Controlling Inflow and Infiltration in the Metro Vancouver Area

Liquid Waste Subcommittee of the Regional Engineers Advisory Committee

March 12, 2019
# Table of Content

Table of Content ............................................................................................................................................ i  
Abbreviations ............................................................................................................................................... iii  
Summary ....................................................................................................................................................... 1  
Purpose ......................................................................................................................................................... 3  
Context .......................................................................................................................................................... 4  
  Overview ................................................................................................................................................... 4  
  Sewer Systems and Ownership ................................................................................................................. 5  
  Sewer Maintenance and I&I Management ............................................................................................... 7  
    Assessing Impacts and Risks of I&I ........................................................................................................ 8  
    I&I Management Cost Effectiveness .................................................................................................... 11  
Measuring and Comparing I&I ................................................................................................................ 14  
  Data and I&I Estimation ........................................................................................................................... 15  
  Wet Weather Peaking Factors .............................................................................................................. 15  
I&I Sources .............................................................................................................................................. 18  
  Sewer Degradation and Defects ............................................................................................................. 19  
  Manholes Covers as I&I Sources .......................................................................................................... 19  
  Pipe Materials ..................................................................................................................................... 21  
  Connection Interfaces and Trenches ..................................................................................................... 21  
  Private Laterals ................................................................................................................................... 22  
  Mimicking Sources .............................................................................................................................. 23  
Sewer System Regulations ....................................................................................................................... 25  
  Liquid Waste Management Plan Requirements .................................................................................... 26  
  New Sewer and Lateral Construction .................................................................................................... 27
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costs &amp; Managing Excessive I&amp;I</td>
<td>29</td>
</tr>
<tr>
<td>Wet Weather Overflows</td>
<td>29</td>
</tr>
<tr>
<td>I&amp;I Mitigation</td>
<td>31</td>
</tr>
<tr>
<td>Experience</td>
<td>31</td>
</tr>
<tr>
<td>Prioritizing I&amp;I Mitigation</td>
<td>31</td>
</tr>
<tr>
<td>I&amp;I Reduction and Asset Remediation</td>
<td>33</td>
</tr>
<tr>
<td>Private Lateral Management</td>
<td>34</td>
</tr>
<tr>
<td>Conclusions &amp; Recommendation</td>
<td>38</td>
</tr>
<tr>
<td>Conclusion</td>
<td>38</td>
</tr>
<tr>
<td>Recommendations</td>
<td>39</td>
</tr>
<tr>
<td>References</td>
<td>40</td>
</tr>
<tr>
<td>Appendix A: Inflow and Infiltration Reduction Program Recommendations</td>
<td>45</td>
</tr>
<tr>
<td>[Sewer System Evaluation Surveys] SSES Work Group Recommendations</td>
<td>45</td>
</tr>
<tr>
<td>I/I Analysis Work Group Recommendations</td>
<td>46</td>
</tr>
<tr>
<td>New Construction Work Group Recommendations</td>
<td>46</td>
</tr>
<tr>
<td>Appendix B: Liquid Waste Management Plan Requirements for I&amp;I Management</td>
<td>47</td>
</tr>
<tr>
<td>2002 Liquid Waste Management Plan I&amp;I Management Policies and Commitments</td>
<td>47</td>
</tr>
<tr>
<td>2010 Integrated Liquid Waste and Resource Management Plan I&amp;I Management</td>
<td>49</td>
</tr>
<tr>
<td>Appendix C: Methods for Estimating Inflow and Infiltration</td>
<td>51</td>
</tr>
<tr>
<td>Appendix D: Findings and Recommendations for New Sewer Construction</td>
<td>53</td>
</tr>
<tr>
<td>Appendix E: Model Bylaw for the Maintenance and Repair of Private Sanitary Sewer Laterals</td>
<td>56</td>
</tr>
<tr>
<td>Appendix F: Example Private Lateral Inspection Certification Application Form</td>
<td>67</td>
</tr>
</tbody>
</table>
## Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADWF</td>
<td>Average dry weather flow</td>
</tr>
<tr>
<td>CCTV</td>
<td>Closed circuit television</td>
</tr>
<tr>
<td>CSO</td>
<td>Combined sewer overflow</td>
</tr>
<tr>
<td>GVS&amp;DD</td>
<td>Greater Vancouver Sewerage and Drainage District</td>
</tr>
<tr>
<td>GDI&amp;I</td>
<td>Groundwater derived inflow and infiltration</td>
</tr>
<tr>
<td>I&amp;I</td>
<td>Rainwater inflow and groundwater infiltration, generally expressed as flow per area (L/ha-d)</td>
</tr>
<tr>
<td>I&amp;IMP</td>
<td>Inflow and infiltration management plan</td>
</tr>
<tr>
<td>IDF</td>
<td>Intensity, duration, frequency: statistical graphs for rainfall</td>
</tr>
<tr>
<td>ILWRM</td>
<td>Integrated Liquid Waste and Resource Management: A Liquid Waste Management Plan for the Greater Vancouver Sewerage &amp; Drainage District and Member Municipalities</td>
</tr>
<tr>
<td>LWMP</td>
<td>Liquid Waste Management Plan</td>
</tr>
<tr>
<td>MMS</td>
<td>Master Municipal Specifications</td>
</tr>
<tr>
<td>PDWF</td>
<td>Peak dry weather flow</td>
</tr>
<tr>
<td>PWWF</td>
<td>Peak wet weather flow</td>
</tr>
<tr>
<td>RDI&amp;I</td>
<td>Rain derived inflow and infiltration</td>
</tr>
<tr>
<td>REAC</td>
<td>Regional Engineering Advisory Committee</td>
</tr>
<tr>
<td>REAC-LWSC</td>
<td>Liquid Waste Subcommittee of the Regional Engineering Advisory Committee</td>
</tr>
<tr>
<td>SSO</td>
<td>Sanitary sewer overflow</td>
</tr>
<tr>
<td>WWTP</td>
<td>Wastewater treatment plant</td>
</tr>
</tbody>
</table>
Summary

