Lake Simcoe Region Conservation Authority

Stormwater Inspection and Record Management Best Practices, Data Model Design, and Comprehensive Report

GHD | 6705 Millcreek Drive, Mississauga, Ontario, L5N 5M4

11115969| 458 | Report No. 1 | February 2017

Table of Contents

Figure Index

Table Index

Appendix Index

1. Introduction

Phosphorus is an ongoing and complicated issue within many watersheds including the Lake Simcoe watershed. Within the Lake Simcoe watershed urban stormwater represents an estimated 31% of the phosphorus entering Lake Simcoe. Managing and ultimately reducing phosphorus within the Lake Simcoe watershed is a priority for the Lake Simcoe Region Conservation Authority (LSRCA) and the Ministry of Environment and Climate Change (MOECC).

Since the late 1990's developers have been mandated to construct stormwater management (SWM) end-of-pipe facilities within new developments. More recently, Low Impact Development (LID) features, defined as 'at-source' lot-level and/or conveyance control, are starting to be incorporated into both new and retrofit land development projects. SWM works perform a critical role in contributing to the overall health of the stormwater flowing throughout a watershed, since most SWM features (i.e. lot-level, conveyance, end-of-pipe facilities) are designed to provide a level of quantity and quality control. However, implementing and adhering to regular intervals of inspection, and executing necessary maintenance when required, are essential for a SWM feature to function as efficiently as possible.

In addition to owning and operating the SWM features within their boundaries, municipalities are obligated to ensure the ponds are inspected, maintained, and that important inspection/maintenance records are preserved effectively. If operated and maintained successfully, SWM facilities may aid to effectively reduce total phosphorus.

LSRCA received a grant from the MOECC to conduct a study and investigate ways of improving the ability of municipalities to adopt best practices for SWM works inspection, maintenance, and record keeping. In order to achieve this objective, the following tasks were undertaken:

a. A current practice review was completed to determine the management of SWM works within each participating municipality, which included an investigation of the frequency of inspection, maintenance completed, and an assessment of the current record keeping practices.

b. A stakeholder workshop was hosted to present the findings from the current practice review, and to discuss possible solutions and alternatives for municipalities to overcome barriers towards adopting best published practices.

c. A second stakeholder workshop was hosted to discuss a data model needs analysis. Topics during this session encompassed how a GIS data model can support SWM works and its associated data, and a review of existing databases, software and data models currently implemented by municipalities within the Lake Simcoe watershed.

d. A draft data model was developed to standardize the data collection process for the municipalities within the Lake Simcoe watershed. The data model's purpose will organize available and future information (inspection and maintenance activities) pertaining to SWM works. A third stakeholder workshop was hosted to review the data model and obtain feedback from participating municipalities.

2. Current Practice Review

2.1 Methodology

A review of current practices of municipalities owning/operating SWM features within the Lake Simcoe watershed was conducted regarding SWM works site inspection, and the record management of SWM works inspection, operation, and legislative compliance. Seventeen municipalities were contacted, and a request was made to receive all pertinent documentation (including SWM operation and maintenance practices and SWM record management practices) by Monday, September 12, 2016.

In addition, confidential in-person interviews with five selected municipalities were requested and coordinated to take place between Monday, August 22, 2016 and Friday, September 16, 2016. Representatives from three municipal departments were asked to be present at the meeting (if applicable): SWM engineering, SWM operation and maintenance, and GIS. The interviews were approximately 1.5 to 2 hours long. The interviews were conducted with staff that were identified by each municipality as being the most knowledgeable with respect to management of SWM infrastructure and record keeping practices. The following topics were discussed:

- An overview of the project's goals and objectives, and
- A review of published SWM and LID best management practices as identified by LSRCA:
    - SWM Facilities Inspection, Operation and Maintenance Guidance (TRCA, June 2016): http://www.sustainabletechnologies.ca/wp/home/urban-runoff-green-infrastructure/conventional-stormwater-management/stormwater-management-ponds/swmf-im-guide-2015/
    - Low Impact Development Inspection, Operation and Maintenance Guidance (TRCA, June 2016): http://www.sustainabletechnologies.ca/wp/home/urban-runoff-green-infrastructure/low-impact-development/low-impact-development-stormwater-practice-inspection-and-maintenance-guide/

An interview-style 'Question and Answer' session was conducted with each staff representative. Questions were asked in the hopes of gaining a better understanding of the following:

- Current practices in SWM works inspection and operation, maintenance and monitoring (OM&M) taking place within the municipality;
- Current record keeping practices of SWM works inspection, operation and legislative compliance; and,
- Challenges a municipality faces with regards to SWM works inspection and maintenance, and record management practices, and identification of barriers to adoption of best published practices.

It was noted during each municipality interview that it was not the intention of LSRCA to single out any municipality, nor to provide specific guidance on the management of SWM infrastructure. As mentioned above, the goal of the project is to obtain an overall understanding of the spectrum of inspection, monitoring, maintenance and record management being conducted within the Lake

Simcoe Watershed and York Region, and to prepare a generic list of barriers that municipalities encounter in adopting (or attempting to adopt) best practices. A meeting agenda and interview meeting summary were issued accordingly.

Once all data was collected from participating municipalities, an assessment of the differences between current SWM works inspection and published best practices were completed and analyzed (as discussed below).

The information gathered from the participating municipalities was used anonymously in preparation for a stakeholder workshop scheduled for Wednesday, October 12, 2016. Lake Simcoe watershed and York Region municipal SWM/Engineering staff were invited to participate during this session. For more information regarding the workshop, please refer to **Section 3.0 – Current Practice Review – Stakeholder Workshop.**

2.2 Analysis of Results

The analysis of results included a summary of the email responses received and interviews conducted in table format, a comparison of current practices to best management practices, and an identification of the barriers to the adaptation of best management practices.

At the time of analysis, LID inspection and OM&M works were non-existent for all participating Lake Simcoe watershed and/or York Region municipalities. The majority of LIDs found within municipalities were either under construction, or were constructed only one to three years ago and have not yet undergone a complete inspection. Furthermore, municipalities had not yet examined nor designed a program on how to inspect, operate and maintain the newly constructed LIDs. Therefore, this section focuses on the inspection and OM&M of SWM facilities and Oil and Grit Separators (OGS) only.

2.2.1 Response Received

In summary, email responses from nine municipalities were received and five in-person interviews were conducted. The name of the municipality and date the response was received, or the date the interview was conducted, are summarized in **Table 1**.

Table 1: Response from Lake Simcoe watershed and/or York Region Municipalities

Municipality	Date Response Received/ Interview Conducted (2016)
Aurora	Aug 16th
East Gwillimbury	Aug 23rd
Bradford West Gwillimbury	Aug 23rd
Markham	Sept 2nd
Newmarket	Sept 6th
Innisfil	Sept 7th
Georgina	Sept 9th
Brock	Sept 12th

Municipality	Date Response Received/ Interview Conducted (2016)

Information was received from fourteen of the seventeen municipalities, representing a response rate of 82%. Comprehensive feedback was received from the participating municipalities, thus allowing a successful compilation of current municipal SWM works inspection, OM&M and record keeping practices.

The email responses and attachments received are provided in **Appendix A-1**. The interview meeting summaries are provided in **Appendix A-2**. Any supplementary materials provided by the municipalities during the interviews are listed in the interview meeting summaries in **Appendix A-2** and provided separately in **Appendix A-3**. Due to the anonymous nature of the final report, it is anticipated that **Appendix A-1** and **Appendix A-3** will only be provided for the purposes of client understanding and review, and will not be made available to stakeholders and the public. Summary of findings from **Appendix A-1**, **A-2** and **A-3** are provided below.

2.2.2 Summary of Findings

Table 2 provides an anonymous summary of current SWM inspection, OM&M and record management practices from the 14 municipalities who provided email responses or participated in interviews.

As summarized in **Table 2**, most municipalities have, at minimum, a rudimentary SWM works inspection and OM&M program (hereon referred to as “the program”) in place. It appears that most programs were implemented after, and subsequent to, the publication of the Lake Simcoe Phosphorus Reduction Strategy (June 2010).

Most municipalities are also utilizing comprehensive SWM facility inspection forms that measure the water level and sediment depth of the permanent pool and forebay, examine structural components (e.g. inlet, outlet, outflow swale and emergency spillway), vegetation (e.g. aquatic, shoreline and surrounding trees/shrubs, etc.), and the overall condition of the facility.

The completion of inspection leads to minor repairs such as structural repairs, clean-out of the inlet/outlet structure and removal of vegetation. Inspection also uncovers major repairs required, such as sediment dredging, excavation, testing, hauling and disposal of sediment, and major earthworks.

As summarized in **Table 2**, record management practices of SWM works inspection and OM&M practices are part of both electronic and hardcopy filing within all but two municipalities.

Table 2 also indicates that municipalities with comprehensive inspection forms do typically perform minor repairs. However, they do not always perform major repairs that may be required due to barriers discussed later in this section.

The interview responses demonstrated that typically, municipalities do not assume and do not inspect privately owned facilities. However, municipalities can legally request the private owner to properly operate and maintain their facility. This request is rare however, since most municipalities view private facilities as "hands-off" and assumes the private owner will adhere to their responsibility for SWM works inspection and OM&M. Municipalities can influence the private property owner to upgrade or perform major repairs on their SWM works when approving re-development applications, as verified by one municipality interviewed.

As noted with anonymous Municipality No. 14 in **Table 2**, there is only one municipality who has assumed a few privately owned facilities through special legal agreements/arrangements with the developer. In this particular case, a portion of public lands are also draining to the assumed, private SWM facility. Private assumption by the municipality may be agreed upon during the planning and development stage and via negotiations with the developer. However, the majority of privately owned SWM works are not inspected and/or assumed within this one specific municipality. In addition, this municipality's operation and maintenance team does not have any information on the majority of their unassumed privately owned SWM works.

