Edmonton

SNIC Monitoring Program Surface Water Loadings Evaluation

2019-2020

Integrated Infrastructure Services

Business Planning and Support

Engineering Services

Clarence Stuart, B.Sc., QEP
Environmental Scientist

INSTITUTE OF PROFESSIONAL ENVIRONMENTAL PRACTICE
CLARENCE H. STUART
QUALIFIED ENVIRONMENTAL PROFESSIONAL
No. 09070020

Nov 27, 2020

Joy Tolsma, B.Sc., PAg
Environmental Technologist

Jessica Zelinski, BASc., C.E.T.
Environmental Technologist

Bretlyne Friday, BA, AIT
Environmental Technologist

November 2020

Table of Contents

EXECUTIVE SUMMARY

This Surface Water Loadings Evaluation presents the 2019/2020 environmental review of the Snow and Ice Control (SNIC) Monitoring Program along with a comparison to historical results, including the 2017/2018 and 2018/2019 Anti-icing Pilot Project. This report encompasses the snowmelt at the City's snow storage sites as well as the environmental outfall data, as provided by EPCOR.

This evaluation includes:

- the 2019/2020 winter maintenance material inventories compared to historical usage (sand, sodium chloride salt, and calcium chloride brine).
- historical cumulative snowfall data at the Edmonton International Airport retrieved from Environment Canada's Monthly Climate Summaries.
- current and historical loadings at major outfalls to the North Saskatchewan River.
- current and historical loadings discharged to the stormwater system from the city snow storage sites.

The winter 2019/2020 data was compared to historical data with similar snowfall years, which provides the necessary information to understand the environmental implications of recent changes to the City's winter road safety program. In addition, changes in city procedures initiated in 2017/2018 relative to the amount of sand and salt usage are considered in the evaluation.

The materials inventory records show that:

- of the total chloride applied to Edmonton roads in 2019/2020, 0.1% was due to the application of calcium chloride brine. During the Anti-icing Pilot Project implemented in the 2017/2018 winter season that was extended to 2018/2019, respectively 4.3% and 0.5% of the total chloride was from calcium chloride brine application.
- comparable amounts of sodium chloride salt were applied to winter roads during 2019/2020 and the Anti-icing Pilot year 2017/2018, which had a similar snowfall volume.
- an average of 90% more sodium chloride salt was applied to winter roads in 2019/2020 compared to years with similar snowfall volumes prior to the Anti-icing Pilot Project.
- a reduction in sand application is evident since the 2017/2018 winter season. Over the winter of 2019/2020, there has been approximately a 60% reduction in sand applied to roads compared to similar snowfall years prior to the Anti-icing Pilot Project.

Chloride loadings at the outfalls are a combination of both City of Edmonton and private applications. The chloride contributions from private businesses and citizens due to winter anti-icing and de-icing are unknown. The volume of stormwater and snow melt that travels by overland flow and infiltrates the subsurface is also unknown.

A compilation and analysis of winter season monitoring data showed that there were no discernible changes in biological oxygen demand, phosphorus, or ammonia loadings to the North Saskatchewan River related to the Anti-icing Pilot Project in 2017/2018 and 2018/2019, or the 2019/2020 winter season. These loadings were also compared to years prior to 2017/2018 that had similar snowfall.

The increased sodium chloride salt application by the City in 2017/2018, 2018/2019, and 2019/2020 was not directly apparent in the environmental outfall data; however, there is a trend for an increase in chloride loadings at the outfalls. Conducting annual Surface Water Loadings Evaluations would help to improve the overall accuracy of the data and the confidence that increased loadings are a trend.

1.0 Introduction

This report documents the surface water loadings for the Snow and Ice Control (SNIC) Monitoring Program led by Infrastructure Operations, Parks and Roads Services, City Operations. The Surface Water Loadings 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 historical environmental monitoring at City of Edmonton snow storage sites. Consideration was given to the evaluation of chloride, phosphorus, ammonia, and biological oxygen demand (BOD), which are constituents of environmental concern.

This report emphasizes the 2019/2020 year and compares this information to the Anti-icing Pilot years, 2017/2018 and 2018/2019, as well as years prior to 2017/2018. The years before 2017/2018 are considered to be the benchmark for this environmental assessment; during these years, sand was used in greater quantities with less sodium chloride salt being applied. The correlation between similar snow years and the amount of sand and salt applied is also examined. The most significant year for calcium chloride application was the Anti-icing Pilot Project year of 2017/2018.

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 (additional abrasives, such as rock chip, may or may not be applied but are not considered in this evaluation). There are two types of salt 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 (NaCl, 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 ($CaCl_2$) 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 roadway material before application depending on ambient temperature and conditions. The City uses calcium chloride brine, which is effective at 25% saturation to -45°C, to pre-wet sand as it is spread to help sand adhere to the road and improve the 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 geological saline formations which is then mixed with corrosion-inhibitor additives. Calcium chloride brine for anti-icing was applied to roads in a thin layer before or during a snowfall event 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 Project was extended to include the 2018/2019 winter season; however, significantly less calcium chloride brine was used because winter temperatures and precipitation conditions were not conducive to anti-icing practices.

In October 2019, Council voted to discontinue the direct application of calcium chloride as an anti-icing agent to City roads for the 2019/2020 winter. Calcium chloride brine was still used in winter road maintenance to pre-wet sand and salt before roadway application and as an anti-icing brine on sidewalks, bike lanes, and pathways.

There are 225 major and minor storm sewer outfalls that discharge to the North Saskatchewan River and its tributaries within the City of Edmonton. Water quality 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 2019/2020 winter season to prior years. There is a correlation between snowfall volumes and both the amount of materials applied to roadways and the total loadings observed at outfalls.

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 sugar beet industry added for corrosion inhibition. The amount of chloride applied by citizens and private businesses 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.

1.2 Objective and Scope

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.

