



Canadian Consulting Engineering Awards 2016- Water Resources Lisgar District Basement Water Infiltration Investigation

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Date: April 21th, 2016
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Entry Consent Form



Full Project Description



Project Description

Dedicated foundation drain collectors (FDCs, or 3rd pipes) were considered by many to be the 'gold standard' for managing foundation water around homes. However, in 2008, after nearly 25 years of experiencing no known problems, the homes in the Lisgar District of Mississauga, Ontario Canada began experiencing basement water infiltration in increasing numbers. A total of 187 homes are known to have been affected to date.

After becoming aware of the scale of this issue, the City undertook a number of actions, including inspections and sealing of the FDC system, as well as various clean-outs and adjustments to surface water features. The engineering consulting firm of Amec Foster Wheeler Environment & Infrastructure was subsequently retained to undertake an engineering study to determine the cause(s) of the basement water infiltration and recommend corrective measures. Amec Foster Wheeler's Engineers and Hydrogeologists were able to explain the basement water infiltration problem by utilizing innovative monitoring and proof-of-concept testing along with cutting edge modelling/analysis to identify the source of the problem and establish integrated solutions.

After a lengthy and comprehensive monitoring period and analysis, the study findings determined the problem to be primarily related to the build-up of water in the bedding material of the utility trenches that contain the storm, sanitary and FDC sewer systems. Amec Foster Wheeler is currently working with the City to implement and monitor solutions, which includes targeted storm sewer lining/sealing to minimize leakage, and a pilot utility trench dewatering system. Additional measures may be considered pending the outcome of these priority solutions.



Figure 1 Osprey March/Lisgar District SWM Facility during Storm Event of April 12, 2013



Figure 2 Tributary of Sixteen Mile Creek through Lisgar District showing Vegetation Clean-Out by City Staff

Project Objectives, Solutions, and Achievements

The main objective of this study was to identify and assess the potential cause(s) of basement water infiltration in the Lisgar District. A related secondary objective was to develop integrated solutions to reduce future instances of basement water infiltration in the Lisgar District.

Based on the City's initial assessments, there was no obvious cause for the reported basement water infiltration. It was noted that homes in this area have not had any known issues prior to 2008, more than 20 years since development began. In addition, the area is serviced by a dedicated foundation drain collector sewer (previously considered to be the 'gold standard' for residential foundation drainage).



Figure 3 CCTV Inspection of the FDC System Showing Leakage/Infiltration

One of the initial steps undertaken in this study was to determine what changes could have possibly taken place since the development of the Lisgar District, and how these changes may have contributed to basement water infiltration. A long-list of potential causes/factors was compiled in consultation with City staff and each possible cause/factor was assessed based on a detailed study, including both field investigations (monitoring and testing), as well as background review and numerical analyses. The primary study activities completed by Amec Foster Wheeler to determine the potential cause(s) of the basement water infiltration are summarized as follows:

Field Monitoring Work

A comprehensive field monitoring program was undertaken over multiple years to collect data needed to help understand the surface water and groundwater interactions in the Lisgar District, and the resulting cause(s) of basement water infiltration. This included a large number of water level and temperature gauges in the FDC sewer system, storm sewer system, surface water features (Sixteen Mile Creek as well as the Osprey Marsh Stormwater Management Facility), and in monitoring wells for the groundwater system.



Figure 3 Storm Sewer Leakage Testing Procedure

Field Testing Work

To better understand the interactions between the various sources of water and drainage system components in the Lisgar District, and to test preliminary theories regarding causes, field testing work was also undertaken. The testing included water quality sampling (to identify the likely source of the water), impermeable collar construction and testing (to assess the potential for inflows from creeks and ponds) and storm sewer leakage testing (to definitively prove that water from leaking storm sewers would ultimately drain into the FDC system).

Analysis Work

Using the data collected over the monitoring period, as well as additional information provided by the City on the FDC system and area services, Amec Foster Wheeler conducted a series of technical analyses. These included a design check of the FDC system (to verify that it was designed properly based on the number of homes being serviced), and computer modelling (to assess the likelihood of different potential causes, and to assess whether certain areas contribute relatively higher flows).

Findings

Based on the comprehensive monitoring, testing and analysis work, Amec Foster Wheeler was able to conclude that the primary cause of the basement water infiltration relates to stormwater entering the utility trench.

