SCHEDULE F – PROJECT COMPLETION REPORT TEMPLATE

VERY IMPORTANT:

Timing: You need to email a report, to your GMF project officer (contact info is in Schedule C), on the dates indicated in Schedule C or whenever FCM asks for such a report.

Copyright: Before you submit a report to FCM, make sure you hold the copyright for the report. If you're hiring a consultant to prepare the report, please make sure to get the copyright (see FCM's copyright tips document), or else FCM will not be able to disburse the Grant Amount.

Accessibility for people with disabilities: Please do not change the format, font, layout, etc. of this report. This template has been specially designed, following FCM's Accessibility Guidelines, in order to be accessible to people with disabilities.

Confidentiality: If your report contains any Confidential Information that you would prefer not be made available to the public (e.g. through a case study or other materials produced by FCM that relate to your Project), please submit two versions of the report:

1. **Complete report including Confidential Information:** Please clearly label this report with the word "**Confidential**" or similar wording and FCM will treat it as confidential.

2. **Abridged report excluding Confidential Information:** This report may be posted on the FCM website and otherwise made available to interested third parties, to help FCM meet its knowledge sharing objectives.

Please contact your project officer to receive an electronic copy of the Completion Report Template.

Upon completion of the project, a copy of the Final Deliverable must be submitted along with this Completion Report.

FCM will post your report on the Green Municipal Fund™ (GMF) website. This is because one of FCM's mandates is to help municipal governments share their knowledge and expertise regarding municipal environmental projects, plans and studies.

How to complete the Completion Report

The purpose of the Completion Report is to share the story of your community's experience in undertaking your project with others seeking to address similar issues in their own communities.

Please write the report in plain language that can be understood by people who are not specialists on the subject. A Completion Report is typically in the range of 5–10 pages, but may be longer or shorter, depending on the complexity of the project.

GMF grant recipients must enclose **final** copies of the Completion Report and the Final Deliverable with their final Request for Contribution. The reports, including all attachments and appendices, must be submitted in PDF format with searchable text functionality. Reports that are not clearly identifiable as final reports, such as those displaying headers, footers, titles or watermarks containing terms like "draft" or "for internal use only," will not be accepted by GMF. Additionally, reports must be dated. If you have questions about completing this report, please consult GMF staff.

GMF number	16726
Name of lead applicant (municipality or other partner)	City of Waterloo
Name, title, full address, phone, fax and e-mail address of lead technical contact for this study	Jessica Kellerman, Manager – Stormwater Operations and Construction - Integrated Planning and Public Works, City of Waterloo, Address: 265 Lexington Court PO Box 337 Station Waterloo, Waterloo, On N2J 4A8, Phone: 1 519 886 2310 Ext 30282, Fax: 1 519 886 5788 Email: Jessica.kellerman@waterloo.ca
Date of the report	November 15th, 2021

1. Introduction

a) Who was involved in doing the Feasibility Study, and what are their affiliations? Please include name, title and contact information. Those involved could include municipal staff, engineers and other consultants, a representative from a non-governmental organization, and others.

City of Waterloo: Jessica Kellerman, Manager – Stormwater Operations and Construction - Integrated Planning and Public Works, Jessica.kellerman@waterloo.ca

Greenland Consulting Engineers: Trevor Boston, Project Manager, tboston@grnland.com

2. The Feasibility Study

a) Describe the process that you undertook to make this feasibility study a reality, from concept, to council approval, to RFP, to final deliverable.
This feasibility study consisted of 6 phases:

Phase 1 – Acquisition and Processing of Existing Relevant Data
This phase included start up meetings, data requests, acquisitions, and analysis, study scoping where 4 priority SWMFs were chosen from 10 relevant Stormwater Management Facilities (SWMFs), literature reviews to find Provincial Water Quality Monitoring Network stations, etc., and SWMF drainage area delineation from the City's Stormwater Management Model.

Phase 2 – Field Investigation Program
The monitoring program set up, implementation, and analysis was the focus of this phase. Grab samples and continuous monitoring stations were strategically placed in locations within the 4 short-listed SWMFs. Grab sample analysis comprised of two (2) phases, including samples submitted to a laboratory for analysis, as well as a field and in-house analysis component. A total of 18 of grab sample rounds were completed at each of the four (4) selected SWMFs and analyzed. Significant precipitation and snow melt runoff events were targeted. Continuous flow and conductivity monitoring stations were also installed in the permanent pools and primary outlet points of each SWMF (excluding SWMF 5). These stations included both pressure transducers (Levelogger® Edge Water Level Dataloggers) to record changes in water level and temperature, as well as conductivity transducers (HOBO® Fresh Water Conductivity Data Logger) to record both conductivity and temperature. All data was continuously captured at 15-minute timestep intervals. Continuous Monitoring Stations were initially installed on September 6th, 2020, and periodic check-ups occurred to ensure continual functionality.