Current and historical data provides the necessary information to understand the environmental implications of the Anti-icing Pilot Project and other policy changes related to the winter roadway maintenance program.

The objective of this Surface Water Loadings Evaluation is to establish the environmental implications associated with SNIC activities and how changes in SNIC policies have contributed to loadings to the North Saskatchewan River. The environmental data review includes all materials used for winter road maintenance in the City of Edmonton. The scope of this report is:

- Winter road maintenance material usage:
  - historical annual sodium chloride salt, calcium chloride brine, and sand quantities applied to City streets.
  - sodium chloride salt, calcium chloride brine, and sand quantities applied to City streets during the winter of 2019/2020
- Water sampling data from outfalls to North Saskatchewan River:
  - monthly data reports for water samples collected at North Saskatchewan River outfalls were compiled. The current and historical 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 beyond the last decade were compared to the 2019/2020 winter season.[2]
- City of Edmonton Snow Storage Sites:
  - snowmelt water monitoring data and loadings from City of Edmonton snow storage sites were evaluated to capture full winter seasons of snowmelt water quality.

[1] EPCOR Outfall Sampling Data. 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 have been compiled for each winter season (November to April) over the last decade.

2.0 Methodology

The following inventory records and environmental monitoring data were used to evaluate the measurable environmental impacts on the North Saskatchewan River by SNIC activities:

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.[4]

The data between the first snowfall in one year (typically October to the last snowfall in March) were used to compare one winter season to the next, herein referred to as a snow year. Data and calculations were verified by the Engineering Services Environmental Compliance Team.

2.1 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. 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.

2.2 Material Inventories

Winter roadway material usage inventories from 2001/2002 to 2019/2020 were provided by Infrastructure Operations. 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. Significant changes in the amount of sodium chloride, calcium chloride, and sand applied were initiated in the 2017/2018 winter season which continued to the 2019/2020 winter season.

2.3 Snow Storage Sites

A portion of the calcium chloride brine, sodium chloride salt, and sand used for road safety is removed with snow 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

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

flow volume data is collected by EPCOR from the snow site discharge point[4], which Engineering Services uses to calculate environmental loadings.

2.4 Outfall Data

Stormwater baseflow samples, flow event samples, and regular chloride samples were collected from four major outfalls: 30th Avenue, Groat Road, Kennedale, and Quesnell. Additional data was collected which included minor outfalls.

Current and historical outfall chloride loadings from the beginning of October to the end of September at each of the four major outfalls were used for an overall assessment of sodium chloride salt and calcium chloride brine impacts due to SNIC activities 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 season loadings (November to April) were used to evaluate potential impacts due to the use of organic corrosion inhibitors added to the calcium chloride brine. The historical "total storm outfalls" chloride, BOD, phosphorus, and ammonia-N loadings were evaluated to establish any observable changes to loadings potentially associated with SNIC activities. Loadings are reported in kilograms or tonnes.

3.0 Historical Cumulative Snowfall

Historical 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 March 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[5] to 2019/2020 were used for comparison purposes of this year's SNIC activities.

[4] EPCOR monitors the water flow volume at the City snow storage sites and provides the City with this data.
[5] Years with similar snowfall was defined as +/-15 cm compared to 2019/2020 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 Year	Cumulative Snowfall (cm)	Year with Similar Snowfall to 2019/2020
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	
2019/2020	120	--

Winter season years during the Anti-icing Pilot Project are shaded orange.
-- denotes the year that the other years are compared to.

4.0 Historical 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 sodium chloride and calcium chloride brine inventory records was calculated and included in the table.

Table 2. Historical Roadway Materials Usage

Winter Season 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 2019/2020 (✓)
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**	
2019/2020	50,101	35,855	**21,751**	107	**23**	**21,774**	--

* Total chloride is the sum of chloride from sodium chloride salt and calcium chloride brine.
Winter season years during the Anti-icing Pilot Project are shaded orange.
-- denotes the year that the other years are compared to.

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 during the 2017/2018 and 2018/2019 winter seasons did not contribute significant amounts of chloride compared to sodium chloride salt.

4.1 Applied Chloride due to Calcium Chloride Brine

Table 3 shows the contribution of calcium chloride brine compared to the total chloride applied by the City for road safety during the Anti-icing Pilot and 2019/2020 winter seasons. The 2019/2020 calcium chloride applications are similar to historical applications prior to the Anti-icing Pilot Project years of 2017/2018 and 2018/2019.

In the 2017/2018 and 2018/2019 winter seasons, calcium chloride brine was used for anti-icing purposes; however, significantly less calcium chloride brine was used in 2018/2019 because the winter temperatures and precipitation conditions were not conducive to anti-icing practices. The chloride contribution from calcium chloride brine was a key environmental performance indicator for the Anti-icing Pilot Project.

Table 3. Chloride Applied by the City During the Anti-icing Pilot and 2019/2020 Winter Seasons

Source of Chloride	Chloride Applied 2017/2018 (tonnes)	Chloride Applied 2018/2019 (tonnes)	Chloride Applied 2019/2020 (tonnes)
Total chloride applied (sodium chloride salt + calcium chloride brine)	23,317	25,660	21,751
Chloride from calcium chloride brine	1000	132	23
% of total chloride from calcium chloride brine	4.3%	0.5%	0.1%

Winter season years during the Anti-icing Pilot Project are shaded orange.

Of the total chloride applied to Edmonton roads for road safety in 2019/2020, 0.1% was due to the application of calcium chloride brine.

The contribution of calcium chloride brine to environmental chloride loadings during the 2019/2020 winter season was negligible at 0.1%. During the Anti-icing Pilot Project in 2017/2018 and 2018/2019, respectively 4.3% and 0.5% of the total chloride was from calcium chloride brine application. The weather conditions in 2018/2019 were not conducive to the use of calcium chloride as an anti-icing agent.

4.2 Sodium Chloride Salt

Presented in Table 4 is the sodium chloride salt applied in 2019/2020 compared to the Anti-icing Pilot Project and historical years prior to 2017/2018.