There are several other instances of why a municipality may assume a private SWM facility. Two examples occur in Oakville. The first instance is located near the intersection of Appleby Line and Dundas Street. A commercial complex was developed prior to the surrounding residential lands. Due to the early construction timeline demanded by the commercial client, the developer was required by the Town to build a SWM facility to control the stormwater within the area. The client was then expected to manage the SWM works until the surrounding residential lands were built and assumed by the Town (which at the time, the Town then assumed control of the SWM facility as well).

The second instance is located near Dundas Street and Third Line. A hospital was built near this intersection and a SWM facility was constructed to the east of the hospital lands. The SWM facility is currently managed by the Province but in time, after residential homes are built and assumed, this SWM works will transfer under the Town's responsibility.

The final instance is located at Bell Canada's head office, located on Eglington Avenue East in Mississauga. There is a private SWM located within Bell's property limits however the City of Mississauga has an easement over this facility, in the event of an emergency that requires City involvement. The SWM work does serve a large drainage area and it is not readily known why the City did not take ownership of the SWM work.

It should be noted that almost all municipalities have contractors that inspect and clean-out oil and grit separators on an annual basis and as such this information is not included in **Table 2**.

Table 2: Summary of findings of current practice review

No.	Total numberof Town owned SWM facilities / Oil Grit Separators	SWM Ponds inspected?	Year SWM Ponds Inspected Commenced?	Comprehensive Inspection Form?	Minor repairs completed?	Major repairs completed?	SWM works inspection,OM&M additional key comments.	Guidance	Record Management	SWM works inspection currentlypart of GIS?	Privately owned SWM facilities assumed?	Privately owned SWM facilities inspected?
1	52	Yes, twice a year Spring (May) and Fall(October)	Spring 2016	Yes	Yes	No		Internal inspectionforms	SWM reports - engineering department. Design drawings - scannedinto drawings database. Maximo (Work and Assessment Management Software) - includes SWM work orders with inspection forms	No, but plan to useGIS for this in the future.	No	No
2,3	Predominantly rural communities. Appears urban SWM work inspection and OM&M non-existent at this time.							Not provided	Not provided	Not provided	Not provided	Not provided
4	26 / 3	No	Not applicable. No regular SWM works, inspection and OM&M program in place.	No	No	No		Not applicable. No regular SWM works, inspection and OM&M program in place.	Daily logbooks and hardcopy filing of workorders	No	No	No
5	18 / 2	Annual inspections from 2016	2012	Yes	Yes	No	Major repairs to be carried out in the near future as per SWMMaster Plan - Part 1.	SWM Master Plan	Hardcopy filing of inspection forms	No	Not provided	Not provided
6	92 / 46	Yes, once a year. Fall	Fall/winter 2015	Yes	Yes	Yes	Two to three SWM pond cleanouts targeted each year.Sometimes, SWM pond is retrofitted instead of a clean- out as facility condition is unacceptable.	ECA or C of A.2003 MOE Stormwater Manual. SWM engineering report operation and maintenance manuals(where available).	Digital copies of all workscompleted	Yes - partially. Includes photos (green stars) and repairs required as a result of inspection (red dots).	Not provided	Not provided
7	6 / 2	Yes, once a year	Year inspections commenced was not provided.	Not provided	Yes	Not clear		ECA or C of A. Internal Environmental Services Policy. Inspections Processes.	Digital copies of all workscompleted	No	Not provided	Not provided
8	75 / 83	Yes, twice a year	Year inspections commenced was not provided.	Not provided	Yes	Yes	Municipality has a unique program and as such is further elaborated: 10 Year Capital Plan for rehabilitationof SWM facilities. Continuous water level monitoring of wet SWM facilities (May-Oct). WaterQuality Sampling (TSS) at selected SWM facilities. Sediment surveys.	Not provided	Not provided	Not provided	Not provided	Not provided

No.	Total number of Town owned SWM facilities / Oil Grit Separators	SWM Ponds inspected?	Year SWM Ponds Inspected Commenced?	Comprehensive Inspection Form?	Minor repairs completed?	Major repairs completed?	SWM works inspection, OM&M additional key comments.	Guidance	Record Management	SWM works inspection currently part of GIS?	Privately owned SWM facilities assumed?	Privately owned SWM facilities inspected?
9	Not provided.	Yes, retains consultant to inspect anywhere from 12 to 22 SWM facilities in 2012, 2015 and 2016.	2012	Yes	Yes	Yes		Consultant reports	Consultant reports – hardcopy filing	No	Not provided	Not provided
10	59 / 7 and 1 LID	Yes, once a year	Year inspections commenced was not provided.	Yes	Yes	Not clear		ECA or C of A. Standard Operating Procedures	Electronic and hardcopy filing of all works completed	Yes - partially. Computerized work order system for operations staff.	Not provided	Not provided
11	10 / 3	Yes, once a year	2016	Yes	Yes	No	Planning to complete major repairs as part of a five year plan initiated in 2016. Also planning to collaborate with MOECC to upgrade or make new ECAs for SWM facilities where none exist.	ECA or C of A	Electronic and hardcopy filing of all works completed	No	No	No
12	55 / 11	Yes, once every two years	2012	Yes, retains consultant	Yes	Only once		Consultant reports	Consultant reports - hardcopy filing	No	No	No
13	16 / 18	Yes, once a year	Year inspections commenced not available.	Yes	No	No		SWM Master Plan	Electronic and hardcopy filing of all works completed	No	No	No
14	93 / 58 and 2 LIDs	Yes, at a minimum once a year. More than once a year if ECA or C of A requires.	2012	Yes	Yes	Yes	Four SWM pond cleanouts targeted each year (permanent pool and forebay)	MOECC will issue an overriding ECA for all municipal SWM works inspection and OM&M by the end of 2016.	Daily logbooks and hardcopy filing of work orders	No	Yes – only a few. Majority – not assumed.	Assumed SWM facilities are inspected.

Figure 1 provides notable deviations of current practices from best published SWM OM&M practices based on municipality responses received and interviews conducted.

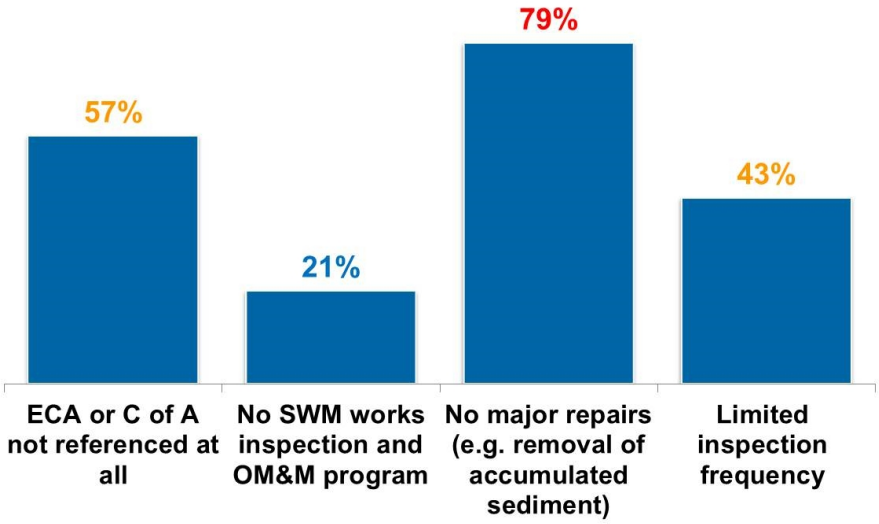


Figure 1: Notable deviations from best published SWM OM&M practices

As shown on **Figure 1**, the greatest deviation from best published practices is that of major repairs (i.e. removal of accumulated sediment) not being completed. Approximately 79% of municipalities have not removed accumulated sediment from SWM facilities at this time. Only three municipalities regularly remove accumulated sediment; however, these municipalities also have the largest number of town-owned works (ranging from 75 to 93 SWM facilities and are situated on a larger urban footprint). The frequency of accumulated sediment removal ranges from two to four SWM facilities a year and includes the permanent pool and forebay. Two additional municipalities have identified a plan to remove accumulated sediment in the near future; however, these municipalities have a small number of town-owned works (ranging from 10 to 18 SWM facilities and are situated on a smaller, but rapidly expanding urban footprint). Please refer to a summary of this information provided in **Table 2**.

Another notable deviation occurs when an ECA (Environmental Compliance Approval) for a SWM facility is not available or does not include referenced supporting document for compliance of inspection and OM&M practices.

It should be noted that an ECA was formerly known and issued as a C of A (Certificate of Approval), before the Ministry of Environment and Climate Change (MOECC) initiated a modernization of their approval process for air, waste, sewage (SWM) works, which was formally adopted on October 31, 2011. As part of this modernization effort, any C of A issued is still active and may also be considered to be an ECA.

There are two notable methods to search for ECA (formerly referred to as C of A) information for a site:

1. Search for Environmental Compliance Approvals, along with other environmental approvals, using Access Environment (https://www.ontario.ca/page/list-environmental-approvals-and-registrations).
2. Submit a Request for a Copy of an Environmental Compliance Approval if you need a signed copy of an ECA, or a copy of an ECA issued before January 1, 2000. The website to submit this request is: http://www.forms.ssb.gov.on.ca/mbs/ssb/forms/ssbforms.nsf/FormDetail?OpenForm&ACT=RDR&TAB=PROFILE&SRCH=&ENV=WWE&TIT=2128&NO=012-2128E.

The MOECC has formulated an innovative, 'system-wide ECA' approach for municipalities to more effectively manage the entire municipal SWM System owned and operated by the municipality, by issuing one overriding ECA. This one ECA describes the SWM system and sets a level of water quality control for erosion protection and water quantity control only. It does not cover municipally-owned sanitary sewage collection system nor the Wastewater Treatment Facility are covered under separate Approvals.

This overriding ECA is designed to better support the following:

- compliance reviews for SWM facilities;
- adherence to maintenance, inspection and operational procedures; and
- new requirements for ECAs in the Lake Simcoe watershed addressing level of water quality monitoring, where stipulated.

Current best practices require inspection after every major rainfall event (greater than 25 mm) or at least four times a year. **Figure 2** illustrates the frequency of inspection for all fourteen municipalities. Most municipalities complete annual inspections or inspections once every two or three years. Only two municipalities inspect twice a year (May and October).