Phase 3 – Interpretation and Use of Integrated Surface / Groundwater Model Results
University of Guelph focused Phase 3 on model building and adapting software code for simulation of salt. The model aligned with locations and drainage areas from the City's stormwater model catchment and conduit data. GIS and other data sets were used. Ongoing communication with the University Research Team with monitoring results analysis and surface model validation continued throughout the study. The Region provided grided outputs from the Regional Groundwater Model that identified contributing areas for well head protection areas within the model boundaries and associated travel times between contributing areas and receptors.

Phase 4 – Feasibility Analysis
Phase 4 included extensive literature review on alternative solutions for winter road maintenance. Greenland interpreted data from pressure transducers, sensors, and grab samples data. Loading of chloride to SWMF was determined as the product of concentration and flow of storm water into each facility. Assessing the difference in chloride load entering and leaving the SWMFs determined the load stored in the facility that is available for infiltration through the bottom of the pond. Level measurements during periods of time with limited inflow / outflow were used to evaluate rate of infiltration. The Regional Groundwater Model identified that SWMF 17 is the facility with the highest likelihood of surface / groundwater connectivity. This, coupled with its high chloride loading from adjacent parking lots, identifies it as the priority SWMF for mitigation efforts.

Cost and benefit analysis investigated mitigation cost or use of alternative means of managing winter road ice conditions. It also considered the benefit associated with avoiding the future cost of using expensive reverse osmosis technology if chloride concentrations continue to rise in source water.

Phase 5 – Consideration of Potential Alternatives to Mitigate Road Salt impacts
Phase 5 consists of Literature Review including a focus on SWMF retrofit opportunities, Best Management Practices, Variable Salt Rate Application Technologies, Road Salt Substitutes, and Structural Alternatives. This phase developed a conceptual solution for capture and reclamation of runoff water exhibiting high concentrations of chloride. The design features use of sensors, conduits, pumps and a containment tank to divert highly concentrated runoff from infiltrating through the bottom of the SWMF or being discharged to surface water. Further, the diverted, high salt concentration water would be reused by a road pre-treatment program where brine is sprayed on roads and parking lots in advance of storm events to reduce the amount of rock salt that needs to be applied. The approach is proposed as a pilot for further study and possible scale-up in the future if successful. It would create a partial closed loop for salt application.

Phase 6 – Approval
The final step of the feasibility study saw the development of a report detailing the data analysis and conceptual design and costing analysis for the mitigation concept. The approach was presented to the City.

b) What were the objectives of the Feasibility Study (what was it seeking to determine)?
Produce a mass balance analysis identifying chloride loading and transport for four SWMFs in the study area. Quantify impacts of road salt use to groundwater through modelling and monitoring. Provide recommendations to reducing chloride concentrations and loading to groundwater with cost/benefits and technical feasibility that show both environmental and economic advantages.

c) What approach (or methodology) was used in the Feasibility Study to meet these objectives?
This study used both primary and secondary research including in-field grab samples and continuous monitoring to collect water quality data and dataset analysis and literature review, respectively.

The feasibility of the mitigation concept was presented as a comparative analysis against the cost of "doing nothing" until the City is forced to treat or replace the water supply.

It looked at the potential cost savings and environmental benefits of adopting brine pre-treatment of roads and parking lots and recovering a portion of applied salt in melt runoff.

d) Please describe any public consultations conducted as part of the Feasibility Study and their impact on the Study.

Public consultation was not a part of the study; however, the Region of Waterloo and researchers at the University of Guelph were engaged by the project team to provide insight.

3. Feasibility Study Findings and Recommendations

a) What were the environmental findings related to the options explored in the Feasibility Study? Please provide quantitative results and summary tables of these results (or the page numbers from the Feasibility Study report).
The findings from this study indicated that there are increasing chloride concentrations in groundwater resulting from high loading rates of road salt for winter maintenance. Road salting can produce salinity levels that are toxic to aquatic species at both short term and long-term exposure levels. They also threaten the integrity of critical aquifers and drinking water supplies. The Drinking Water Quality threshold limit for chloride of 250 mg/L has been exceeded at the William Street Pumping Station (the focus receptor in the study) and the trend appears to be toward increasing concentrations without further intervention.

b) What were the financial findings related to the options explored in the Feasibility Study (for example, results of a cost-benefit analysis, financial savings identified, and so on)? Please provide quantitative results and summary tables of these results (or the page numbers from the Feasibility Study report).
The financial findings suggest that prevention of increasing levels of chloride is the better alternative compared to advanced water treatment requirements in the future. Reducing the quantity of chloride entering the groundwater by improving management of winter road maintenance and road salt spreading and improving collection ability of SWMF, specifically SWMF in wellhead protection areas, is less expensive than constructing and operating a more advanced water treatment facility using R.O. technology. Based on the results of this analysis, the proposed 2-part mitigation strategies could save an average of $15,235 per tonne of chloride removed/year in capital and operational costs and would reduce chloride loading to groundwater by 70.5 tonnes per year.