Table 4. Sodium Chloride Salt (NaCl) Applied During the 2019/2020 Winter Season Compared to Previous Years

Winter Season Year	NaCl Salt Applied (tonnes)	Snowfall (cm)	2019/2020	
			Salt Applied in 2019/2020 Compared to Salt Applied in Other Years	Similar Snowfall Year
2001/2002	17,280	123	2.1X	✓
2002/2003	30,252	140	1.2X	
2003/2004	17,400	111	2.1X	✓
2004/2005	13,041	64	2.7X	
2005/2006	9,719	61	3.7X	
2006/2007	16,599	140	2.2X	
2007/2008	13,688	96	2.6X	
2008/2009	20,284	106	1.8X	✓
2009/2010	16,030	82	2.2X	
2010/2011	22,743	160	1.6X	
2011/2012	19,886	101	1.8X	
2012/2013	25,275	138	1.4X	
2013/2014	18,806	151	1.9X	
2014/2015	21,194	106	1.7X	✓
2015/2016	10,260	53	3.5X	
2016/2017	19,309	138	1.9X	
2017/2018	36,789	117	1.0X	✓
2018/2019	42,082	145	0.9X	
2019/2020	35,855	120	--	--

Winter season years during the Anti-icing Pilot Project are shaded orange.
-- denotes the year that the other years are compared to.
Example: 2.1X or 110% more sodium chloride salt was applied in 2019/2020 than was applied in 2001/2002

An average of 1.9 times or 90% more sodium chloride salt was applied to winter roads in 2019/2020 compared to years before to 2017/2018 with similar snowfall amounts. Comparable amounts of sodium chloride salt were applied to winter roads during the 2019/2020 snow year and the Anti-icing Pilot Project.

4.3 Sand for Winter Traction

The amount of sand applied in 2019/2020 compared to sand applications during similar snowfall years is presented in Table 5. Similar snow years were identified in Table 1.

Table 5. Sand Tonnages Applied During the 2019/2020 Winter Season Compared to Previous Years

Winter Season Year	Sand (tonnes)	Snowfall (cm)	2019/2020	
			Sand Applied in 2019/2020 Compared to Sand Applied in Other Years	Similar Snowfall Year
2001/2002	114,858	123	0.4X	✓
2002/2003	148,537	140	0.3X	
2003/2004	133,806	111	0.4X	✓
2004/2005	155,421	64	0.3X	
2005/2006	73,695	61	0.7X	
2006/2007	159,635	140	0.3X	
2007/2008	146,270	96	0.3X	
2008/2009	152,511	106	0.3X	✓
2009/2010	89,806	82	0.6X	
2010/2011	118,520	160	0.4X	
2011/2012	66,123	101	0.8X	
2012/2013	125,412	138	0.4X	
2013/2014	97,691	151	0.5X	
2014/2015	92,913	106	0.5X	✓
2015/2016	56,374	53	0.9X	
2016/2017	109,085	138	0.5X	
2017/2018	38,949	117	1.3X	✓
2018/2019	48,840	145	1.0X	
2019/2020	50,101	120	--	--

Winter season years during the Anti-icing Pilot Project are shaded orange.
-- denotes the year that the other years are compared to
Example: 0.4X or 60% less sand was applied in 2019/2020 than was applied in 2001/2002

A reduction in sand application is evident since the 2017/2018 winter season. Compared to years before the Anti-icing Pilot Project with similar snowfall volumes, approximately 60% less sand was applied over the winter of 2019/2020.

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. Municipal, residential, and commercial anti-icing and de-icing activities contribute to the chloride measured at the City's major outfalls. 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 historical chloride loading data from these major drainage basins are presented in Table 6. Figure 1 shows the City's major drainage basins.