It is Metro Vancouver’s members who determine and fund their inflow and infiltration (I&I) management programs while it is the effectiveness of these programs that determines the costs members contribute to supporting the GVS&DD’s storage, conveyance and treatment of excessive I&I.

Since the mid-1990s, Metro Vancouver and its GVS&DD members have collaborated to understand I&I issues and develop cost-effective I&I management solutions. In 2002, GVS&DD members made commitments to the Ministry of Environment on I&I reduction and management. However, over the last two decades I&I management efforts and reductions have been mixed. Municipal I&I that is substantially in excess of the regional I&I allowance of 11,200 L/ha∙d continues to contribute to sanitary sewer overflows from Metro Vancouver’s sewers, and continues to consume conveyance and treatment capacity provided for population growth by unnecessarily conveying and treating rainwater and groundwater.

Working with the Regional Engineering Advisory Committee’s Liquid Waste Sub-committee (REAC LWSC), the last two decades of I&I management programs in Greater Vancouver were reviewed along with best practices and observations from other jurisdictions.

This report concludes that the tools and know-how to control and manage I&I have been available to GVS&DD members for several decades. The primary challenge for local governments in controlling I&I appears to be a broad perception that I&I management is a lower municipal priority and the costs of unmitigated I&I on the regional sewer system are disconnected from the impacts to municipal finances.

Based on this review and in consideration of the commitments made by GVS&DD members’ municipal councils, which form regulatory requirements under two liquid waste management plans, the REAC LWSC recommends to following to address I&I:

1. That GVS&DD members continue to use the Envelope Method or the RTK Method to estimate sewer catchment I&I.
2. That by July 2019, GVS&DD members review their I&I management plans to contribute and develop a regional (Metro Vancouver-wide) list of municipally prioritized and targeted catchments that may be contributing to excessive I&I.
3. That by December 2019, GVS&DD members and Metro Vancouver evaluate members’ inspection practices for the new construction of sewers and public and private laterals and identify recommendations for improvements to bylaws, policies and procedures that will reduce I&I in new construction.
4. That by December 2019, GVS&DD members and Metro Vancouver identify suitable strategies for sewer lateral I&I management based on local work and North American case studies.
5. That by July 2020, GVS&DD members and Metro Vancouver identify guidelines for annual municipal sewer programs needed to address excessive I&I in prioritized and targeted catchments.
6. That by July 2020, GVS&DD members develop implementation options for private lateral I&I management to reduce excessive I&I.

7. That by December 2020, GVS&DD members and Metro Vancouver establish a coordinated strategy and implementation timeline for municipal I&I management priorities that will reduce the occurrence of wet weather SSOs and prioritize members’ I&I reduction efforts.

8. That by December 2020, GVS&DD members and Metro Vancouver develop a public education strategy and program blueprint to support private lateral I&I management.
Purpose

Since 2002, Metro Vancouver and its members have committed through two Liquid Waste Management Plans\(^1\) to better manage and reduce I&I. However, progress in I&I reductions over the last 20 years has been mixed. Consequently, excessive I&I has not been sufficiently reduced in all areas and I&I continues to consume sewer capacity allocated for future capacity growth as well as contribute to sewer overflows during wet weather. In 2017

This purpose of this report is to summarize current I&I management issues and recommend steps to better address the I&I management commitments outlined in the Liquid Waste Management Plans.

---

\(^1\) I&I management commitments were made by the GVS&DD Board and member municipal councils in both Liquid Waste Management Plans (Greater Vancouver Regional District, 2002, pp. 8, 29-30; Metro Vancouver, 2011, pp. 15-16). These commitments were approved by the Minister of Environment.
Context

Overview

“The causes of I&I are almost entirely due to human factors related to design, construction, quality assurance, inspection, monitoring and maintenance. Performance problems can also be further exacerbated by environmental factors such as soils and groundwater conditions, as well as the quality of materials. It is not for a lack of materials, methods and technology that I&I problems continue to be witnessed in sanitary sewer systems, rather it is a failure to account for all of the factors impacting performance and then to address them in an effective manner.”

