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DESIGN AND CONSTRUCTION OF A SNOWMELT MANAGEMENT FACILITY IN SOUTHERN ONTARIO

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Abstract: Winter conditions, including snow and ice, are a reality for Canadian drivers, including those in Southern Ontario. Local municipalities and other government agencies are typically charged with ensuring safe roadway conditions for motorists, including clearing and plowing snow. In areas with limited space within the roadway right-of-way, plowed snow may need to be transported off-site and disposed of, with little or no environmental or runoff controls. Untreated snowmelt water has been demonstrated to be a significant environmental concern to downstream receiving watercourses, resulting in elevated levels of suspended solids, chloride (salt), as well as numerous other water quality contaminants.

A recent example of the design, and ultimate construction of a snowmelt management facility in Hamilton, Ontario is presented. An integrated "treatment train" approach was employed for the facility, which included the design of a large appropriately graded asphalt melting pad, an oil/grit separator for pre-treatment, and a specifically designed wet pond facility involving a retrofit of an existing stormwater management (SWM) facility for final treatment and dilution. The system was also designed to have a complete SWM function (quantity and quality control) under non-snowmelt (i.e. rainfall-driven) conditions.

Design considerations specific to the management of snowmelt contaminants (salt in particular) are discussed and presented. Perspectives of different stakeholders involved in the management of roadway snow are also considered, including municipalities (engineering and operations and maintenance groups), regulatory authorities, and practitioners.

1 INTRODUCTION

As a northern hemisphere nation, Canada experiences seasonal winter conditions, including snow and ice. Given Canada's geography, the winter season may be extensive. In the City of Hamilton, located in Southern Ontario, the daily average temperature is below zero degrees Celsius for December through March, although snow routinely occurs in April and November (Environment Canada, 2018). Winter conditions may therefore be present for up to one third of the calendar year.

Maintaining roadway transportation links during the winter period is critical, to ensure the uninterrupted movement of goods and services, and to allow citizens safe travel. Government agencies are typically charged with ensuring safe roadway conditions for users; including Provincial agencies for major highways (the Ministry of Transportation in Ontario), and local governments (upper and lower tier municipalities) for arterials, collectors, and local roadways. Winter roadway maintenance typically involves a number of different activities, including monitoring, de-icing (brine spray), plowing, and salting and sanding (Ministry of Transportation, 2018). Salt is most effective at temperatures of -12ºC or higher, whereas sand may be used at lower temperatures, or in locations where there is an immediate need for traction, such as hills, curves, bridges and intersections (Ministry of Transportation, 2018). The City of Hamilton typically relies on a blend of road salt and sand, typically referred to as “pickle”. This mixture consists of varying ratios of salt to sand (1:3, 1:5, or 1:10) depending on requirements.

In most cases, plowed snow is simply directed to the side of the roadway right-of-way; either the ditch (rural roadway cross-section) or between the curb and the sidewalk (urban roadway cross-section). In areas with limited space within the right-of-way (older urban areas, bridges), or in other areas with space constraints, such as parking lots, plowed snow may be collected by trucks and transported off-site for storage and melting.

The water quality of plowed snow from roadway areas has been recognized as being a significant environmental concern. Snowmelt water from such plowed sources may be contaminated with a number of different pollutants, including petroleum products/additives, corded or abraded metals, de-icing and anti-skid agents (i.e. salt and sand), abrasion of roadway surfaces and litter (Marsalek et al., 2003). Road salt in particular is a primary contaminant of concern in roadway snow. As such, the proper disposal and management of snow is a key consideration for government agencies tasked with winter road maintenance and ultimately those dealing with excess snow management.

This paper briefly reviews considerations and guidance with respect to the design of snowmelt management facilities in Southern Ontario. A recent example of the design and ultimate construction of a snowmelt facility in the City of Hamilton, Ontario is presented. Perspectives of different stakeholders involved in the management of roadway snow are also considered, including municipalities (engineering and operations and maintenance groups), regulatory authorities, and practitioners.