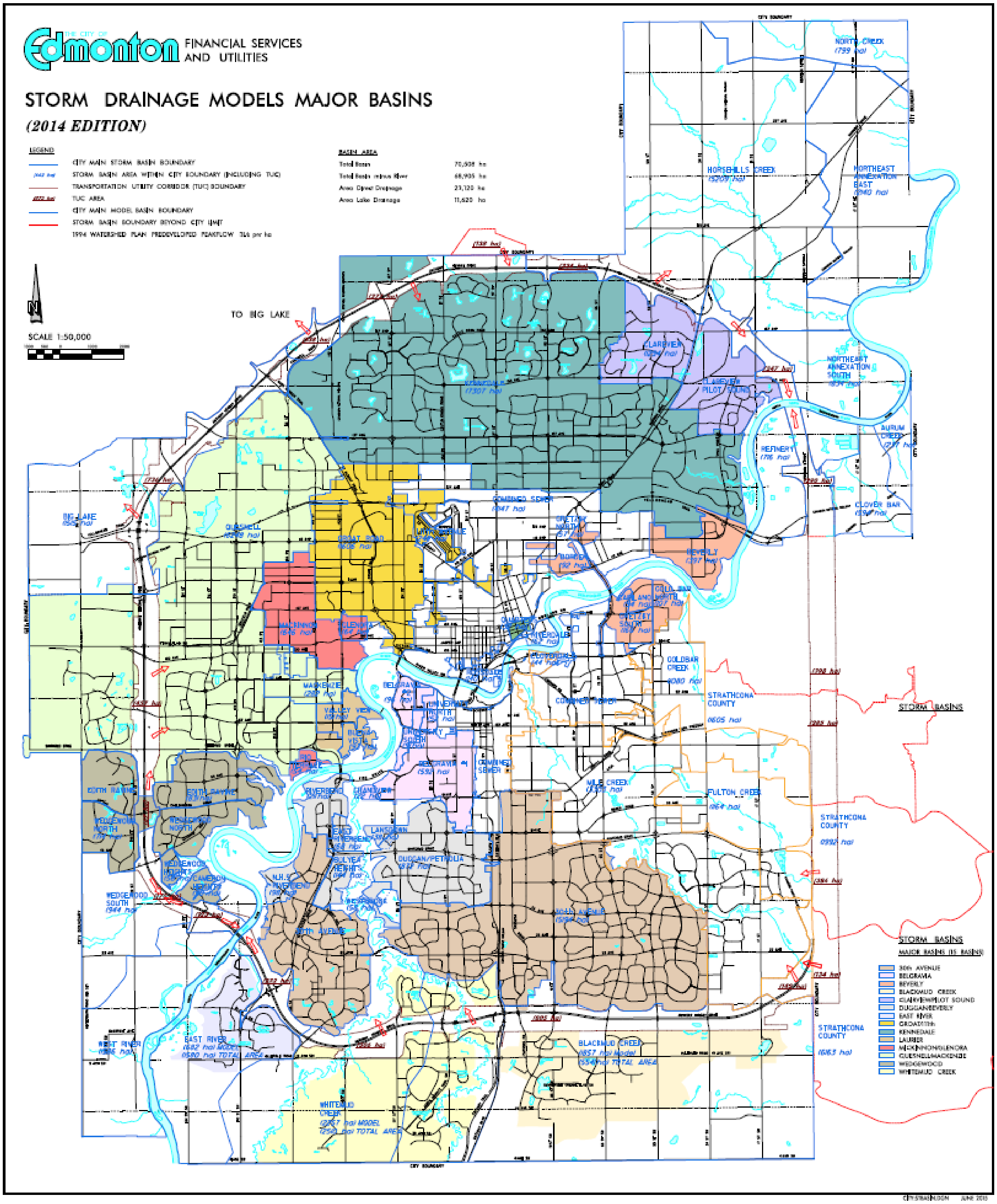


Figure 1: The City's major stormwater drainage basins.

5.2 Influence of Snowfall on Chloride Loadings at Outfalls

The outfall chloride data during 2019/2020 was compared to years with similar snowfall beginning with the 2001/2002 winter season (Table 6 and Figure 2 compare each year).

Table 6. Historical Chloride Loadings from Major Outfalls to NSR

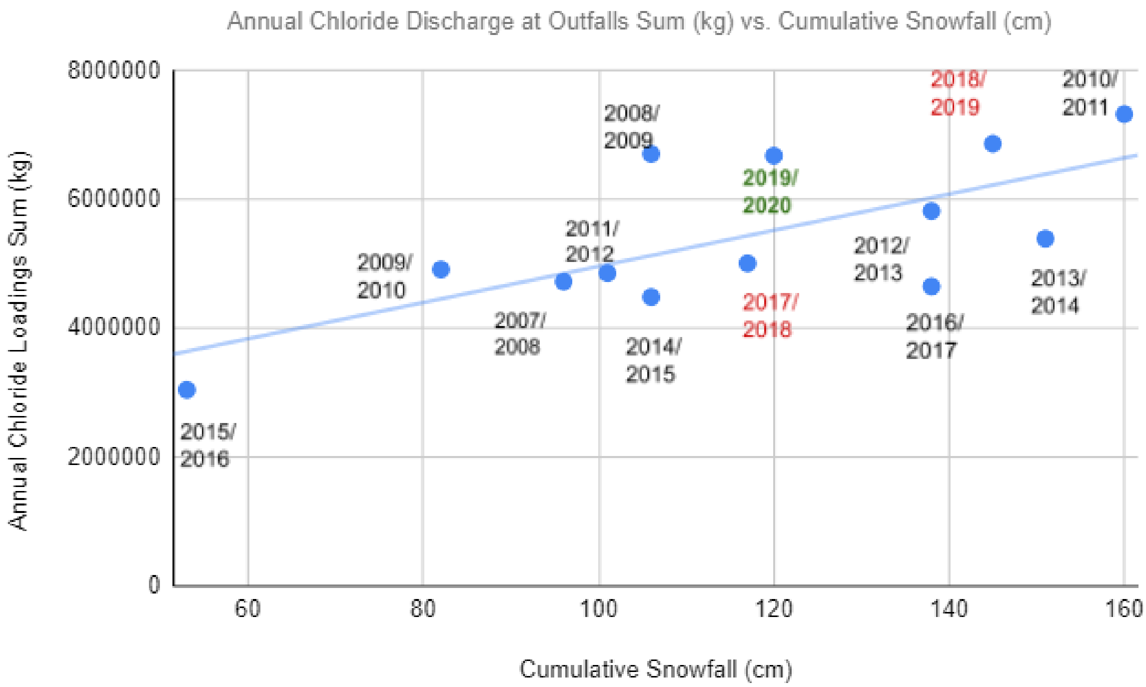
Year Oct - Oct	30th Ave (tonnes of Cl^-)	Groat (tonnes of Cl^-)	Kennedale (tonnes of Cl^-)	Quesnell (tonnes of Cl^-)	Sum of Loadings (tonnes of Cl^-)	Annual Snowfall (cm)	Similar Snowfall Years as 2019/2020
2001/2002	-	-	-	-	-	123	✓
2002/2003	1068.7	-	-	-	-	140	
2003/2004	1056.3	-	-	-	-	111	✓
2004/2005	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	
2019/2020	2080.9	262.1	999.6	3342.4	6685.0	120	--

Winter season years during the Anti-icing Pilot Project are shaded orange.
-- denotes the year that the other years are compared to.

The following observations were made from the historical data, the Anti-icing Pilot Project, and the 2019/2020 snow year:

- Generally, there is a trend for higher snowfall years to have increased chloride loadings (Figure 2).
- During typical snow years, the chloride loadings from the four major outfalls in Edmonton are variable. The average chloride loadings over the last decade prior to the Anti-icing Pilot Project are calculated as 5,196 tonnes with a standard deviation of 1,207 tonnes of chloride discharged.
- The chloride loadings discharged from the major outfalls to the North Saskatchewan River during the 2017/2018 and 2018/2019 Anti-icing Pilot Project were 5,011 and 6,871 tonnes, respectively; this compares to 6,685 tonnes in the 2019/2020 snow year.
- Average snowfall in the City of Edmonton for the decade before the Anti-icing Pilot Project was 113 cm with a standard deviation of 33 cm.
- During the Anti-icing Pilot Project, the Edmonton area received 117 cm of snow in 2017/2018 and 145 cm of snow during 2018/2019; this compares to 120 cm of snow in 2019/2020.