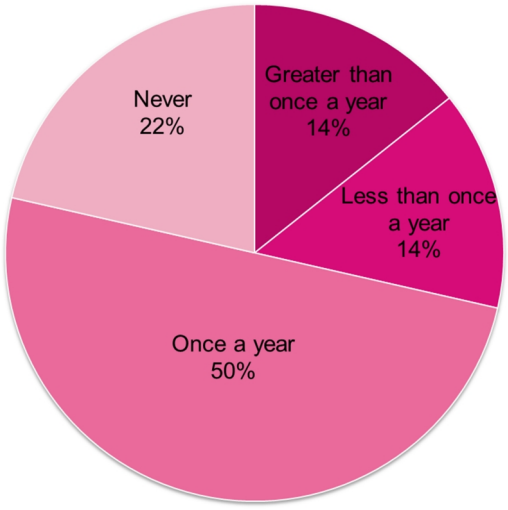


Figure 2: Frequency of SWM works inspections

In addition, a few municipalities have no SWM works inspection or OM&M program in place and as a result, there are likely no inspections or even minor repairs completed at the SWM facilities.

Figure 3 illustrates the barriers to adoption of best published practices as identified by municipalities.

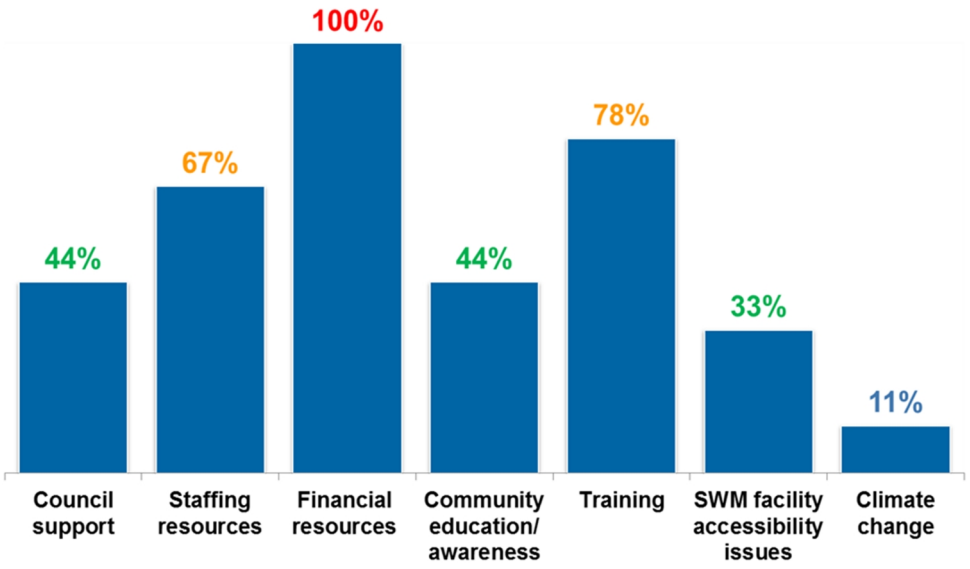


Figure 3: Barriers to adoption of best published practices identified by municipalities

As shown in **Figure 3**, the greatest barrier to adopting best published practices is limited financial resources. Most often the restricted allocation of funds is primarily due to the lack of political will and lack of support from the community at large to prioritize the adoption of best published practices. Sometimes other municipal initiatives are perceived more important than SWM works inspection and OM&M.

The second greatest barrier to adopting best published practices is training. While inspections are typically carried out once a year for most municipalities, often times the inspector is a summer student with inadequate training. In addition, the majority of municipal staff have articulated they are not properly trained themselves and an appropriate training course is currently not available.

The third greatest barrier is staffing resources. This barrier ties back, and is linked to, limited financial resources and political support in order to acquire the necessary staff.

Political support and community education/awareness was identified as the fourth and fifth greatest barriers to adoption of best published practices. As mentioned earlier, financial resources, political support, and community education/awareness barriers are highly interlinked. For example, awareness within the community can prompt political support, which can lead to the availability of financial resources for SWM works inspection and OM&M. Staffing resources, training and SWM facility accessibility issues (discussed below) can only be addressed when financial resources are available.

Furthermore, the participating municipalities recommended political support for implementation of innovative SWM works demonstration projects in high traffic areas in order to enhance community education and awareness on SWM issues.

It also appears that some SWM features do not have a maintenance/access road or sediment storage/drying areas which are desired features when undertaking major repairs. In turn, some SWM works would require retrofits to their existing SWM features in order to obtain proper access. Furthermore, during the SWM facility approvals process, a municipality should ensure that the SWM facility design includes access required for SWM facility minor and major repairs.

In summary, the majority of municipalities have, at minimum, a SWM works inspection and OM&M program in place with a comprehensive inspection form and do complete minor repairs. The quality of the inspections may be undermined due to inadequate training. In addition, 79% of municipalities are not removing accumulated sediment as per best published practices due to, primarily, lack of financial resources (interlinked with political support and community education/awareness), limited staffing resources, and pond accessibility.

3. Current Practice Review – Stakeholder Workshop # 1

3.1 Introduction

Municipalities within the Lake Simcoe Watershed were invited to a half-day stakeholder workshop held on October 12, 2016. The intent of the workshop was to present the findings of the current practice review for SWM works inspection, OM&M, record management, and obtain feedback to overcome barriers to the adoption of best published practices. Representatives from the municipalities of Aurora, Barrie, Brock, Bradford West Gwillimbury, East Gwillimbury, Georgina, Innisfil, Kawartha Lakes, Markham, Newmarket, Orillia, Richmond Hill, Uxbridge, Vaughan, and Whitchurch-Stouffville were present at the workshop. The Regional Municipality of York, Seneca College, and MOECC (the project sponsor) also participated.

A presentation began the workshop, which included a brief introduction of the project's objective, a summary of published best practices, and a review of current practices (summary of findings, deviations from best published practices, and barriers to the adoption of best published practices). Immediately following the presentation, the stakeholders were divided into four groups to brainstorm potential solutions to the barriers for adopting best practices. A facilitator from the LSRCA was present within each group to help guide the discussion and record notes. At the completion of the break-out sessions, next steps of the project, including how the workshop's findings would be incorporated going forward, were discussed.

The summary of findings from the break-out sessions are discussed in the next section.

3.2 Summary of Findings – Workshop # 1

During the break-out sessions, each of the four groups was provided various scenarios and suggestions to brainstorm and comment on. The feedback received from the stakeholders was

documented by the facilitator at each table and is provided as part of **Appendix B**. A concise summary of findings for each break-out session is presented in **Tables 3 – 8**.

Table 3 summarizes feedback to overcome budgetary constraints for a SWM facility clean-out within five years. **Table 4** summarizes feedback to overcome significant workload challenges related to transferring paper/electronic records to GIS. **Tables 5** and **6** summarize feedback to gain political support, and to gain public support respectively. **Tables 7** and **8** summarize feedback to overcome barriers related to sufficient training and understanding of the necessary tasks related to OM&M, and regarding SWM facility accessibility respectively.

Table 3: Potential approaches to overcome budgetary constraints for SWM feature cleanout

Question Posed	Feedback Received
The municipality has a SWM feature that needs to be cleaned out (i.e. removal of sediment). However, there is no budget for this. Please brainstorm and provide ways in which the municipality may approach this problem so that it is resolved in the next five years?	**Initiative and planning:** • Integrate SWM into municipal asset management program • Pressure for political support to integrate SWM into operational budgets (education on SWM, from efficiencies obtained from elsewhere in the capital budget, etc.) • MOECC complaint driven inspections to generate initiative and necessary revenue • Consider additional cost of clean-out today versus clean-out five years from now and costs associated with flooding and other impacts (lifecycle cost analysis) • LSRCA to provide SWM inspections based on Service Level Agreements; will help municipalities reduce costs and manage liabilities **Sources of funding:** • Standardized SWM utility fee for urban areas (rural areas oppose this fee as they see little benefit for SWM) or SWM utility fees: neutral fees for residential, higher fees for commercial • Legal requirement: budget must be allocated in order to remain in compliance (refer to existing Drainage Act, R.S.O. 1990, which requires any drainage works (including SWM works) shall be maintained and repaired by the local municipality) • Developer fees implemented during the build-out stage within a municipality • Grants (CA, federal, provincial) if/when funding applications are available • Partial revenue from gas tax funding has helped to offset cost of feature clean-out (in Barrie and Vaughan)

Table 4: Potential solutions to overcome significant workload for transferring paper/electronic records to GIS

Question Posed	Feedback Received
Recordkeeping: Most municipalities rely on paper or electronic records, entering into GIS could be a significant workload. Please provide ways in which this issue can be successfully resolved?	**Establish a system first:** • Standardized checklist for recordkeeping to be created • Propose to government as a long-term initiative • Consider having a system developed with buy-in from departments involved. LSRCA and York Region to help build forms/apps as required **Transfer all data to GIS:** • Reduce cost by using summer students • Set standards for data entry and uphold to ensure accuracy of information • Transfer all hard copies to electronic database (i.e. scan to pdf) and then link to GIS **Continued use:** • Make it easy for the end user (i.e. phone app or tablet for GIS staff to upload inspections forms and for field staff to use for documenting) • Share resources across the watershed

Table 5: How to gain political support

Suggestions	Feedback Received
External support from LSRCA or MOECC for ongoing maintenance, including long-term cost savings if maintenance occurs.	Most participants leaned towards educational support, as opposed to maintenance support from LSRCA or MOECC, especially with respect to educating government. Not only a presentation (e.g. SWM 101), but also an in-field tour of several facility sites. Any education provided by LSRCA or MOECC needs to be relevant and have the ability to entice the right staff to participate. Training regarding LIDs is necessary.
MOECC to complete regular compliance checks.	Compliance checks occur, but not regularly. Most participants were in favor of regular compliance checks by MOECC. Regular compliance will force government to acknowledge the issue and understand the importance of regular inspection, and operation and maintenance of facilities. ECAs should stipulate the frequency of bathymetric surveys or depth measurements.
MOECC, Conservation Authority, municipal councilors, government officials, municipal staff and developers to work together	Most participants were in favor of this suggestion, but some participants do not want developers involved in the funding model discussion.