2 SNOWMELT MANAGEMENT

2.1 Snowmelt Contaminants

The water quality of urban snowmelt water has been recognized as being a significant environmental concern. Melt water may be contaminated with a number of different pollutants, including petroleum products/additives, corded or abraded metals, de-icing and anti-skid agents (i.e. salt and sand), abrasion of roadway surfaces and litter (Marsalek et al., 2003). Numerous studies have reviewed the processes involved with pollutant accumulation and release in urban snowmelt (i.e. Exall et al (2010)). A substantial portion of snowmelt pollutants can be attributed to atmospheric sources (combustion, incineration, processing and manufacturing). Notwithstanding, snowmelt pollutants are also clearly linked to urban land uses and vehicle activity and traffic density (Exall et al., 2010). Aged snowpacks, or snowpacks which have been extensively processed and worked may also be expected to have higher levels of contaminants.

Road salt is a particular contaminant of concern in urban snow from roadway and paved areas. It has been estimated that approximately 5 million tonnes of road salt are used per year in Canada (Environment Canada and Health Canada, 2001). Road salt is highly soluble, and the majority of applied road salt will ultimately impact surface water (creeks, rivers, lakes) or groundwater sources. As an example, monitoring studies have shown that Ontario’s Lake Simcoe (surface area of approximately 750 km2) has experienced a five-fold increase in salt concentrations from the 1970s to present (McDiarmid, 2017). As part of its 2001 report, Environment Canada considered road salt to be “toxic” and recommended it be listed as such as per the Canadian Environment Protection Act. Ultimately however, this did not occur, reportedly due to concerns from the salt and transportation industries (Chung, 2008). Environment Canada however promotes a voluntary “code of practice” to reduce salt usage, which the majority of Ontario municipalities have adopted. While this practice appears to have contributed to a reduction in the “normalized” application rate, it has not translated in an overall reduction in salt usage (Lembcke et al, 2016).

2.2 Regulatory Guidance and Experience in Southern Ontario

Based on the preceding, urban snowmelt is expected to have an adverse impact on receiving systems. Notwithstanding, based on a review by Environment Canada (2012), only 16% +\- of municipal road organizations have runoff and meltwater collection engineered sites in place (with no change since 2007). The same study however indicated that 77% of municipal road organization implement “good housekeeping practices” at snow disposal sites (Environment Canada, 2012).

Within southern Ontario, the earliest and most well-known snowmelt management facility is operated by the Town of Richmond Hill. This facility, constructed in 2003, was the first of its kind in southern Ontario. The facility uses a three step “treatment train” approach, with a large asphalt melting pad, oil/grit separator for pre-treatment, and a wetland stormwater management facility (Exall et al, 2010). Since that time however, there remains few other reported examples of snowmelt management facilities constructed in Southern Ontario. Some other examples in eastern Ontario include the Carp snow disposal facility outside the City of Ottawa.

The Ontario Ministry of the Environment and Climate Change (MOECC) has generated “Guidelines on Snow Disposal and De-icing Operations in Ontario” (2011). Those guidelines provide general guidance on snow disposal, however do not provide any specific or formal direction on the design of snow disposal sites or snowmelt management facilities, beyond suggested criteria in the selection of a suitable site.

The Transportation Association of Canada (TAC) does provide guidance on snow storage and disposal (2013). Similar to the MOECC guidelines, TAC provides suggestions on the assessment and evaluation of candidate sites, including snow hauling distances, land use (both the site and surrounding area, i.e. zoning), and environmental considerations (surface and sub-surface). The “treatment train” approach is again promoted, with a solid melting pad (able to accommodate trucks and heavy equipment) and meltwater collection pond, fitted with impermeable bases to limit infiltration and protect groundwater resources (TAC, 2013). The guidelines also suggest the potential consideration of an oil/grit separator for pre-treatment.