The chloride loadings to the North Saskatchewan River during the 2018/2019 Anti-icing Pilot year and the 2019/2020 snow year were higher than the historical average of 5,196 tonnes. There is a data trend of increased city-wide chloride loadings at monitored outfalls in the last two years which may not be entirely related to increased snowfall, but instead likely to the application changes of sodium chloride salt.



*Note: **Red** font signifies years of Anti-icing Pilot Project
Green font signifies 2019/2020 snowmelt year

Figure 2: Chloride loadings at the four major outfalls compared to snowfall, 2007/2008 to 2019/2020.

The significant scatter in the historical 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's storm sewer system may contain water and measurable chloride concentrations at any time during the winter.

5.3 City of Edmonton Contributions to Major Storm Outfalls

The totalled chloride loadings for the 2019/2020 snow year were divided by the loadings calculated for other years to produce a multiplier factor (Table 7). When compared to similar snowfall years prior to the beginning of the Anti-icing Pilot Project there was a 25% increase in total loadings of chlorides at the outfall in 2019/2020. When averaging change in loadings of 2019/2020 to all years prior to the Anti-icing Pilot Project there was a 35% increase in chloride loadings at the outfall. The 2018/2019 and 2019/2020 seasons had comparable sodium chloride salt application rates and outfall chloride loadings.

Table 8 allows for a simpler comparison of the sodium chloride applied and outfall chloride loading changes referencing the 2019/2020 winter season.

Table 7. Outfall Chloride Loadings in 2019/2020 Compared to Chloride Loadings in Other Years (tonnes)

Year Oct - Oct	Annual Snowfall (cm)	Outfall** Chloride Loadings (tonnes)	2019/2020	
			Outfall Chloride Loadings** in 2019/2020 Compared to Chloride Loading in Other Years	Similar Snowfall Year
2007/2008	96	4727.4	1.4X	
2008/2009	106	6711.4	1.0X	✓
2009/2010	82	4916.3	1.4X	
2010/2011	160	7329.1	0.9X	
2011/2012	101	4859.0	1.4X	
2012/2013	138	5827.0	1.1X	
2013/2014	151	5397.7	1.2X	
2014/2015	106	4488.6	1.5X	✓
2015/2016	53	3047.5	2.2X	
2016/2017	138	4653.2	1.4X	
2017/2018	117	5011.4	1.3X	✓
2018/2019	145	6870.6	1.0X	
2019/2020	120	6685.0	--	--

**Outfall Chloride Loadings: the sum of the four major storm outfalls (30 Ave, Groat, Kennedale, Quesnell).
Winter season years during the Anti-icing Pilot Project are shaded orange.
-- denotes the year that the other years are compared to.
Example: 1.4X or a 40% increase in the amount of chlorides were discharged to the outfalls in 2019/2020 compared to 2007/2008.

Table 8. Comparison of City Applied Sodium Chloride (NaCl) to Outfall Chloride Loading (tonnes)

Year Oct - Oct	Annual Snowfall (cm)	NaCl Salt Applied (tonnes)	NaCl Applied in 2019/2020 Compared to NaCl Applied in Other Years	Outfall** Chloride Loadings (tonnes)	Outfall Chloride Loadings** in 2019/2020 Compared to Chloride Loading in Other Years	Similar Snowfall Year
2007/2008	96	13,688	2.6X	4727.4	1.4X	
2008/2009	106	20,284	1.8X	6711.4	1.0X	✓
2009/2010	82	16,030	2.2X	4916.3	1.4X	
2010/2011	160	22,743	1.6X	7329.1	0.9X	
2011/2012	101	19,886	1.8X	4859.0	1.4X	
2012/2013	138	25,275	1.4X	5827.0	1.1X	
2013/2014	151	18,806	1.9X	5397.7	1.2X	
2014/2015	106	21,194	1.7X	4488.6	1.5X	✓
2015/2016	53	10,260	3.5X	3047.5	2.2X	
2016/2017	138	19,309	1.9X	4653.2	1.4X	
2017/2018	117	36,789	1.0X	5011.4	1.3X	✓
2018/2019	145	42,082	0.9X	6870.6	1.0X	
2019/2020	120	35,855	--	6685.0	--	--

**Outfall Chloride Loadings: the sum of the four major storm outfalls (30 Ave, Groat, Kennedale, Quesnell).
Winter season years during the Anti-icing Pilot Project are shaded orange.
-- denotes the year that the other years are compared to.
Example: 2.6X the amount of sodium chloride salt was applied in 2019/2020 than 2007/2008, representing a 160% increase whereas the outfall chloride loadings in 2019/2020 were only 1.4X, or a 40% increase compared to 2007/2008.

5.4 Spring Melt

The major outfalls discharge water from major drainage basins across the City and the chloride measured in the outfall water is assumed to be 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 the majority 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: Historical Spring Melt Chloride Contribution (spring loading compared to entire season loading, %)

Year March, April May & June	30th Ave Outfall (%)	Groat Road Outfall (%)	Kennedale Outfall (%)	Quesnell Outfall (%)	Similar Snowfall Years as 2019/2020
2002/2003	61	N/A	N/A	N/A	
2003/2004	44	N/A	N/A	N/A	✓
2004/2005	43	N/A	N/A	N/A	
2005/2006	50	N/A	N/A	N/A	
2006/2007	55	N/A	N/A	N/A	
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	
2019/2020	52	56	65	61	--

N/A denotes data was not available.
Winter season years during the Anti-icing Pilot Project are shaded orange.
-- denotes the year that the other years are compared to.