Suggestions	Feedback Received
to come up with a feasible financial funding model.	
System-wide ECA for all stormwater facilities within a municipality	Participants did not comment how this suggestion could help gain political support. There was confusion on what this suggestion meant and there was noted concern regarding how unique requirements for different facilities may be lost with one overriding ECA. It was suggested one system-wide ECA for all LIDs within a municipality should be investigated further.
Other. Please describe.	It was further reiterated municipal government requires education on SWM works function, impacts related to flooding and safety issues, and funding approaches. Legal liability and a discussion of repercussions associated with regular inspection and maintenance or the lack thereof should be brought forward to government. With the current funding constraints all municipalities are facing, it is very difficult, if not impossible, to meet the approval of both MOECC SWM requirements and Lake Simcoe Protection Plan. Community driven initiatives and complaints will force government to take action.

Table 6: How to gain public support

Suggestions	Feedback Received
Enhanced signage/ educational boards – explaining Stormwater Management (SWM) facility purpose and function.	This was accepted to be a good idea. However, access to most SWM facilities is limited and newer ECAs require facilities to be surrounded by natural habitat. Oftentimes facilities are not situated in public access areas. If they are, having a trail system nearby provides a good opportunity. Interpretive panels and permanent signage were noted. This information should also be posted within municipal council chambers and municipal offices.
High profile stormwater clean outs as demonstration projects, to help the public understand that ponds are infrastructure (not habitat).	Most participants were in favour of this. However it is important to be sensitive to the public perception of this action. It was also noted not to call the facilities “ponds” as that leads to public/government misconceptions of intended mandate and use. It would be useful to have resources (i.e. door-to-door flyers, signage, newspaper advertisement, etc.) developed and shared amongst municipalities.
Flyers to homes for better awareness of related issues (i.e. rainwater harvesting cisterns and discounts available).	Half of the participants did not see value in this suggestion. Half of the participants suggested flyers to be distributed only to landowners immediately adjacent to the SWM facility, or advertising of SWM initiatives within the annually-distributed municipal waste management calendar.
Articles in the local	A brief video (1-2 minutes) was suggested.

Suggestions	Feedback Received
newspaper and/or municipal websites during earth week, or during clean-outs	Other participants indicated this initiative is already taking place within their municipality but seems to have limited positive or negative effect.
Education program for school children (through municipalities or LSRCA) about the importance of stormwater	Participants listed current initiatives/programs they are aware of (e.g. yellow fish road program, 'public works week' at schools) and are in favour of these programs continuing. School children take understanding/lessons learned home and educate parents.
Community events celebrating nature, rain, importance of SWMF and how this links back to flooding, water quality and health of communities (putting it into perspective).	Questions were raised by participants regarding whose responsibility it is to create and promote these types of community events. Many participants feel there is value in these events but funding and resources are required. Suggestions included Girl Guides and Scouts volunteering at community events and at Farmers' Market booths in order to educate SWM.
Other. Please describe.	Communication to the public/nearby residents during engineering design and planning stages. Municipalities, LSRCA, and developers should partner in developing communication/education materials.

Table 7: Sufficient training and understanding of the task

Suggestions	Feedback Received
On-site (field) training on an annual basis, for operators, designers, and reviewers/approvers on how to inspect stormwater facilities.	Training needs/requirements will vary based on role. Both formal training (of best practices and existing provincial/CA policies) and providing the necessary tools to implement the knowledge learned is key (i.e. inspection sheets). Training also has to ensure inspection form responses are consistent (e.g. 'good' vs 'repairs required') and to know the difference between each. One day training may not be sufficient to outline/teach inspection of SWM facilities. Low cost training a must. Training on one specific aspect on SWM facility inspection (i.e. vegetation management) could be completed in one day.
Summer students - either develop a train-the-trainers program, or develop a module that could be used in on the job training.	Some participants found these suggestions worked well for their municipality, while some participants found these suggestions did not work well (mainly because the level of expertise needed to complete all required inspection tasks takes years of experience, not 1 or 2 summers). It is noted periodic retraining is necessary.
On-site or in-class training on an annual basis, for operators, designers, and reviewers/approvers on how to inspect LID features	Most participants were in favour of this suggestion. It is noted there are many municipal staff who would likely require this training (operations, parks, and design staff). A strategy for private LIDs should be developed.
Workshops (perhaps through SWM Technical group) on the most up to date information on major repairs – i.e.	Most participants were in favour of this suggestion. Some participants noted they preferred this method of training instead of a 1 day training session.

Suggestions	Feedback Received
removal of accumulated sediment	Participants would like to review case studies presented by their peers.
Demonstration by a municipality that is removing accumulated sediment (either through SWM Technical group, or through a tour day)	Participants provided a wide-range of thoughts: this initiative does not provide value as only certain individuals have/require experience in the sediment removal process, only implement this suggestion if new technology is to be introduced (but should not be touted as a contractor advertisement), while other participants simply saw good value in this suggestion, and other participants did not provide any comments.
Accessibility of necessary documents: Operations and Maintenance Manual Environmental Compliance Approvals (ECAs) As-built drawings	Most participants saw value in this suggestion. Additional comments include: have the documentation easily accessible via organization's intranet (easy access), documents should be referred to during review process and before facilities are assumed, and documents are often only referred to after there's an issue on-site.
Other. Please describe.	Add a course to STEP Program related to facilities (similar to how bridges are inspected (every 2 years)). Experts from various disciplines to inspect SWM facilities every few years to ensure integrity of SWM facilities. O&M staff could complete visual inspections and technical inspections could be contracted out.

Table 8: SWM facility accessibility

Suggestions	Feedback Received
Improved communication protocol between operations team and approvals team during design and approval process for new SWM facilities.	Participants noted this suggestion is already implemented to some level. Planners and developers are being directed towards intensification of available land – drying blocks are no longer realistic for newly developed facilities. Alternative solutions need to be considered. Access roads are required and should be incorporated in any new development. Most recently developed features are surrounded by trees, which may cause an access issue during inspection and maintenance.
MOECC Approvals branch to make sure new SWM facility designs comply with SWM facility best published practices (**Section 2.0**); so this does not become an issue for future SWM facilities.	Some participants agreed with this suggestion, while others did not comment at all, or commented compliance was not a major issue to be further addressed at this time.
The SWM features should be retrofitted when it is time for a major sediment clean-out.	Most participants did not comment on this suggestion. Some participants view this suggestion as an aspirational goal: a risk assessment would be required, and the decision

Suggestions	Feedback Received
Financial support may available for retrofits.	would likely be determined by how much value is obtained from carrying out this suggestion.
Other. Please describe.	Access roads may double as walking trails, which will allow parks staff easier access to features. Another suggestion is to use municipal sidewalk inspectors to perform minor inspections.

4. Data Model Design – Stakeholder Workshops # 2 and # 3

4.1 Introduction

An enhanced understanding of current SWM/LID practices, the associated barriers to best practice adoption, and potential solutions to overcome the cited barriers within the municipalities of the Lake Simcoe Watershed allowed the project to move into the next phase of the project: data model design. This component of the project was divided into two stages: a data model needs assessment and the development of a draft data model.

4.2 Data Model Needs Assessment / Stakeholder Workshop #2

Municipalities within the Lake Simcoe Watershed were invited to a half-day stakeholder workshop held on November 8, 2016. A representative from the TRCA was also invited to provide their input and to have an opportunity to share their organization's experiences and knowledge. The intent of the workshop was to facilitate a discussion regarding two topics: the potential uses of data related to SWM works that a data model could support, and provide a review of existing data models, software, and databases currently implemented by municipalities in York Region and through the Lake Simcoe watershed. Representatives from the municipalities of Aurora, Barrie, Brock, Bradford West Gwillimbury, East Gwillimbury, Georgina, Innisfil, King, Markham, Newmarket, Richmond Hill, Uxbridge, Vaughan, and Whitchurch-Stouffville were present at the workshop. York Region, the TRCA, and the MOECC (the project sponsor) also participated.

A presentation began the workshop, which included a review of: the project's objective, the published best practices, the current practices within each municipality, the deviations from best published practices, and the barriers to adoption of best published practices. A summary of findings from Workshop #1's breakout sessions was also presented and discussed in more detail (refer to **Section 3.0**).

4.2.1 Data Model Definition and Purpose

The presentation then shifted to the data model needs assessment, and workshop attendees were provided a working definition of a data model: "a description of the rules by which data is defined, organized, queried, and updated within a database". The concept of a data model was given a likeness to that of a filing cabinet; the files within the filing cabinet are the SWM works data and the

cabinet itself is the data model. The purpose of the filing cabinet (data model) was to consider the information gathered to date and build a model that will allow municipalities to:

- Address guidelines, policies, and procedures in terms of inspection and OM&M for all SWM works,
- Keep track of inspections and the content entered on inspection forms,
- More quickly access and efficiently respond to colleagues, supervisors, other government agencies and the public's request for information.

Several other terms used throughout the report require definition and/or discussion to ensure clarity of the information collected and input into the data model:

- SWM pond/facility – an artificial lake, wet or dry in nature, which protects receiving water by temporarily storing the urban stormwater runoff and allows the pollutants within the sediment to settle to the lake bottom.
    - End-of-pipe SWM works – the generally accepted 'last step' in a SWM treatment train approach (following lot level controls and conveyance controls). End-of-pipe SWM works can include: wet and dry, wetlands, underground storage, and infiltration trenches.
- LID – "a stormwater management strategy that seeks to mitigate and impacts of increased runoff and stormwater pollution. LIDs promote the use of natural systems for infiltration, evapotranspiration, and reuse of stormwater." (U.S. EPA, 2007)
- OGS – "water quality control devices designed to allow grit to separate from stormwater and allow oils to float and be separated out." (LSRCA, 2016)

The features listed above should be delineated separately within GIS (refer to **Table 9** for further details).