Some technical guidance in the design of snow storage disposal facilities is also provided in an overarching study on road salt management undertaken by the University of Waterloo (Stone et al, 2010). This document also promotes the “treatment train” approach to snowmelt, with a melting pad and wet pond SWM facility, an oil and grit separator for additional pre-treatment. The document provides similar guidance to the other sources on considerations with respect to the siting and sizing of potential facilities.

In general, the foregoing guidelines promote removal of debris and sediments (and contaminants attached to sediments, such as metals), and advocate a dilution-based approach to chloride management, to avoid shocking receiving systems. As it is a dissolved contaminant, physical processes alone (i.e. settling; typical of stormwater treatment) cannot remove chloride. Wastewater treatment processes would be required, which are typically not considered as part of snowmelt management systems, given cost and the associated operations and maintenance requirements. Consideration can be given connecting snowmelting areas to the sanitary sewer system (and ultimately a wastewater treatment plant), however such a connection may not be feasible in all cases, due to servicing or capacity constraints. Halophytic (salt-tolerant) plantings could potentially be considered, to aid in the uptake of dissolved chloride. However, such plants are typically non-native and considered invasive species, which can result in other negative impacts.

3 PROJECT EXAMPLE

3.1 Project Location and Purpose

As outlined in the preceding section, frequently a planning study is undertaken by the government agency or municipality charged with roadway snow removal, in order to identify preferred sites for snow disposal and management. For the subject project example, this process was not required. The City of Hamilton historically used its Public Works yard on Upper Ottawa Street for winter maintenance activities (ref. Figure 1).

Figure 1: City of Hamilton Upper Ottawa Works Yard Site

The site is bounded by two major roadways, the Lincoln Alexander Parkway to the north, and Upper Ottawa Street to the west. The south and east limits of the site are generally forested/naturalized and include the headwater/outlet of Red Hill Creek, which is enclosed in a large storm sewer structure upstream of the site. The site itself (covering some 6 ha +\-) is generally open space, with a salt storage shed structure in the centre (including a hydro transformer for lights, and a brine storage tank area). In previous years, the City of Hamilton would pile plowed snow informally in available spaces on site. An informal dry pond feature was located at the south limits of the site, receiving sheet flow drainage (including meltwater) from the site. The pond ultimately discharged to the adjacent watercourse receiver, Red Hill Creek.

In 2015, the City of Hamilton engaged Amec Foster Wheeler to support the re-development of the site, to formalize the snowmelt and snow disposal management process, and to make other site improvements, including consideration of privacy measures to limit impacts to existing residents on the west side of Upper Ottawa Street, immediately opposite the site. The City of Hamilton further expressed a desire to address environmental concerns with the project, while also developing a cost-effective, relatively low maintenance system, which also addressed secondary concerns, such as impacts to adjacent residents.

3.2 Snowmelt Management Facility Design Considerations

The snowmelt management facility (SMF) was designed using guidance from available regulatory sources and best practices, as summarized in the preceding sections. It was considered that the "treatment train" approach was the most appropriate, combining an asphalt melting pad, an oil/grit separator, and a wet pond. The layout of the site and SMF are presented in Figure 2.