5.5 Snow Storage Sites

The City's snow storage sites are open to internal and external snow haulers - this includes private citizens, contractors, and other municipalities. The exception to this is Kennedale which only accepts snow from internal haulers. Snow is stockpiled at the snow storage sites until the snow melts and ultimately drains into the site's respective outfall.

Two of the five snow sites, Poundmaker and Kennedale, discharge to major outfalls. 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. Typically, higher chloride loadings are observed with higher annual snow volumes.

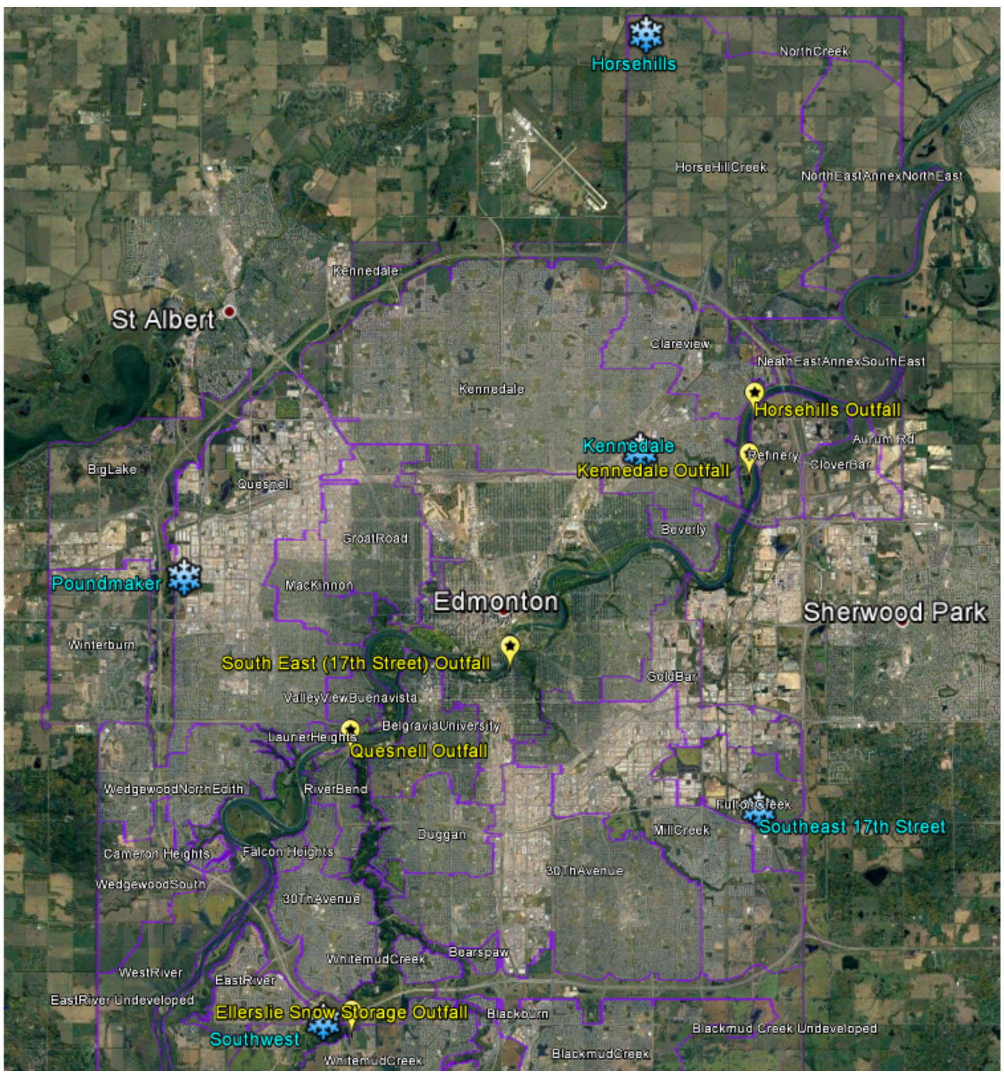


Figure 4: Location of City snow storage sites (❄), major outfalls and snow storage site outfalls.

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

(Approx. April to September)	17 Street Snowsite (kg)	Poundmaker Snowsite (kg)	Kennedale Snowsite (kg)	Horsehills Snowsite (kg)	Ellerslie Snowsite (kg)	Sum of Loadings (kg)	Similar Snowfall Years as 2019/2020
2007/2008	263,200[i]	N/A	137,000[i]	N/A	N/A	**	
2008/2009	N/A[ii]	N/A[ii]	N/A[ii]	N/A[ii]	N/A[ii]	**	✓
2009/2010	N/A	N/A	N/A	N/A	N/A	**	
2010/2011	529,639	264,681	463,057	N/A	422,389[iii]	**	
2011/2012	7,765	1,533	N/A[ii]	N/A	2,587	**	
2012/2013	268,866	170,043	86,304	N/A	66,426	**	
2013/2014	324,410	125,985	N/A[v]	214,900[iv]	103,387	768,682+	
2014/2015	152,784	112,410	61,867	76,803	75,170	479,034	✓
2015/2016	44,375	7,768	N/A[v]	27,125	13,178	92,446	
2016/2017	79,111	179,115	19,127[vi]	7,339	22,792	307,484	
2017/2018	242,822	188,170	107,846	69,268	204,272	812,378	✓
2018/2019	131,765	238,354	123,858	116,027	155,867	765,871	
2019/2020	211,035	255,304	40,400	39,322	65,369	611,430	--

N/A denotes data that was not available at the time.

[i]Alberta Environment and Parks 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.**

[ii]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.**

[iii]The first year of operation for Ellerslie snow storage site was 2010/2011.

[iv]The first year of meltwater flow monitoring for the Horsehills snow storage site was 2013/2014.

[v]Kennedale Snowsite was not operational in 2013/2014 and 2015/2016.