The LID spatial dataset outlined within **Table 9** (in **Section 4.3** further below) only addresses the basic data collection requirements. Should additional information and details concerning LID features be required, please refer to the latest documentation available from LSRCA http://www.lsrca.on.ca/permits/rainscaping/lid-guidance-documents), or review the LID best practice document (hyperlink provided on **page 2** of this report).

Figure 4 illustrates the significant benefits when municipalities adopt a data model for SWM Works.

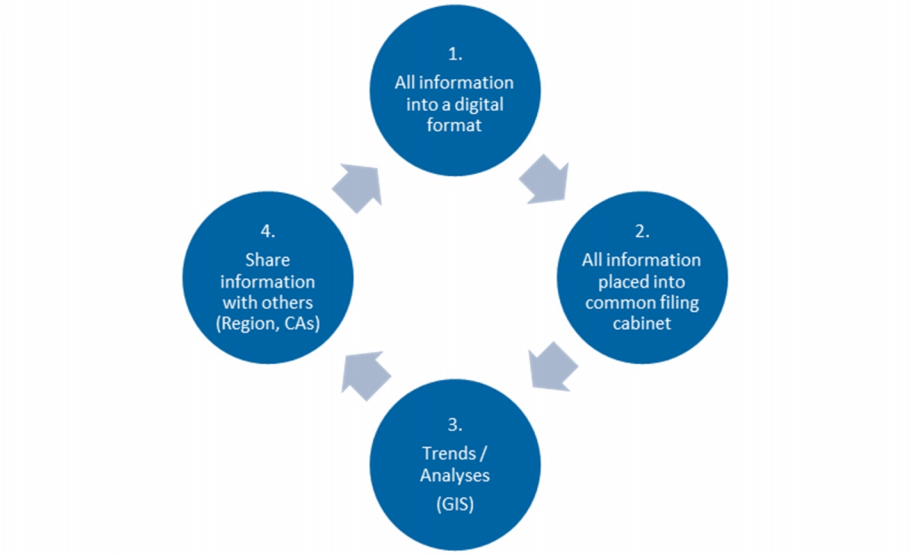


Figure 4: Benefit of a SWM Works Data Model

1. The most important step in the data model adoption process is collecting SWM work information from employees' organizational knowledge and from hard copy format, and entering this data into a digital format.
2. All digital information is placed into a common filing cabinet (data model) within GIS.
3. GIS is the main software to store, access, and update the digital information and can also provide cartographic output and trends and analyses.
4. Storing the digital data in GIS allows for a central repository in which information can be shared with others quickly and efficiently.

4.2.2 Existing Data Models, Software, and Databases

There are several SWM works data models implemented by progressive municipalities across North America, and one model provided by Environmental Systems Research Institute (ESRI).

4.2.2.1 The Village of Royal Palm Beach, Palm Beach County, FL

Items to note:

- Florida DOT standards were used;
- Heads-up digitizing of inlets, storm mains, fittings, endwalls, drainage channels, retention/ detention areas;
- Attribution – diameter, etc.;
- Link source record drawing within GIS; and

Table 1. The table lists all feature classes in the Stormwater GIS geodatabase with an example of a unique field.

Feature Class	Example of an Included Field
Ditch Bottom Inlets	FDOT Inlet Types (A–K)
Curb Inlets	FDOT Curb Inlet Top Types (1–10)
Gutter Inlets	FDOT Inlet Types (A–K)
Manholes	Structure Bottom Type (J or P)
Yard Drains	RPB ID (Royal Palm Beach Unique ID)
Control Structures	Bleeder Type (i.e., Notch, Circular, or Rectangular)
Pond Control Points	Type (Intake or Discharge)
Fittings/Endwalls	Type (i.e., Mitered End Section, Concrete End-wall, Concrete Collar, Plug)
Pipes/Culverts	(2) Upper Invert and Lower Invert
Lateral Drains	Material (i.e., PVC, HDPE)
Drainage Channels	Slope (Side or Longitudinal Slope)
Retention/Detention Areas	Control Elevation (ft.)

- Geometric network created for QA/QC.
  - Edges snapped, lines split where necessary, lines have endpoints.

http://www.waterworld.com/articles/print/volume-23/issue-7/feature/creating-a-comprehensive-stormwater-geodatabase.html

4.2.2.2 City of Norfolk, Virginia

Items to note:

- Pipe size, shape, elevation and their connection have to be known in order to analyze the capacity of storm water system;
- Pipe material, installed year, and their condition have to be known for the maintenance tracking
- Since many pipes are underground, measure the two ends of a pipe within the corresponding structures;
- Structure size (opening size, depth, shape, etc.), lid material and condition must also be known in order to analyze the capacity and for maintenance purposes; and
- In addition, the data system should include all the attributes required, and the operation needs to be easy and fast so that the updating work can be performed in a timely manner.

Field Name	Data Type	Length	Comments
OBJECTID	Long int		Automatic number
StruNo	Text	10	Structure Number
StruType	Text	4	Structure Type
LidType	Text	2	Lid's type
LidSize	Text	10	Lid's size
RimElev	Double		Rim Elevation
InvElev	Double		Invert Elevation
CntPipe	Int		Count of the pipes
YrInstalled	Int		The year installed
Condition	Text	4	Structure condition
SurveyDate	Date		Survey date
Northing	Double		Y coordinate
Easting	Double		X coordinate
…	…	…	…

Table 1. The Data Organization and Types of Structures

Field Name	Type	Length	Meaning
OBJECTID	Long int		Automatic number
UPNO	Text	10	Up-structure number
UPElev	Double		Up-structure elevation
DNNO	Text	10	Down-structure number
DNElev	Double		Down-structure elevation
UP_DNSTRCT	Text	21	Up-down Stru. numbers
MAT	Text	4	Pipe's material code
GEOM	Text	2	Pipe's shape code
…	…	…	…

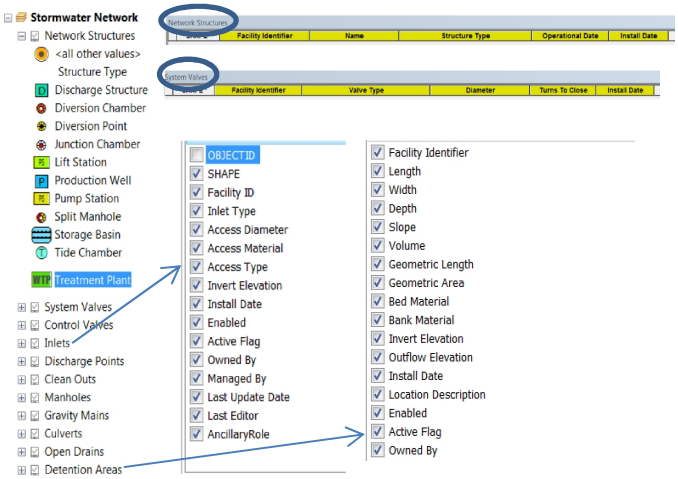
Table 2. The Data Organization and Types of Pipes

http://www.isprs.org/proceedings/XXXVII/congress/4_pdf/22.pdf

4.2.2.3 ESRI – Stormwater Network

Items to note:

- ESRI provides a geodatabase with sample stormwater network data from the City of Naperville, Illinois.
  - Includes layers for network structures, system valves, control valves, inlets, discharge points, clean outs, manholes, gravity



mains, culverts, open drains, and detention areas (data circa July 2015).

http://solutions.arcgis.com/utilities/water/help/stormwater-network/#what-you-get

4.2.2.4 Data Models implemented Ontario

Within southern Ontario, there are several data models currently implemented within various organizations. A brief description of each is provided:

a. **Town of Markham** – a geodatabase of SWM works data including: name, ID, type, function, status, watershed, MOECC/C of A number and approval date, year assumed, hyperlink to SWM works Windows Explorer folder.

b. **Town of Whitchurch-Stouffville** – a geodatabase of SWM works data pertaining to: catchbasins (ID, install date, elevation, street name), culverts (ID, install date, material, diameter), discharge points (ID, discharge details (average, peak), type, install date), facilities (ID, type, year built, year assumed, year cleaned, C of A number, inspection, drawings, development status, access), manholes (ID, install date, rim elevation, depth (m), diameter, status, ownership), stormwater mains (ID, install date, type, material, diameter, invert us/ds, expected life, lining type, facility name, system name, status, ownership).

c. **TRCA** – SWMsoft software to capture SWM works data including: ID, name, municipality, status, year built, C of A number, type, function, watershed, permanent pool (minimum, designed, as-built), access and associated restrictions, location, document references.

d. **York Region – All Pipes Working Group** – has derived geodatabases for water and wastewater data. Water network includes data pertaining to: pumps, valves, wells, treatment plants, hydrants, pumping stations, watermain pipes, and flowmeters. Wastewater network includes data pertaining to: manholes, valves, pumping stations, flowmeters, pumps, sewershed, wastewater mains.

Immediately following the presentation, the stakeholders were divided into groups to brainstorm the specific types of files (data) to go into the filing cabinet (data model), and provide details of what the filing cabinet (data model structure) should look like. At the completion of the break-out sessions, next steps of the project, including how the workshop's findings would be incorporated going forward into a draft GIS data model, were discussed.

The summary of findings from the break-out sessions are discussed in the next section.

4.3 Summary of Findings – Workshop # 2

During the break-out sessions, each of the groups was provided various questions to brainstorm and comment on. The feedback received from the stakeholders was documented at each table and is provided as part of **Appendix C**. A concise summary of findings for each break-out session question is presented in **Tables 9 – 12**.

Table 9 summarizes feedback for what files (data) should be stored in the filing cabinet (data model) based on information requests from colleagues, other government agencies, the public, and based on requirements from the MOECC. **Table 9** also summarizes feedback pertaining to the filing cabinet structure: what the cabinet (data model) should look like, what information must be

collected and what information is optional, and how the data should be displayed within GIS. The "phases" listed within Column C are further discussed within **Section 4.4**.