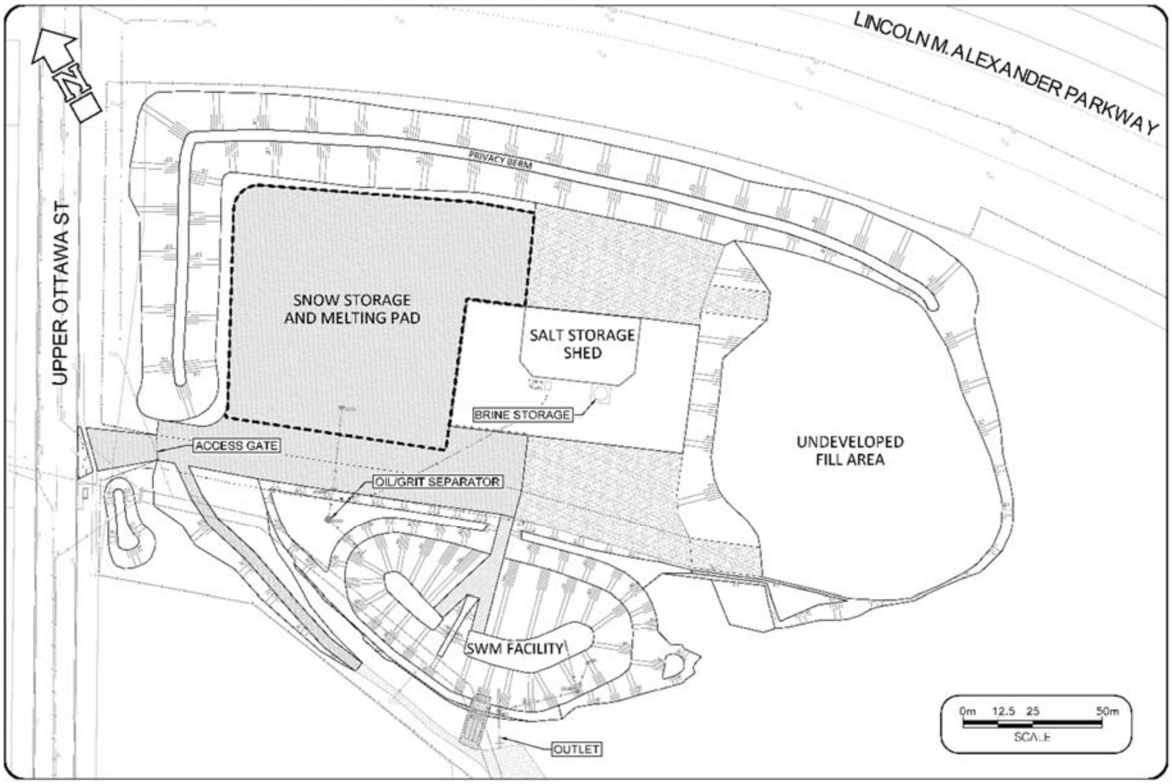

Figure 2: Upper Ottawa Snowmelt Management Facility Layout

As part of maintaining a cost-effective design, a cut/fill balance for earthworks was a design objective to avoid the high cost of off-site disposal of material. Material removed to support the creation of the wet pond and grading/sub-grade for the asphalt melting pad was used to create a privacy berm around the west and northern limits of the site, to reduce light and noise impacts to adjacent residents from operations work. Additional material was also used to grade a uniform fill area at the east limits of the site, which was considered for temporary stockpiling and other maintenance activities by the City.

A large (1.0 ha +\-) asphalt melting pad was the first component of SMF design, intended to promote melting and settling of larger sediment and debris/garbage. The asphalt structure of the pad was carefully designed, accounting for the loads expected from dump trucks full of snow, as well as other snow management equipment. As per available design guidance, relatively gentle melting pad slopes of 1-2% are typically recommended to promote settling of coarser sediments and debris, with a sloping plane or v-shaped pad to allow for the collection of meltwater and associated direction of flow (Stone et al, 2010). Due to site grading constraints, designed grades ranged from 0.5 to 3%, however the majority of the grades remained consistent with the suggested 1-2% range. Concrete curbs were also implemented to direct flow and separate the melting pad area from adjacent uses. The pad was designed to drain from north to south, allowing for south facing exposure for melting.