[vi]Kennedale Snowsite was used minimally in 2016/2017.

Winter season years during the Anti-icing Pilot Project are shaded orange.

-- denotes the year that the other years are compared to.

** during 2012/2013 and earlier years snow was deposited on a land site other than Horsehills / totals would not be accurate and not used for comparisons. From 2013/2014 on, all sites discharged to the storm drainage system

+2013/2014 unusually high snow year

The Kennedale and Poundmaker snow storage sites discharge to the storm sewer system that connects to the Kennedale and Quesnell outfalls, respectively. Tables 11 and 12 examine these two snow sites to evaluate the contribution of snowmelt water from snow storage sites compared to the total chloride loadings 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[i]	1,327,591	10.3
2008/2009	N/A[ii]	1,007,498	N/A
2009/2010	N/A	609,459	N/A
2010/2011	463,057	1,405,376	32.9
2011/2012	N/A	649,712	N/A
2012/2013	86,304	714,539	12.1
2013/2014	N/A[iii]	596,414	N/A
2014/2015	61,867	471,408	13.1
2015/2016	N/A[iii]	306,384	N/A
2016/2017	19,127[iv]	646,513	3.0
2017/2018	107,846	616,110	17.5
2018/2019	123,858	1,034,634	12.0
2019/2020	40,400	999,553	4.0

N/A denotes data that was not available at the time.

[i]Alberta Environment and Parks 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.**

[ii]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.**

[iii]Kennedale Snowsite was not operational in 2013/2014 and 2015/2016.

[iv]Kennedale Snowsite was used minimally in 2016/2017.

Winter season years during the Anti-icing Pilot Project are shaded orange.

An average of 13% of the total chloride loadings measured at the Kennedale outfall since 2007 may be attributed to snow removed by the City. Kennedale does not accept snow from outside haulers.

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	N/A	2,430,951	N/A
2008/2009	N/A	2,684,582	N/A
2009/2010	N/A	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
2019/2020	255,304*	3,342,406	7.6

N/A denotes data that was not available at the time.
*Missing partial flow data. Missing flow data was extrapolated.
Winter season years during the Anti-icing Pilot Project are shaded orange.

Since 2007/2008, an average of 6% of chloride loadings measured at the Quesnell outfall may be attributed 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 winter snow clearing (routes, snow event volume, temperature).

The major outfalls discussed in this section do not represent loadings from the entire storm sewer system in Edmonton. The City-wide stormwater system discharges to 225 major and minor outfalls. Chloride contributions from private businesses and citizens due to winter anti-icing and de-icing are unknown. The volume of stormwater that travels by overland flow and infiltrates in the subsurface is also unknown.

6.0 Environmental Impacts of Corrosion Inhibitors

Infrastructure Operations investigated four brine products with various corrosion inhibitor additives during the Anti-icing Pilot Project in 2017/2018:

- Calcium chloride brine with an organic based corrosion inhibitor
- 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 an organic based corrosion inhibitor

During all other years before and after the 2017/2018 pilot, calcium chloride brine with 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 is 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 has adverse effects on aquatic life. ***Phosphorus*** is an essential nutrient and a component of fertilizers, but at high concentrations degrades water quality by overstimulating algal growth (which decreases dissolved oxygen).

Key environmental indicator data are presented in the following tables[6]:

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

[6] Loadings in Tables 13 and 14 are calculated using EPCOR Outfall Sampling data for total stormwater discharge.

Winter season data from November 1 to April 30, were used to assess BOD, phosphorus, and ammonia loadings. The warm weather months of monitoring were excluded from the data in order to isolate anti-icing related impacts and eliminate potentially elevated summer:

- BOD levels due to warm weather and summer runoff that contains oxygen consuming waste
- Phosphorus levels due to runoff that contains applications of phosphorus, such as fertilizer
- Ammonia-N levels due to runoff that contains applications of ammonia-N, such as fertilizer or decomposition of organic waste matter.

The analysis of the monitoring data showed that there were no significant changes to BOD, phosphorus, or ammonia loadings to the North Saskatchewan River related to the Anti-icing Pilot Project, or the 2019/2020 winter season.

Table 13. Biological Oxygen Demand (BOD), Total Phosphorus, and Ammonia-N Loadings Measured at Outfalls

Year (Nov - Apr)	BOD loading (kg)	Total Phosphorus (kg)	Ammonia - N (kg)	Annual Snowfall (cm)	Similar Snowfall Years as 2019/2020
2007/2008	269,588	12,304	24,422	96	
2008/2009	274,045	12,838	25,792	106	✓
2009/2010	221,079	9,608	25,606	82	
2010/2011	558,366	25,902	55,439	160	
2011/2012	320,878	13,128	31,323	101	
2012/2013	390,247	18,564	27,789	138	
2013/2014	372,012	17,114	23,624	151	
2014/2015	460,675	19,421	27,898	106	✓
2015/2016	253,085	8,105	24,061	53	
2016/2017	270,915	15,974	29,652	138	
2017/2018	302,488	15,680	33,828	117	✓
2018/2019	315,504	13,256	23,516	145	
2019/2020	168,906	9,204	16,252	120	--

Loadings are from the period November 1 to April 30
Winter season years during the Anti-icing Pilot Project are shaded orange.
-- denotes the year that the other years are compared to.

Table 14. Average BOD, Phosphorus, and Ammonia-N Loadings at Major Outfalls

Statistics	BOD (kg)	Total Phosphorus (kg)	Ammonia-N (kg)
Average winter season loadings 2007/2008-2016/2017**	339,089	15,296	29,561
Standard Deviation, 2007/2008-2016/2017	+/- 106,422	+/- 5,246	+/- 9,431
2017/2018**	327,389	15,528	30,897
2018/2019**	315,504	13,256	23,516
2019/2020**	168,906	9,204	16,252

**Loadings are from the period November 1 to April 30
Winter season years during the Anti-icing Pilot Project are shaded orange.