The following pertains to **Table 9:**

- Column A – a list of files (data) to be stored in the filing cabinet (data model). Please note: the presented list not the comprehensive list compiled during the second workshop, but the final list as agreed to during Workshop #3 (December 1, 2016) and finalized by the Project Team (during a team meeting December 15, 2016). If desired, please refer to **Appendix C** for workshop #3 participant group responses.
- Columns B and C – a list of mandatory and optional features to be collected based on workshop feedback, Project Team feedback, and MOECC requirements. Also refer to **Section 4.4** for additional information regarding "Phase 1" and "Phase 2" and "Phase 3" (not listed within the chart).
- Column D – a list of how the data should be represented in GIS (point, line, polygon, or combination of several).
- Column E – nomenclature for GIS attribute table (i.e. column header name).
- Column F – how to represent the data within the GIS attribute table (i.e. text, date, double, integer (short or long), or hyperlink).
- Column G – definition of file (data).

Table 9: List of files (data) to be stored in the filing cabinet (data model)

File Folder	Mandatory Data Collection Fields (Phase 1)	Optional collection of data by Phase	How to represent data in GIS	Nomenclature for GIS attribute table	How to represent data in attribute table	Definition
Feature (i.e. SWM/LID/OGS)						
Common GIS attributes						
Common Name	X			FacName	Text	Common name of works/facility
ECA/C of A ID	X			ECAID	Text	Env. Compliance Approval/Cert. of Approval ID
- Date	X			ECADate	Date [1]	Date of authorizing letter
- Desciption	X			ECADesc	Hyperlink [2]	Hyperlink to authorizing letter
Cert. of Completion ID		Phase 1		CofCompID	Text	Cert. of Completion ID (if applicable)
- Date		Phase 1		CofDate	Date [1]	Date of authorizing letter
- Description		Phase 1		CofDesc	Hyperlink [2]	Hyperlink to authorizing letter
Facility Location	X			Location	Text	Intersection/Address
Facility Location II	X			Northing	Double	Coordinates (UTM) (captured at outfall for SWM, if possible)
Facility Location III	X			Easting	Double	Coordinates (UTM) (captured at outfall for SWM, if possible)
Subdivision Name		Phase 1		SubName	Text	Subdivision name in which works/facility is located
Parcel ID		Phase 1		ParcelID	Text	Registered plan (M-Plan) parcel ID (if applicable)
Municipality	X			MunName	Text	Municipality name
Conservation Authority		Phase 1		ConsAuth	Text	Governing Conservation Authority name
Subwatershed	X			Wtrshed	Text	Subwatershed within governing Conservation Authority
Drainage / Catchment Area	X			CatchArea	Double	Unique ID of drainage/catchment area spatial layer
Ownership	X			Owner	Text	Includes private land name/description
Management		Phase 1		Mgmt	Text	Details/name of management (if applicable)
Online/Offline		Phase 1		OnOffline	Text	Online/offline
Year Built	X			YrBuilt	Short Integer	Year facility was constructed
Year Assumed		Phase 1		YrAssmd	Short Integer	Year facility was assumed
Year Inspected	X			YrInspect	Short Integer	Most recent year works/facility was inspected
Year Cleaned	X			YrCleaned	Short Integer	Most recent year works/facility was cleaned
GIS metadata		Phase 1		-	-	-
- last date modified		Phase 1		GISDate	Date [1]	Most recent date GIS data was modified
- last editor		Phase 1		GISStaff	Text	Most recent name of GIS editor of data
Notes	X			Notes	Text	Notes / Important information
File - Stormwater Management Feature (Pond/Facility)						
GIS attributes						
Unique ID - primary key	X		polygon	SWMID	Text	SWM_ID
Multi-Stage Facility		Phase 1		MSFac	Text	Y/N
Facility Draw Down		Phase 1		-	-	-
- method		Phase 1		FDDMthd	Text	Drawdown method within works/facility
Facility Area		Phase 1		FacAreaM	Double	Area of facility (polygon boundary = top of slope) m^2
Facility Material		Phase 1		FacMat	Text	Material contained within works/facility
Facility Type	X			FacType	Text	Wet/Dry/Wetland/Hybrid/Pretreatment/Other
Facility Function		Phase 1		FacFunc	Text	Flood control, etc.
File - Low Impact Development Feature (if applicable within watershed)						
GIS attributes						
Unique ID - primary key	X		polygon/line/point	LIDID	Text	LID_ID
Facility Type	X			LIDType	Text	Bioretention, Perforated pipe infilration/exfiltration system, Media filters, Vegetated filter strips, Permeable pavement
Infiltration Storage	X			LIDVol	Text	Y/N
Volume		Phase 1		LIDVolm3	Text	Volume of storage (m^3)

Table 9: List of files (data) to be stored in the filing cabinet (data model)

File Folder	Mandatory Data Collection Fields (Phase 1)	Optional collection of data by Phase	How to represent data in GIS	Nomenclature for GIS attribute table	How to represent data in attribute table	Definition
Files - Oil/Grit Separator (if applicable within watershed)						
GIS attributes						
Unique ID - primary key	X		point	OGSID	Text	OGS_ID
Permanent Storage Volume		Phase 1		OGSVolm3	Text	Permanent storage volume (m³) (as-built data)
Facility Type	X			OGSType	Text	OSG Manufacturer
Facility Size	X			OGSSize	Tex\	Separator size
Files - Additional Data *Each file must be linked to SWM/LID/OGS Facility unique ID*						
GIS attributes						
Easement		Phase 1	polygon	Esmt	Text	Description of easement (if applicable)
Access			polygon	FacAccess	Text	Y/N
- Type			-	AccessTyp	Text	Driveway, Turnaround, Gate, Lock
- Facility Fence and Type			polyline	FenceType	Text	Chain link, metal, other
Overland Flow			polygon	-	-	-
- Elevation			-	OvFlElev	Double	Overland flow elevation
- Location			-	OvFlLoc	Text	Overland flow location
Emergency Spillway By-Pass			polygon	-	-	-
- Elevation			-	EmSpElev	Double	Emergency spillway by-pass elevation
- Location			-	EmSpLoc	Text	Emergency spillway by-pass location
Sediment Drying Area			polygon	SDADesc	Text	Sediment drying area location description
Utilities nearby			point/line/polygon	UtilDesc	Text	Listing and description of nearby utilities
Inlet/Outlet			point/point	-	-	-
- inlet pipe size			-	InSize	Short Integer	Inlet pipe size
- inlet pipe type			-	InType	Text	Inlet pipe type
- inlet invert elevation			-	InvtElev	Double	Inlet invert elevation
- outlet pipe size			-	OutSize	Short Integer	Outlet pipe size
- outlet pipe type			-	OutType	Text	Outlet pipe type
- outlet invert elevation			-	OutElev	Double	Outlet invert elevation
- submerged inlet			-	InSubmerg	Text	Y/N
Control Structure			point/polygon	-	-	-
- description			-	CoStDesc	Text	Control structure description
- orifice-type			-	CoStOrif	Text	Control structure orifice type (v-notch, pipe, plate, weir, etc.)
- size			-	CoStSize	Short Integer	Control structure size
- quantity			-	CoStQuan	Double	Holds water back and releases slowly over extended period of time
- quality			-	CoStQual	Text	Method used to improve discharge of water quality
- elevation			-	CoStElev	Double	Control structure elevation
Safety Features			point/line/polygon	SafeFeat	Text	e.g. lifesaving stations
Special Features			point/line/polygon	SpecFeat	Text	e.g. clay liner, forebay concrete
Retrofits			point/polygon	RetDesc	Text	Type of retrofit and description

Table 9: List of files (data) to be stored in the filing cabinet (data model)

File Folder	Mandatory Data Collection Fields (Phase 1)	Optional collection of data by Phase	How to represent data in GIS	Nomenclature for GIS attribute table	How to represent data in attribute table	Definition
Files - Inspection, Operation, Maintenance *Each file must be linked to Facility unique ID*						
GIS attributes						
Inspector's Name		Phase 2	polygon - SWM/LID	InspName	Text	Name of inspector
Sediment Accumulation Status				-	-	-
- Date				SACDate	Date [1]	Sediment accumulation - date of collected information
- Volume (m³)				SACVol	Double	Sediment accumulation - volume (m³) from date of collected data
Current Permanent Pool				-	-	-
- Elevation				PoolElev	Double	Permanent pool elevation (as-built data)
- Volume				PoolVol	Double	Permanent pool volume (m³) (as-built data)
100 Year Elevation				Elev100y	Double	100 year flood event elevation
Condition				FacCond	Text	Works/Facility condition
Sampling				Sampling	Hyperlink [2]	Year to year volume records
Cleaning Frequency				FreqClean	Text	Frequency of works/facility cleaning
Inspection Frequency				FreqInspt	Text	Frequency of works/facility inspection
Maintenance Record		Phase 1		-	Hyperlink [2]	Hyperlink to maintenance records (Windows Explorer folder)
Repairs				-	Hyperlink [2]	Hyperlink to repairs (Windows Explorer folder)
Deficiencies				-	Hyperlink [2]	Hyperlink to deficiencies (Windows Explorer folder)
Complaints				-	Hyperlink [2]	Hyperlink to complaints (Windows Explorer folder)
SWM reports				-	Hyperlink [2]	Hyperlink to SWM reports (Windows Explorer folder)
Inspection Reports				-	Hyperlink [2]	Hyperlink to inspection reports (Windows Explorer folder)
Monitoring Reports				-	Hyperlink [2]	Hyperlink to Monitoring reports (Windows Explorer folder)
- effluent objects				-	-	-
- sediment and erosion control				-	-	-
- record keeping				-	-	-
- Source Water Protection				-	-	-
O&M Manual				-	Hyperlink [2]	Hyperlink to O&M manual (Windows Explorer folder)
Drawings				-	Hyperlink [2]	Hyperlink to drawings (Windows Explorer folder)
Surveys				-	Hyperlink [2]	Hyperlink to survey information (Windows Explorer folder)
Costs				-	Hyperlink [2]	Hyperlink to Excel table (Windows Explorer folder)
-construction				-	-	-
-maintenance				-	-	-
Site Photos/Drone Video				-	Hyperlink [2]	Hyperlink to site photos/drone video (Windows Explorer folder)

[1] mm/dd/yyyy hh:mm:ss and a specification of AM or PM
[2] hyperlink to Windows Explorer network folder

Table 10 presents feedback from the municipalities regarding the feasibility of collecting and maintaining the data listed in **Table 9** (based on budgeting, staffing, training, need). **Table 11** summarizes feedback regarding the medium of existing SWM information: be it hard copy, digital, or human knowledge, and if not digital, what steps have to be taken to collect and convert the data to a digital format. **Table 12** summarizes feedback on how the collected SWM works information will allow for better inventory, inspection, and record keeping management.