Meltwater from the pad is collected/captured by a double catchbasin, and directed to an oil/grit separator (the second component of the SMF) for pre-treatment and settling of coarser sediment material. The oil/grit separator is intended to reduce maintenance frequency for the downstream wet pond facility, given that the oil/grit separator can be more easily cleaned and maintained using mechanical means such as a hydrovac truck. In order to size the unit appropriately, a higher event mean concentration (EMC) of sediment (600 mg/L) was assumed as compared to typical stormwater (80 to 125 mg/L). A coarser particle size distribution was also assumed based on the use of sand for winter maintenance. The unit was ultimately sized for an average annual total suspended solids (TSS) removal of 81%. Sizing calculations undertaken by the manufacturer were also used to ensure that the storage sump within the unit was sufficient to require clean-out no more than annually based on sediment concentrations and expected snowmelt volumes.

The final component of the SMF is a wet pond facility. The wet pond facility is intended to provide final settling of suspended sediment material (and attached contaminants such as metals), as well as dilution of chloride to the extent possible, to minimize “shock” discharges. Based on a review of available literature, there is a lack of guidance on specific wet pond design parameters for snowmelt management. As such, the guidance and direction available within the Ontario Ministry of the Environment’s Stormwater Management Planning and Design Manual (2003) were applied. Futhermore, an oversized permanent pool volume was provided (approximately 2.7 times the minimum required value), to assist in diluting dissolved chloride concentrations.

Monitoring (i.e. Richmond Hill Facility) has noted that high concentrations of chloride during snowmelt periods can lead to a density-based stratification within the wet pond due to heavier chloride-laden water (Exall et al, 2011). The facility was able to delay and dilute chloride concentrations in the released flows, however releases could still occur at toxic levels given that a wet pond ultimately does not remove the dissolved chloride (Exall et al, 2011). Other studies (Lembcke et al, 2016) have also shown stratification in wet ponds, with higher chloride concentrations noted at the bottom of the facility. By contrast, thermal stratification also occurs in wet ponds particularly during warm weather conditions, where the difference between the top and bottom of the wet pond permanent pool can be substantial (up to 9oC in Lembcke et al, 2016).

Stone et al (2010) note that reverse sloped outlet pipes (which are typical for conventional SWM facilities to draw cooler water from the bottom of the permanent pool) may actually release denser water with elevated chloride concentrations due to stratification. That study suggested that surface outlets (i.e. weirs) or adjustable outlets may be preferable for that reason. For the Upper Ottawa SMF, a compromise approach was sought, to balance the desire to discharge lighter, less chloride laden water during melt periods, but to also discharge cooler water during summer month periods. A reverse sloped pipe outlet was implemented, however the pipe draws water from the mid-point of the permanent pool.

While the wet pond facility was designed primarily for snow melt management, consideration was also given to operation during conventional warm weather conditions as the Public Works Yard operates year-round. The wet pond facility was designed to achieve “post to pre” stormwater management peak flow control for the 2 through 100 year return period events. Extended detention times in excess of the required 24 hour were also designed for warm weather events (i.e. 4 hour, 25 mm storm event) as well as a “snowmelt” event. The latter was developed by using the maximum estimated snowmelt rate (based on a review of both historical data and available empirical snowmelt equations), and an assumption that this rate would occur during primary daytime melting hours (i.e. 10 AM to 4 PM).

Consideration was given during the design phase to the use of halophytic (salt-tolerant) plantings within the wet pond facility, to aid in the uptake of dissolved chloride. Notwithstanding, following consultation with landscape architect and ecology specialists, this approach was not pursued, given that available halophytic plant species are all non-native and in many cases invasive species.

