Control Policy 2018-2019. In 2018/2019, the winter temperatures and precipitation conditions were not conducive to effective anti-icing, so fewer anti-icing applications were carried out than during the previous winter pilot year.

The winter material application tonnages and volumes compared to historical data revealed the following key findings.

Of the total chloride applied to Edmonton roads for road safety in 2018/2019, 0.5% was due to the application of calcium chloride brine.

During the previous winter season (2017/2018), 4.3% of the total chloride was from calcium chloride brine application.

The material inventory records from two full winter seasons of City-wide anti-icing clearly demonstrate that the calcium chloride brine applied for anti-icing did not contribute significant amounts of chloride compared to sodium chloride salt.

During the same time frame as the anti-icing pilot, a separate undertaking to reduce road sand resulted in an increase in sodium chloride salt use:

- Over the winter 2018/2019, about twice the amount of sodium chloride salt was applied to winter roads compared to historic years with similar snowfall.
- Over the winter 2018/2019, about 60% less sand was applied to winter roads compared to historic years with similar snowfall.

Similar material usage changes for salt and sand were apparent in the previous year (2017/2018). It would be prudent to conduct a full evaluation of the costs, environmental and safety implications of the sand reduction initiative.

There is a significant amount of scatter in the historic weather, environmental, and material usage data that is likely a reflection of variabilities in winter weather patterns and temperatures, rather than total snowfall amount. Unusual winter weather events such as freezing rain may create icy conditions that require higher than usual chloride based applications by the City, private industry, and residents for safety reasons. However, there is enough historic data to state some generalities:

- There is a general historic trend for higher city-wide chloride loadings at major outfalls with increased snowfall.
- The City of Edmonton's sodium chloride salt application during the pilot years was higher than previous years with similar snow;
- The City of Edmonton's increased salt application was not apparent in the chloride loadings at major storm outfalls.

Outfall data is collected systematically on a consistent frequency and subjected to an accepted quality assurance process. The historical outfall data was used as a benchmark for comparison to evaluate the anti-icing impacts to outfalls.

The average chloride loadings to the North Saskatchewan River during the pilot winter years was higher than the historical average; however, so is the average snowfall. The average chloride contribution during the anti-icing pilot years was relatively typical for the average annual snowfall.

There appears to be an appreciable difference between the calculated factors for salt applied by the City of Edmonton and the outfall chloride loadings. If the City was the primary contributor of chloride loadings to major outfalls, then the increased sodium chloride salt application during the two pilot years should be apparent in the factors and of similar magnitude. This lack of relationship suggests that chlorides applied to streets by the City of Edmonton may not be the primary source of chloride loadings.

The use of anti-icing brine and the increase in salt application over the last two years of winter maintenance is not apparent in the outfall data.

The lack of relationship between the City of Edmonton's chloride application and the measured outfall loadings may be due to infiltration; overland flow; contributions of chloride ice-melt products from other sources, such as private business and citizens that contribute to baseline chloride concentrations in stormwater; or other unidentified factors. Data error is considered unlikely due to the quality assurance and consistency of the historical sample collection.

The chloride contributions from calcium chloride brine used during the anti-icing pilot produced no discernable impact on the chloride loadings in stormwater discharge to major North Saskatchewan River outfalls compared to the available historical data.

There were no discernible increases to BOD, phosphorus, or ammonia loadings to the North Saskatchewan River due to the Anti-icing Pilot Project.

Overall, the calcium chloride brine used during the Anti-icing Pilot Project has had no detrimental effect on stormwater quality that discharges to the North Saskatchewan River. Further, the use of calcium chloride has several environmental benefits over sodium chloride. Calcium chloride brine for anti-icing was discussed during a technical presentation provided to the City by a representative of Alberta Environment on February 26, 2019. While it was agreed that chlorides are an environmental concern, regardless of where they come from, from an environmental point of view, calcium chloride application has definite advantages over the use of sodium chloride:

- Sodium chloride salt causes more problems than calcium chloride brine from a plant growth perspective because of the negative effect of sodium on soil water uptake.
- Sodium in soil negatively impacts soil structure and trafficability on unpaved roads, whereas calcium is often used to improve both soil structure and trafficability.

8.0 Conclusions

This Environmental Monitoring and Metrics Report presents the 2018/2019 environmental review of the Anti-icing Pilot Project, along with a comparison to the results of last year's pilot season (2017/2018). This report is subsequent to a preliminary report released in May of 2019.

The material inventory records show that:

- Of the total chloride applied to Edmonton roads for road safety in 2018/2019, 0.5% was due to the application of calcium chloride brine. During the previous winter season (2017/2018), 4.3% of the total chloride was from calcium chloride application.
- Over the winter of 2018/2019, approximately twice the amount of sodium chloride salt was applied to winter roads compared to historic years with similar snowfall.
- Over the winter of 2018/2019, approximately 60% less sand was applied to winter roads compared to historic years with similar snowfall.

Less calcium chloride brine was used in the winter of 2018/2019 compared to the previous pilot year because the winter temperature and precipitation conditions were not conducive to anti-icing practices.

Based on the data available at the time of reporting, the anti-icing pilot has produced no discernable impact on the quality of the City's stormwater that discharges to the North Saskatchewan River. Literature research and discussions with Alberta Environment and Parks representatives suggest that calcium chloride brine has a number of environmental benefits compared to sodium chloride salt.

The increased sodium chloride salt application by the City did not cause observable effects in the outfall water quality data. The widespread use of chloride salts by the public and commercial enterprises for winter safety may partially explain why impacts due to the City's maintenance practices are not observable in the historic chloride loadings at outfalls to the river.

A compilation and analysis of monitoring data showed that there were no discernible impacts on BOD, phosphorus, or ammonia loadings to the North Saskatchewan River related to the Anti-icing Pilot Project.

9.0 Recommendations

The following recommendations are offered as a result of the findings:

1. A focus on source reduction and the lowest reasonably achievable application rates for all road safety products should be established as an operational objective, recognizing that the City holds paramount public safety.

10.0 References

Annual Winter Materials Usage 2015/2016, March 10th 2017

Annual Winter Materials Usage 2016/2017, January 19th 2018

Annual Winter Materials Usage 2017/2018, March 22th 2018

Annual Winter Materials Usage 2018/2019, February 20, 2019

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Outfall Monitoring Data Total Suspended Solids, Chloride, Total Phosphorus, EPCOR Drainage Services

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Document Approval

Submitted By:

Name	Title	Submit Date
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