Table 10: Feasibility of collecting mandatory features

Question Posed	Feedback Received
Is it feasible to collect and maintain the information/data (listed in Table 9) (based on budget/staffing, training, need)?	• Age of information > level of effort • Historical data is non-existent or not in a digital format • Basic inspections can determine future work/inspections – need $ and staff • Additional digital information may add strain to IT servers • Tailor data model to meet needs of different departments (so they only see the data they need to see; not be overwhelmed)

Table 11: Current medium of information/steps required to convert

Question Posed	Medium of Information	Steps Required to Convert
What medium is the information (listed in Table 9) currently in?	• Paper/hard copy • Human knowledge • Digital/non-GIS/CADD • Available only via consultants (information has been lost or is not in-house)	• Have staff and budget dollars allocated to this task • Devise a plan to consolidate all information • Find, compile, scan information (OCR); interview long-time employees, obtain information from consultants • Link data into GIS • Develop a digital work order/inspection system

Table 12: How SWM works information collect will allow for better inventory, inspection, and record management practices

Question Posed	Feedback Received

How does/will this information (specifically) allow you to better inventory, inspect, and record manage your SWM data?	• Consolidates information
	  ○ allows for inter-departmental access
	  ○ ease the search for data (spatially associated, visual, tabulated)
	  – Past/Present/Future information requirements
	  ▪ historical data to identify trends/issues
	  ▪ flood risk assessment
	  ▪ future planning for development and/or facility retrofits
	  ○ greater efficiencies for staff and reduces

Question Posed	Feedback Received
	redundancies ○ standardized process / forces documentation/BMP ○ tracking of type/frequency/prioritization of inspection/maintenance ○ Identify information/data gaps • Greater accuracy for calculations and modelling • Compliance with MOECC / C of As or ECAs • Future budgeting / asset management / political support

4.4 Summary of Findings – Workshop #3

Municipalities within the Lake Simcoe Watershed were invited to a half-day stakeholder workshop held on December 1, 2016. A representative from the TRCA was also invited to provide their input and to have an opportunity to share their organization's experiences and knowledge. The intent of the workshop was to facilitate a discussion regarding: the feedback received from Workshop #2 (the data model needs analysis held November 8, 2016), and to review and provide comment on the draft data model for SWM works. Representatives from the municipalities of Aurora, Barrie, Brock, Bradford West Gwillimbury, East Gwillimbury, Georgina, Innisfil, King, Markham, Newmarket, Oro-Medonte, Richmond Hill, Uxbridge, Vaughan, and Whitchurch-Stouffville were present at the workshop. The Region of Durham, York Region, TRCA, Ryerson University, and the MOECC (the project sponsor) also participated.

The workshop commenced with a presentation which included a brief review of the project's objective, the published best practices, the current practices within each municipality, the deviations from best published practices, and the barriers to adoption of best published practices. A summary of findings from the workshop #1's breakout sessions was also presented and discussed in more detail (refer to Chapter 4). The presentation discussed the results of the feedback provided from Workshop #2 (as discussed in **Section 4.3**).

The workshop continued with a moderated discussion of the draft data model prepared: an early version of the data model now represented as **Table 9**. Each file (dataset) to be included within the filing cabinet (data model) was discussed and modified (Column A). Each subsequent column (B through G) were also reviewed and discussed.

Based on the feedback obtained during Workshop #2, stakeholders generally agreed the data model should be created in a GIS format (with a unique ID for each works/facility), and have the ability to hyperlink to supporting and/or supplementary files (within Windows Explorer).

Furthermore, the Project Team discussed their relative benefits and recommends a spatial data model, over a simple Microsoft Excel table for SWM works information during the Project Team meeting (held December 15, 2016). The Team agreed it is imperative for all municipalities to prepare for the future stormwater modelling requirements within their jurisdiction and for the future data needs within their organization. GIS is utilized by most municipalities within the Lake Simcoe Watershed. For those stakeholders who have not yet implemented GIS software within their organization, the LSRCA has offered to provide services in order to spatially maintain their

mandatory SWM files (datasets) within a GIS environment. Please contact LSRCA for further information and discussion of your GIS data requirements.

As a stand-alone figure, the data model was also presented to the stakeholders as follows:

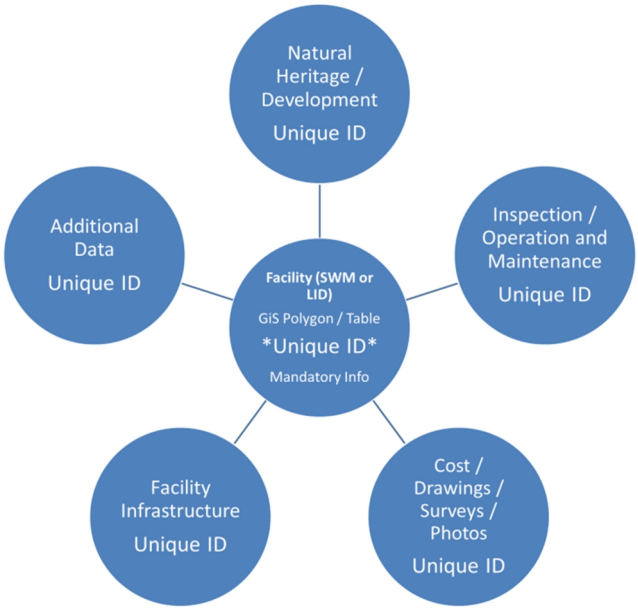


Figure 5: Filing Cabinet (Data Model) Structure

During a Project Team meeting held December 15, 2016, the Team agreed to split the collection of the files (data) within the filing cabinet (data model) into phases, described as follows:

Phase 1 – the scope of this project: the "what" and "where" of SWM/LID works / a 'facilities only' model;

Phase 2 – detailed SWM/LID works information (as included in **Table 9**); and

Phase 3 – will include detailed information regarding the contributing pipe/storm network data (including flow direction).

The timeline of implementing Phases 2 and 3 will be discussed with LSRCA and the municipalities within its watershed at a future date.

Table 9 provides common standards recommended for data capture including: what files (data features) to collect and how to collect the data within a GIS environment. The standards presented are based on best practices, existing data models implemented, feedback obtained in Workshop #3 (December 1, 2016), and feedback obtained during the Project Team meeting held December 15, 2016. The data model (Table 9) enables all Lake Simcoe watershed to collect the same base information, while at the same time, having the ability to supplement their data collection with any additional information their organization wants/needs to collect within a GIS.

The participants of Workshop #3 (December 1, 2016) and the Project Team (during a meeting held December 15, 2016) discussed the frequency in which to obtain and update the mandatory features

within the GIS data model. It was generally agreed data should input into GIS as new facilities come "on-line" and historical information should be gathered and updated as frequently as possible, and as budget and staffing (in terms of both GIS and O&M/engineering staff) permits.

At the completion of the break-out sessions, next steps of the project, including how the workshop's findings would be incorporated going forward into a draft GIS data model, were discussed.

During a final Project Team meeting (held February 9, 2017) the team discussed the inspection of various features and the creation of a data model specific to infrastructure inspections. The "Pond / Wetland Maintenance Inspection Form" found within the *Inspection and Maintenance Guide for SWM Ponds and Constructed Wetlands* (URL provided on **page 2** of this document) provides a comprehensive outline (specifically pages 142-147) of the applicable data files required for a GIS inspection file folder (data model).

Basic file information (GIS attributes) such as: facility number, watershed, property classification, and date and time of the inspection are included. Focus areas within the inspection form include: outfall channel, downstream and upstream of dam bank, spillway, riser, low flow, weir, control valve, permanent pool, dry storage, wet pond vegetation, special structures, and various miscellaneous items. Each of these areas is scored within the form to determine if future, routine, or immediate repairs may be required.

A data model specifically created and curtailed for SWM feature inspections and implemented on a tablet device will greatly assist in the data collection and knowledge sharing process, not only within a specific organization, but within the larger data-sharing community (perhaps various upper and lower tier municipalities, LSCRA, and the MOECC).

It should be mentioned there are inspection forms available for various LIDs, each of which can be found within the *Low Impact Development Stormwater Management Practice Inspection and Maintenance Guide* (Appendix D – Inspection Field Data Forms – pages 311-347). Due to the complex nature of the inspection forms, additional future effort will be necessary to convert the forms into a GIS data model format. In the meantime, the existing forms will remain as a file (GIS attribute) within the "Inspection, Operation, Maintenance" LID file folder (data model) as a hyperlinked Windows Explorer file folder.

4.5 Implementation of Filing Cabinet (Data Model)

In order to successfully implement Phase 1 of the SWM works data model, several additional topics require discussion.