3.3 Operations and Maintenance

Site works were largely constructed over the course of September to November, 2017. Top course asphalt paving and landscaping activities are planned for spring 2018. Notwithstanding, snow management activities have occurred over the course of December 2017 and January 2018. Preliminary observations have noted the need for a clear operations and maintenance procedure, which needs to be communicated with City staff undertaking work on the site. Snowpiling activities initially occurred at the south limits of the site, on top of the melting pad outlet (double catchbasin). This greatly reduced or eliminated settling of coarse sediments and debris, and could have also lead to an outlet blockage and on-site ponding/flooding. In other areas, snow was piled above and beyond the melting pad curb limits and onto pervious areas. This tended to allow for infiltration of contaminated water, and could also have a negative impact on landscaping and soil stability, due to the expected high chloride levels. In general, for the City of Hamilton SMF snowpiling activities should be restricted to the melting pad area, and should proceed from north to south to maximize potential settling. Consideration should also be given to the space required for maintenance equipment, and safe limits of snow piling. While such experiences may initially be discouraging, they provide an opportunity to improve site operations procedures and ensure that best practices are established appropriately.

As part of the conditions of approval from the Ministry of the Environment and Climate Change (MOECC), the City of Hamilton is required to prepare and implement and operations and maintenance manual, which will largely follow the guidance provided as part of the design submissions made by Amec Foster Wheeler (2017). Other references will also be considered for guidance, including Stone et al (2010) and the Transportation Association of Canada (2013). A field monitoring program of the SMF will also be undertaken by the City of Hamilton as part of the Conditions of Approval from the MOECC; the results of this program may yield further insights.

In addition to winter operations, spring time maintenance activities will also be important. It is expected that a streetsweeper will be required to remove coarse sediment and debris from the melting pad area post snowmelt, and prior to spring rainfalls, which would tend to wash this material downstream. The oil/grit separator unit should be inspected during this period, and a clean-out (likely using a hydrovac truck) co-ordinated as required. The wet pond facility should also be visually inspected for any potential issues. Following spring maintenance activities, the asphalt melting pad should not be used for stockpiling loose materials which could unnecessarily consume capacity within the oil/grit separator.

4 SUMMARY AND FUTURE CONSIDERATIONS

Winter road maintenance, including plowing and disposal of excess snow, will continue to be a consideration for public sector agencies tasked with these works. Based on available data, formal snowmelt management systems have not been widely implemented by these agencies. Given the significant environmental concerns associated with uncontrolled snowmelting, it is expected that snowmelt management facilities will become increasingly common in Southern Ontario and beyond.

A recent example of the design and construction of a snowmelt management facility (SMF) in Hamilton, Ontario was presented. Based on a review of best practices, the SMF was designed using an integrated “treatment train” approach, including an asphalt melting pad, an oil/grit separator for pre-treatment, and a specifically designed wet pond facility. Operations and maintenance considerations are considered key to the long-term success of the facility.

While it is considered that this paper has provided an overview of design considerations and best practices, it is noted that there are a number of other related considerations that merit further review; these include:

- A larger discussion is warranted regarding salt management. Ultimately SMFs can only dilute, not remove chloride concentrations. Reductions in chloride/salt can only be achieved through more careful application/use for road management activities. This may include reduced use (and better winter driving education), alternative de-icing products and procedures, and other options. This discussion would necessarily include cost considerations, including the costs of salt and other maintenance work, as well as liability costs for road safety, and the environmental costs.
- The preceding discussion has focused on disposal of plowed/removed snow for public roadways. Consideration should also be given to the impacts of snowmelt from other roadways (i.e. where snow is piled within the right-of-way), as well as removal and disposal from private sites (i.e. large commercial parking lots).
- The project example cited herein was designed using best practices. However, as part of the site selection consideration should also be given to the sensitivity of the drainage system receiver, including the characteristics of the aquatic community. In some cases, alternative locations, strategies or targets may be warranted.
- Current best practices recommend liners or impermeable barriers to eliminate potential infiltration of snowmelt water. While this is a preferred approach in areas with sensitive groundwater resources (i.e. sourcewater protection zones, particularly in areas which source drinking water from groundwater), in other areas infiltration may be preferable to surface water impacts. This should be considered further,

particularly given the current direction towards the promotion of infiltration based techniques for stormwater management (i.e. low impact development best management practices) in the Province of Ontario.

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