7.0 Discussion

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. In October 2019, Council voted to discontinue the direct application of calcium chloride as an anti-icing agent to City roads for the 2019/2020 winter. Calcium chloride brine was still used in winter roadway maintenance to pre-wet sand and salt before roadway application and as an anti-icing brine on sidewalks, bike lanes, and pathways.

There is a significant amount of scatter in the historical weather, environmental, and material usage data that is likely a reflection of variabilities in winter weather patterns and temperatures, rather than total snowfall amounts. 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 historical data to state some generalities:

- There is a general historical 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 2017/2018 and 2018/2019 was higher than in previous years with similar snowfall. The trend for higher sodium chloride salt application and reduced sand application has continued into 2019/2020.

- The City of Edmonton's increased sodium chloride salt application may have some impact on the chloride loadings at major storm outfalls. Conducting annual Surface Water Loadings Evaluations would help to improve the overall accuracy of the data and the confidence that increased loadings are a trend.

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

There are 225 major and minor storm sewer outfalls that discharge to the North Saskatchewan River and its tributaries within the City of Edmonton. Water quality 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.

The difference in chloride loadings at the outfalls compared to the applied chloride by the City of Edmonton may be due to infiltration; overland flow; chloride ice-melt products from other sources, such as private businesses and citizens that contribute to baseline chloride concentrations in stormwater; or other unidentified factors. The chloride application quantities represent the complete chloride application to the City road network.

8.0 Conclusions

This Surface Water Loadings Evaluation presents the 2019/2020 environmental review. This report provides comparisons to the Anti-icing Pilot Project conducted in 2017/2018 and 2018/2019. Historical data prior to 2017/2018 is used as a benchmark.

- Calcium chloride application has a minimal impact on the total chloride loading. Of the total chloride applied to Edmonton roads for road safety in 2019/2020, 0.1% was due to the application of calcium chloride brine. During the Anti-icing Pilot Project implemented in the 2017/2018 winter season and extended to 2018/2019, respectively 4.3% and 0.5% of the total chloride was from calcium chloride brine application.

- An average of 90% more sodium chloride salt was applied to winter roads in 2019/2020 compared to years prior to 2017/2018 with similar snowfall volumes.

- A reduction in sand application is evident since the 2017/2018 winter season. Compared to years before 2017/2018 with similar snowfall volumes, approximately 60% less sand was applied over the winter of 2019/2020

- Based on the Kennedale and Poundmaker snow storage facilities assessment, snow sites contribute a small amount of overall outfall chloride loadings.

- A compilation and analysis of monitoring data showed that there were no significant changes to BOD, phosphorus, or ammonia loadings to the North Saskatchewan River related to the Anti-icing Pilot Project, or the 2019/2020 winter season.
- The majority of chloride loadings to the North Saskatchewan River from storm sewer outfalls occur during the spring melt (March, April, May, and June).
- There is a relationship between annual chloride discharge loadings at the outfalls and the cumulative snowfall in a particular year as more sodium chloride salt is applied.
- The increased sodium chloride salt application in the last three years is significant; this is especially apparent in the 2018/2019 and 2019/2020 snow years. More annual data is required to substantiate the loading trends due to changes in chloride application.
- The widespread use of chloride salts by the public and commercial enterprises for winter safety may influence chloride loadings at the outfall, the amount of influence is unknown.

10.0 References

Annual Winter Materials Usage 2015/2016, March 10, 2017. City of Edmonton, Parks and Roads, Infrastructure Operations.

Annual Winter Materials Usage 2016/2017, January 19, 2018. City of Edmonton, Parks and Roads, Infrastructure Operations.

Annual Winter Materials Usage 2017/2018, March 22, 2018. City of Edmonton, Parks and Roads, Infrastructure Operations.

Annual Winter Materials Usage 2018/2019, February 20, 2019. City of Edmonton, Parks and Roads, Infrastructure Operations.

Annual Winter Materials Usage 2019/2020, November 18, 2020. City of Edmonton, Parks and Roads, Infrastructure Operations.

Baroga, Enrico V., 2003. Washington State Department of Transportation 2002-03 Salt Pilot Project, August 2003. Washington State Department of Transportation.

Dinwoodie, Gordon, 2019. AEP Regulatory Update. “Tech Talk” presentation, February 26, 2019.

City of Edmonton Bylaw 18093 Drainage Bylaw, January 22, 2019

Cumulative Snowfall, Environment Canada’s Monthly Climate Summaries. https://climate.weather.gc.ca/prods_servs/cdn_climate_summary_e.html

Outfall Monitoring Data Total Suspended Solids, Chloride, Total Phosphorus, (2020). EPCOR Drainage Services

Pacific Northwest Snowfighters, 2010. *Pacific Northwest Snowfighters Snow and Ice Control Chemical Products Specifications and Test Protocols for the ONS Association of British Columbia, Colorado, Idaho, Montana, Oregon and Washington*, Revision 12-10, 2010. Retrieved from URL http://pnsassociation.org/wp-content/uploads/PNSSPECS.pdf on July 31, 2018.

Transportation Association of Canada, 2013. Syntheses of Best Practices - Road Salt Management

Government of Canada (modified 2017-02-01). *Code of practice: road salts environmental management.* https://www.canada.ca/en/environment-climate-change/services/pollutants/road-salts/code-practice-environmental-management.html downloaded August 9, 2018.

Change History

Version	Date	Author	Description
1	September 11, 2020	Clarence Stuart Joy Tolsma Jessica Zelinski	SNIC Monitoring Program PRELIMINARY Surface Water Loadings Evaluation 2019-2020
2	November 27, 2020	Clarence Stuart Joy Tolsma Jessica Zelinski Bretlyne Friday	SNIC Monitoring Program Surface Water Loadings Evaluation 2019/2020 Data updates

Document Approval

Submitted By:

Name	Title	Submit Date
Clarence Stuart	Environmental Scientist	November 27, 2020