Table 13: Implementing the filing cabinet (data model)

Work plan for developing the filing cabinet (data model) in-house (Phase 1 mandatory files (datasets)) and migrating data (from other formats) if/as necessary	• Create data model shell containing mandatory, optional, and organization mandated files (datasets/ in attributes) GIS as (a) shapefile(s) or as a geodatabase • Gather required data for mandatory files (datasets/attributes) for each SWM/LID facility managed within jurisdiction. Information for optional files could be gathered at the same time, resources permitting

Topic / Discussion Point	Feedback Received / Action Required

Budget requirements for work plan	• Populate into GIS shapefile(s) or geodatabase as information becomes available
	• Have appropriate O&M/engineering staff QA/QC data entered into GIS
	• There is potential for funding (from the MOECC) to support these efforts
	• Very difficult to definitively measure. Will depend on:
	  ○ Number of works/facilities within each municipality
	  ○ Availability of data (if mandatory data is generally in digital format this will result in implementing Phase 1 much more quickly than most of the mandatory data being stored via human knowledge and/or hard copy documentation)
	  ○ Availability of staff to assist with gathering required files (data mining) and staff to input necessary file information (data attributes) into the filing cabinet (data model)
	• **Estimated** cost of data model implementation for *urban* municipalities: ~ $14,000 per municipality
	  ○ Assumptions:
	  ▪ Municipality has ~ 100 facilities
	  ▪ 1 staff person @ $350/day for 40 days of time (a 7 hour work day) to verify/collect data (~ 2 facilities / day) within a 6 –12 month timespan
	  ▪ most of the mandatory data is readily available in a digital format (Windows Explorer, GIS, CAD, etc.); staffing resources can be allocated to obtain remaining data and QA/QC existing data
	• **Estimated** cost of data model implementation for *semi-urbanized* municipalities: ~ $21,000 per municipality
	Assumptions:
	• Municipality has ~ 50 facilities
	• 1 staff person @ $350/day for 60 days of time (a 7 hour work day) to verify/collect data (~ 1 facility / day) within a 6 – 18 month timespan
	• some of the mandatory data is readily available in a digital format (Windows Explorer, GIS, CAD, etc.); staffing resources can be allocated during slow periods/ at times to obtain remaining data and QA/QC existing data
	• **Estimated** cost of data model implementation for *urbanizing* municipalities: ~ $14,000 per municipality
	  ○ Assumptions:

Topic / Discussion Point	Feedback Received / Action Required
	• Municipality has ~ 20 facilities • 1 staff person @ $350/day for 40 days of time (a 7 hour work day) to verify/collect data (~ 1 facility / 2 days) within a 12 – 24 month timespan • mandatory data is not readily available in a digital format (Windows Explorer, GIS, CAD, etc.); staffing resources may need to be hired to obtain data and QA/QC existing data
Responsibilities to implement work plan	• Each municipality is responsible for building and/or populating the data model (refer to **Table 9**) • Senior management to obtain necessary approvals for staff time (and associated budget) and champion initiative • SWM staff (as 'subject matter experts') to project manage the work plan and mobilize the necessary O&M, Engineering, and GIS staff to assist with gathering required files (data mining) • Use co-op/summer students as necessary/available to assist with gathering required files (data mining) and GIS data entry into filing cabinet (data model) • Ongoing maintenance of data model • Potential MOECC / LSRCA support • Engage senior management where necessary • Provide/coordinate co-op/summer students as a resource to assist with gathering required files (data mining) and GIS data entry into the filing cabinet (data model) • Request data on oil/grit separators from manufacturers • Provision of stormwater facility inspection/data collector tool training

Timeline to implement work plan	• December 2018
	  ○ Allows for development of funding agreement
	  ○ Allows for development of data collection tools
	  ○ Allows for developing a communication plan and discussing with municipalities, as necessary
	  ○ Allow for budgeting (staff/time/resources) including the assistance of summer/co-op students, if feasible
	  ○ Milestone goals:
	  ▪ Stormwater inspection and data entry training: May 2018
	  ▪ Three to four "data-ready" municipalities completed: June 2018
	  ▪ Seven to eight "data not ready" municipalities completed: December 2018

5. Conclusions and Recommendations

The project's objective allowed the LSRCA an opportunity to investigate, analyze, and develop solutions to better improve the ability of municipalities to adopt best practices for inspection, maintenance, and record-keeping for SWM works.

The current practice review found most Lake Simcoe watershed municipalities have a SWM works inspection protocol in place, but the comprehensiveness of facility inspections, the frequency in which inspections take place, and the ability and training/education of staff varies significantly. The majority of municipalities complete the required minor repairs but often cannot afford to complete major repairs due to financial and staffing constraints. Most municipalities have electronic and/or hard copy SWM works documents pertaining to maintenance and inspection practices, but these records generally have not been entered into a GIS.

Municipalities within the Lake Simcoe watershed listed the most significant barriers to adoption of best published practices as: financial resources, staff not receiving the necessary training to complete SWM works inspections and repairs, not having access to enough staff resources to be able to complete necessary inspections and associated maintenance, a lack of political support, and a lack of communication education and awareness.

Comprehensive feedback was received from workshop participants regarding alternatives and solutions to overcome barriers to the adoption of best management practices. In summary they include:

- Utilize an asset management program to plan and budget for SWM works inspection, operation, and maintenance;
- Make a clear case to government: the longer a SWM feature waits for its required clean-out, the greater the financial cost will be in the future;
- Develop, standardize, and utilize stormwater utility fees for urban areas. Ensure municipal staff and government is aware of all types of grants and funding available (via all levels of government). Developer fees should be implemented during a municipality's build-out stages;
- Establish a record management system in GIS, utilize summer students to transfer all hard copy files to electronic, and ensure the system is straightforward for field staff to use (phone/tablet applications);
- Allow documents to be accessible for the operations and maintenance team, inspectors and temporary field staff (i.e. summer students);
- Provide in-class and in-field training/tours for SWM facility and LID education; this was a preferred option;
- Enlist summer students to inspect easier protocols. More complicated protocols, or those with a higher risk to staff may be contracted out, or completed by LSRCA;
- The complexity of a SWM or LID feature inspection should not be understated. A training session one day in length may be not be sufficient to cover all aspects of the SWM or LID

feature inspection process. Refresher training either annually or every few years should also be provided;

- SWM facilities and LIDs encompass a variety of disciplines. As such, in addition to regular inspections, experts from various disciplines (i.e. geomorphologists, professional engineers, ecologists, etc.) should perform inspections on a SWM feature periodically in order to preserve the integrity of the SWM feature, and to be able to provide their professional expertise regarding future issues and/or maintenance concerns; and,
- Road/trail accessibility to SWM features are limited. Planners and developers are no longer required to provide land for SWM sediment drying due to the pressures of intensification. There is therefore now a need for the generation of innovative alternatives to improve accessibility.

The data model needs assessment brought forward the desire of municipalities to possess a more efficient method to respond to colleague, partner, and the public's information requests. The needs assessment also contributed to the better understanding of having SWM works inspection and record-keeping information in a digital format and stored in a common filing cabinet (data model). This process will allow GIS to perform powerful spatial analyses, predict future trends, and disseminate information more quickly.

Municipalities provided important feedback and ideas into the data model development. It was deemed critical for the data model to be created in a GIS format, and to have the ability to hyperlink to supporting and/or supplementary files within the Windows Explorer environment. The Project Team and participating municipalities agreed that it is imperative to prepare for future stormwater modelling requirements and for future data needs within their organization.

The collection of SWM works data was divided into phases with only the basic/critical facility data being required at this time (**Table 9**). Future phases will address the collection of detailed facility information and contributing pipe/storm network data. The data model provides common data capture standards for municipalities. These standards include guidelines on what files (data) to collect, how often to obtain and update, and how to collect the required "phase 1" information.

The project team envisions the data model, beyond the December 2018 timeframe outlined in **Section 4.5**, to be championed by York Region and LSRCA. Both organizations are technologically equipped, are advanced in their GIS capabilities, and are data leaders within their respective public sectors.

SWM works best published practices will remain an aspirational target. The suggested best practices presented in this report (**page 2**) dictate a level of expectation that is simply unachievable at the present time. However, it should be noted that there was unanimous agreement from all stakeholders that numerous opportunities exist for municipalities to continue to work towards 'better practices' for all of their SWM (and LID facilities) within their jurisdiction.

6. References

Coleman, D., & Anzyeski, B. (n.d.). Creating a Comprehensive Stormwater Geodatabase. Retrieved from http://www.waterworld.com/articles/print/volume-23/issue-7/feature/creating-a-comprehensive-stormwater-geodatabase.html

Environmental Systems Research Institute, Inc. (n.d.). Stormwater Network (Version July 2015) [Computer software]. Retrieved from http://solutions.arcgis.com/utilities/water/help/stormwater-network/#what-you-get

Government of Ontario, Ministry of Environment and Climate Change. (2010). Lake Simcoe Phosphorus Reduction Strategy. Retrieved from https://dr6j45jk9xcmk.cloudfront.net/documents/872/5-6-4-lake-simcoe-phosphorus-reduction-en-pdf.pdf

Lake Simcoe Region Conservation Authority. (2016). LSRCA Technical Guidelines for Stormwater Management Submissions. Retrieved from http://www.lsrca.on.ca/Shared%20Documents/permits/swm_guidelines.pdf

Toronto and Region Conservation Authority (TRCA) and CH2M Canada. 2016. Inspection and Maintenance Guide for Stormwater Management Ponds and Constructed Wetlands. Toronto and Region Conservation Authority, Vaughan, Ontario.

Toronto and Region Conservation Authority (TRCA). DRAFT 2015. Low Impact Development Stormwater Practice Inspection and Maintenance Guide. Prepared by the Sustainable Technologies Evaluation Program. Vaughan, Ontario.

United States Environmental Protection Agency, NEPIS. (2007). Reducing Stormwater Costs through Low Impact Development (LID) Strategies and Practices. Retrieved from https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=60000LWT.txt

Xie, M., White, J. M., & Rhees, B. (n.d.). Development of a New GIS-Based Storm Water Database Updating System: From Field Data Collection to Geodatabase Creation. Retrieved from http://www.isprs.org/proceedings/XXXVII/congress/4_pdf/22.pdf

7. Glossary of Terms and Abbreviations

C of A	Certificate of Approval
CADD	Computer Aided Design and Drafting
DOT	Department of Transportation
ECA	Environmental Compliance Approval
ESRI	Environmental Systems Research Institute
GIS	Geographic Information System
LID	Low Impact Development
LSRCA	Lake Simcoe Region Conservation Authority
MOECC	Ministry of Environment and Climate Change

OCR	