c) Based on the environmental and financial findings above, what does the Feasibility Study recommend?
This feasibility study recommends the City of Waterloo attempt to achieve the target water quality objective of 250 mg/L through the following means:

- Strategically using alternatives to road salt such as sand or sand / salt mixes where feasible;
- Significantly reducing overall annual salt applications;
- More efficient applications via:
    - optimized timing of application,
    - pre-treatment using brine,
    - increased level of adherence to asphalt,
    - optimized application rate for conditions;
- Improved training for municipal operators;
- Bringing private property owners, insurance companies, contractors and the public on-side with better understanding of the implications of excessive release of salt to environmental receptors;
- Enabling further investigation, research and development into a partially closed loop system that would divert and reclaim brine from catch basins and permanent pool stratified layer and allow it to be used in pre-treatment of roads.

A semi-closed loop, brine collection and reuse system on SWMF 17, the facility found to contribute the highest chloride load to groundwater, is a recommended pilot project. From the parking lot located in the immediate upstream drainage area, an annual chloride load reduction between 0.9 and 3.8 tonnes, dependant on the finalized design (target loads), could be achieved.

The City / Region should consider a more rigid accounting system for road salt use that captures usage by the City and its contractors, private institutional / commercial property owners and their contractors and private residents including retail sale of de-icing products. Knowledge of application rates by public and private practices is the first step to develop programs to educate operators and the general public on salt usage, improve City / Region operator compliance and develop detailed programs on further reducing road salt usage.

A strict quota system that rewards more efficient use and holds accountable road salt misuse needs to be enacted as part of a City or Region-wide plan. In more rural parts of the Region of Waterloo, strategic use of wind breaks to block wind-driven snow from accumulating on roads should be implemented through incentivizing and working with land owners. Higher prices and public warnings about the impacts of salt in the environment and to drinking water need to be used to communicate potential impacts.

4. Lead Applicant's Next Steps

a) Taking the Feasibility Study's recommendations into account, what next steps do you as the municipality plan to take? What potential benefits or internal municipal improvements would result from these next steps?
The City of Waterloo intends to evaluate our salting practices and go back to the broader source water protection working group (made up of local municipalities/townships and the Region) to provide guidance for future evaluation and breakdown our results. The City will also aim to collaborate with the University of Waterloo and the Region to obtain further grant funding to complete the recommended pilot study at Pond 17.

5. Lessons Learned

In answering the questions in this section, please consider all aspects of undertaking the Study — from the initial planning through each essential task until the Final Study was prepared.

a) What would you recommend to other municipalities interested in doing a similar Feasibility Study? What would you do differently if you were to do this again?

Mass balance load analysis of chloride to SWMFs is important in helping to quantify costs, savings and impacts. Unfortunately, winter monitoring of runoff flows and concentrations entering and leaving SWMFs is very challenging without damage to equipment. Data can be easily fouled by ice accumulation and other complications that make interpretation challenging.

Keep an open mind when considering alternatives to conventional use of road salt.

b) What barriers or challenges (if any) did you encounter in doing this Feasibility Study? How did you overcome them?
Various challenges include:
- lack of direct access to the Regional Groundwater Model – model outputs received provided sufficient results for chloride loading validation
- Interpretation of technical/operation as-builts of the SWMFs and the hydraulics and hydrology of facilities and contributing areas.
- Data management must be carefully executed with extreme consistency and forward planning.
- The nature of winter monitoring resulting in ice buildup that required complex data correction.

- Lack of information regarding current road salt/winter maintenance operations and loading rates in the study area was a significant issue – extensive literature review provided some level of understanding and likely usage rates but are a poor substitute for actual data.

6. Knowledge Sharing

a) Is there a website where more information about the Feasibility Study can be found? If so, please provide the relevant URL.
There is no website for this study.

b) In addition to the Feasibility Study results, has your Feasibility Study led to other activities that could be of interest to another municipality (for example, a new policy for sustainable community development, a series of model by-laws, the design of a new operating practice, a manual on public consultation or a measurement tool to assess progress in moving toward greater sustainability)? If so, please list these outcomes, and include copies of the relevant documents (or website links).

We will be developing documents and updating the draft guidance manual for evaluation of risk with the source water protection working group. This will come in the future once we've agreed to a uniform approach to evaluating the risk of our facilities within the high risk source water protection areas. This feasibility study will provide the framework for updating the guidance manual.

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