As storm sewers are not inherently built to be watertight, and due to cracks and leaks expected through normal aging, stormwater is able to leak out during storm events and migrate into the utility trench, where the bedding material, made of gravel and other granular soils, can allow water to move very quickly. Over time, water builds up in the utility trench from storm sewer leakage, as well as through other sources (other utilities, groundwater, etcetera), and is unable to drain away quickly due to the relatively impermeable nature of the native soils surrounding the trench. If the build-up of water is significant enough it can travel up the bedding material around the FDC laterals servicing the homes and into the foundation weeping tiles. This water then drains directly into the FDC pipes through the



Figure 4 Storm Sewer Leakage Testing Procedure

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weeping tiles which may result in excess flow in the FDC system (surcharge). However, this condition by itself may not lead to basement water infiltration. It is this condition in combination with certain storm conditions (preceding rainfall followed by a sufficiently large storm event) and local lot drainage that may lead to water around the weeping tiles being unable to drain and potentially seeping into the basements of homes.

During the course of the investigations, a number of other factors were identified which may be impacting the overall operation of the FDC system; however, based on the information available, none of them, either alone or in combination was deemed to cause water to seep into the basements to the extent reported.

Based on the findings of the study, two measures were recommended as the highest priorities for the City to address the basement water infiltration issue. These measures are the strategic lining of priority storm sewers (to minimize leakage), and the construction of a pilot utility trench dewatering system. Amec Foster Wheeler is currently working with City staff to implement these measures and monitor their effectiveness. Depending on their success, other measures may be considered for implementation, including permanent FDC and utility trench pumping stations for high flows, and replacing hydraulically deficient FDC pipe lengths



Figure 5 FDC Water Level Monitoring Gauge Installation

when they reach the end of their engineered lifespan. It was also suggested that residents who qualify for the City's Lisgar District Sump Pump Subsidy Program (now replaced by the FDC Sump Pump Subsidy Program) take advantage of the program.

Technical Excellence and Innovation

The investigation provided the opportunity for Amec Foster Wheeler to demonstrate its technical capabilities and the innovative ideas of its employees. The study required careful interpretation of a large amount of monitoring data from different sources, as well as forensic computer modelling to understand the sources of excess water. The primary cause of the basement water infiltration is also highly atypical and required innovative thinking to determine and mitigate; no such similar cause is known based on Amec Foster Wheeler's review of other municipalities with a similar residential foundation drainage system. A number of the field monitoring and testing activities advanced as part of this study are also highly innovative (i.e. have never been implemented before to the knowledge of Amec Foster Wheeler). This includes sewer monitoring gauge installations (designed to eliminate potentially dangerous personnel entries), the design and implementation of impermeable collars (to assess and eliminate water from surface sources), and storm sewer leakage

testing (as proof-of-concept that water from leaking storm sewers would ultimately drain into the FDC system).

Level of Complexity and Project Challenges

The investigation was a highly complex study. The interactions between the various components of the drainage system in the Lisgar District have proven to be extremely complex and varied. In order to undertake a complete and thorough investigation, a review of all potential causes of basement water infiltration was required. As field monitoring data were collected and analyzed through the course of the study, Amec Foster Wheeler was able to eliminate some potential causes, and focus on others. As the potential causes were narrowed, additional field work, testing and analysis activities were carried out to clearly prove or disprove theories. This iterative process was lengthy, necessitating multiple years of activities. This process has ensured that a complete and thorough investigation has been undertaken and that appropriate mitigation measures are recommended to reduce the risk of future instances of basement water infiltration.

A challenge during the initial field monitoring phase was weather conditions and rainfall. Without the reoccurrence of impact causing weather conditions experienced during the basement infiltration events, it would have been difficult to fully assess how the drainage system responded during those events, and understand the likely primary causes of basement water infiltration. Accordingly, monitoring work extended over multiple years in order to collect sufficient representative field data.

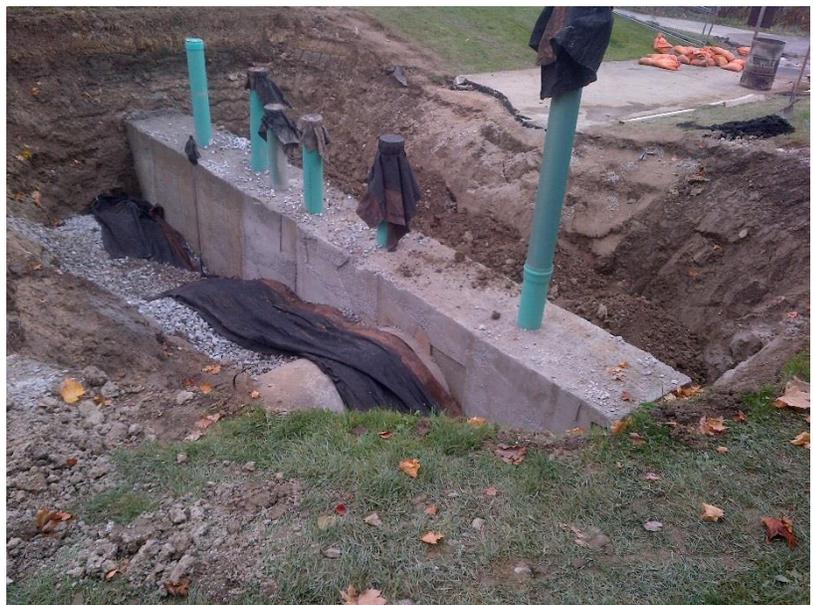


Figure 6 Utility Trench Collar under Construction

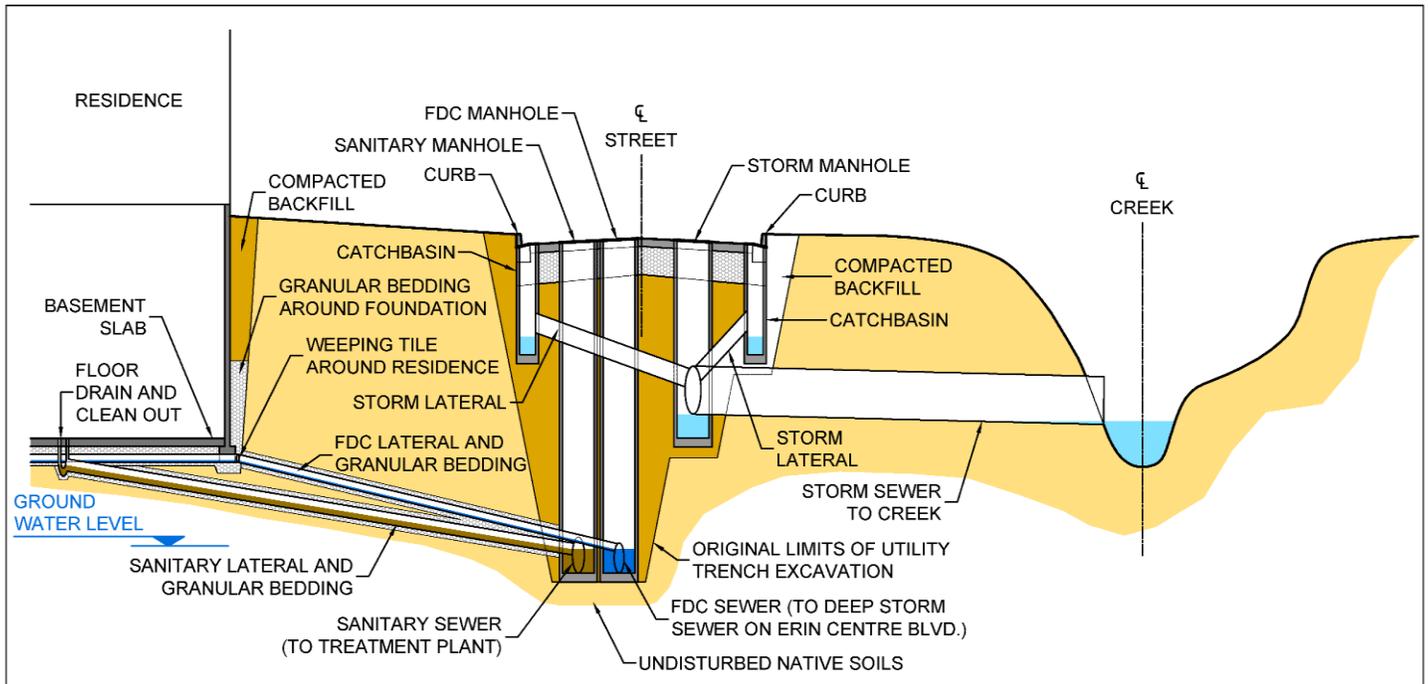
Due to the public importance of this project, it was necessary to ensure that the residents of Lisgar District were kept informed of Amec Foster Wheeler's progress and findings. This was a challenge given the extremely complicated series of programs (monitoring, analysis, refined monitoring, etc.) and possible causes. Through a series of Public Information Meetings, Amec Foster Wheeler's team of experts were successful in communicating in a way that was understandable by non-technical residents.

Contribution to Economic, Social and/or Environmental Quality of Life

The unexpected basement water infiltration that was experienced by the 187 Lisgar District residents since 2008 was devastating to the community. When the City of Mississauga retained Amec Foster Wheeler to solve the mystery, their Engineers and Hydrogeologists made it a top priority to not only identify the cause of the basement water infiltration but also to devise clear mitigation measures and solutions to protect the residents from potential future occurrences. After several years of extensive field work and analysis Amec Foster Wheeler was successful in determining the primary cause of the basement water infiltration, and other related factors. Based on their findings they were able to develop defensible mitigation measures and solutions which were presented to the City of Mississauga and Lisgar District residents in a report as well as a public presentation. Amec Foster Wheeler is currently working with City staff to implement the highest priority recommendations, which will improve the drainage system's performance and reduce the risk of future basement water infiltration. By reducing the risk of future basement water infiltration, the economic, social and environmental impacts that a future potential incident could have on the lives of residents will also be reduced.

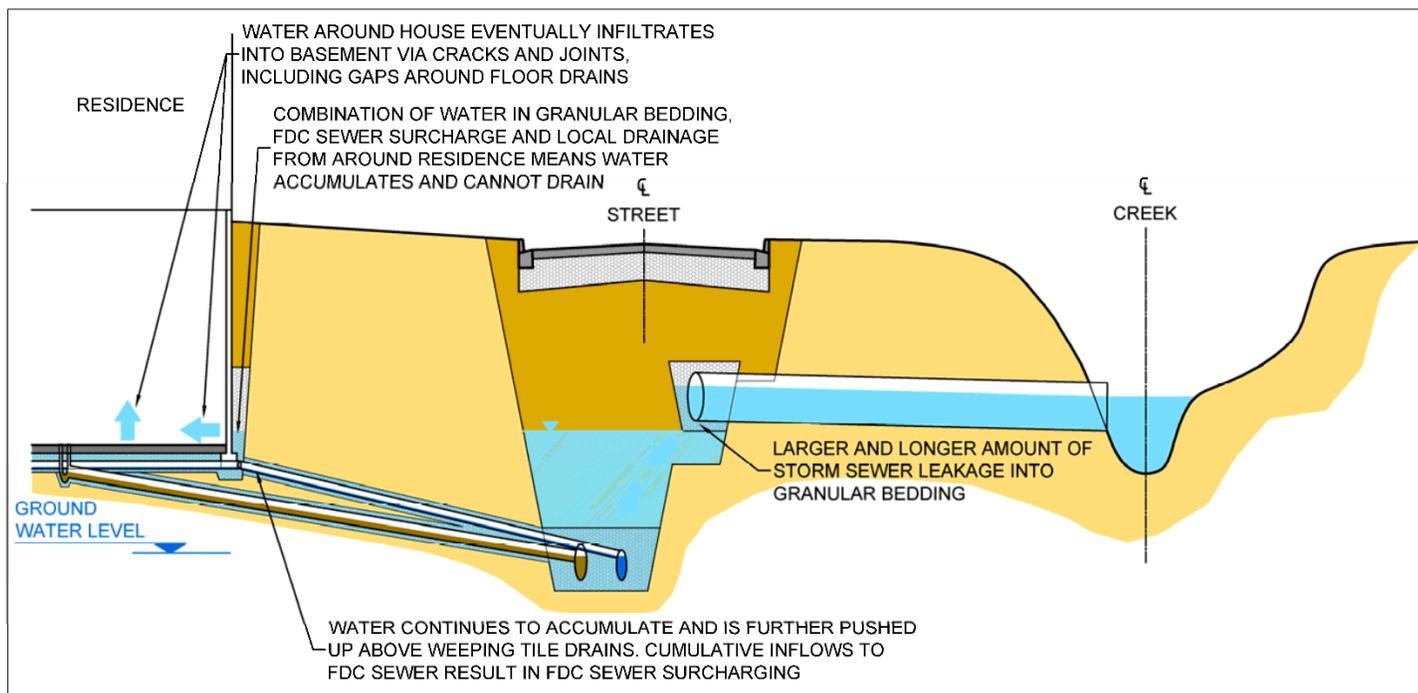
Drawings and Sketches

1. TYPICAL UTILITY TRENCH CROSS-SECTION





6. UTILITY TRENCH AND BEDDING - FORMATIVE STORM (2)



Project Photos



Closed Circuit Television Inspection of the FDC System Showing Leakage/Infiltration



Top View of Typical FDC/Storm Sewer Maintenance Hole Gauge Installation



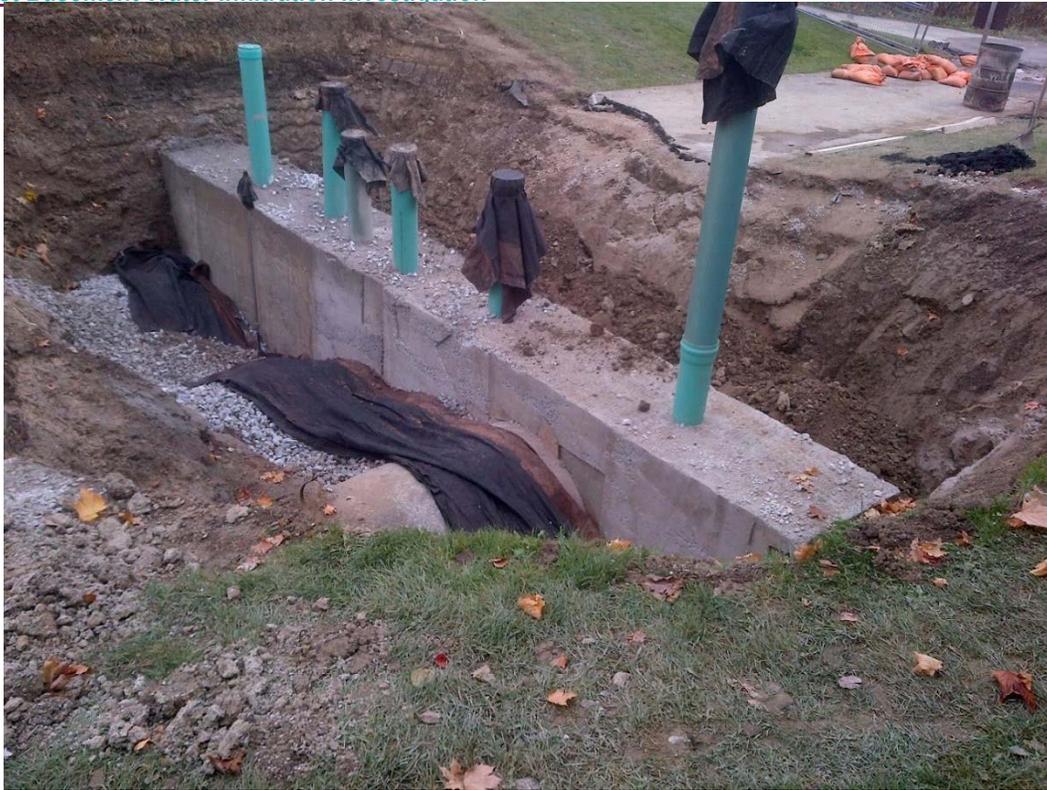
FDC Water Level Monitoring Gauge Installation



Tributary of Sixteen Mile Creek through Lisgar District showing Vegetation Clean-Out by City staff



Osprey Marsh/Lisgar District SWM Facility during storm event of April 12, 2013



Utility trench collar under construction



Storm sewer leakage testing procedure