(Kesik, 2015, p. 45)

It is Metro Vancouver’s members who determine and fund their inflow and infiltration (I&I) management programs while it is the effectiveness of these programs that determines the costs members contribute to supporting the GVS&DD’s storage, conveyance and treatment of excessive I&I.

I&I has been identified as a problem for sanitary sewers since the region’s first modern sanitary sewers were constructed in New Westminster around 19102. With the switch from separated sewers to combined sewers in 1912, I&I only emerged as an issue with the reintroduction of sanitary sewers and the need for wastewater treatment in the 1950s3.

ABR Consultants (1991, pp. ES-1, ES-3) reported that managing I&I is needed to reduce impact on the sanitary sewer network and this task has been an objective of the GVS&DD and its members since the early-1990s. During the mid-1990s, Metro Vancouver, its members, and the Ministry of Environment formed I&I task groups to examined different facets of I&I and provide guidance through a series of reports. These reports were intended to provide members with a common framework and methodology to address I&I (Greater Vancouver Regional District, 1995b, p. 5); key recommendations are summarized in Appendix A.

---

2 Contrary to the advice of Richard S. Lea and others, combined sewers were constructed for Burnaby, New Westminster, South Vancouver, Vancouver and Point Grey as a cost saving measure in place of dual sanitary and storms systems (Blackman, 1917; Lea, 1917). The University Endowment Lands was also serviced with combined sewers, while the City of North Vancouver had a few combined sewers installed in Moodyville, but serviced the rest of the city with separated sewers (Rawn, Hyde, & Oliver, 1953, p. 85).

3 Many sanitary sewers constructed in the Cities of Vancouver and Burnaby prior to the 1960s were built with combined laterals. The City of North Vancouver was serviced primarily with sanitary sewers; however, storm sewers were omitted for many streets and the presence of combined laterals is suspected for older properties (Metro Vancouver, 2016, p. 8).
Subsequently, these reports were used to inform the development of the 2002 Liquid Waste Management Plan (LWMP) which states:

“The sanitary sewer system currently experiences a fairly high level of wet-weather inflow and infiltration of rainwater because of system deterioration. This results in the overloading of existing trunk sewers and treatment plants with capacity being reached well in advance of what the need would be if their use were confined to sanitary sewage. Consistent and prudent investment in maintenance and rehabilitation can stretch system capacity, thereby delaying expensive capital expenditure, and reducing the frequency of emergency spills and overflows.”

(Greater Vancouver Regional District, 2002, p. 8)

and

“The District [GVS&DD] and its member municipalities will establish sewer system infrastructure management programs that will maintain the regional trunks and interceptors, the municipal collection system, and the private laterals in a state of good repair. The objective will be to ensure the sustainability of the collection system so that expensive repair and rehabilitation is not deferred to future generations and that the average daily infiltration and inflow will not exceed 11,200 litres per hectare per day as a result of a storm with less than a five year return period.”

(Greater Vancouver Regional District, 2002, p. 29)

Following the LWMP’s approval in 2002, GVS&DD members have undertaken I&I management programs with variable results. Based on the research by the GVS&DD and its members in the 1990s, an I&I allowance of 11,200 L/ha∙d was introduced to the region with the 2002 LWMP. In the 2002 LWMP, Metro Vancouver committed to a policy of providing its members with sufficient service to convey dry weather flows plus an I&I allowance of 11,200 L/ha∙d (Greater Vancouver Regional District, 2002, p. 29).

While the objectives of the 2002 Liquid Waste Management Plan remain valid, achieving the I&I allowance has proven difficult due to the complexities of the different sewer systems and the three tiers of sewer ownership: regional, municipal and private.

In the development of the ILWRMP, it was recognized that I&I management required additional actions. New actions which include the development and implementation of I&I management plans and private lateral certification were added to the ILWRMP. A list of the I&I management policies, commitments and actions in the 2002 LWMP and 2010 ILWRMP are provided in Appendix B.

Sewer Systems and Ownership
Local government sewers can be classified into one of three groups: sanitary, combined and stormwater. I&I is only a concern for sanitary sewers as these are generally not designed to convey significant quantities of rainwater or groundwater. An exception is semi-combined sewers which may
be considered as a fourth class of sewer but are most often described as sanitary sewers. These are legacy sewer that are still very common throughout Canada. The difference between semi-combined sewers and sanitary sewers is that semi-combined sewers are designed to accept building foundation drainage and consequently are intended to convey significant amounts of rainwater and groundwater. The extents of semi-combined sewers in the Metro Vancouver region is unclear, but they are not believed to be widespread. They have generally been classified as sanitary sewers in municipal asset inventories and are likely limited to areas serviced prior to the mid-1960s and are designed for greater rates of inflow and infiltration as compared to true sanitary sewers.

With respect to ownership, there are multiple sewerage system and owners in the Metro Vancouver region. These systems include many small, private sewerage systems which service strata developments in rural or semi-rural areas, as well as small public systems which service local communities such as the Village of Lions Bay. However, the vast majority of the region is serviced by five major sewerage networks connected to five regional wastewater treatment plants. These systems are operated and connected under three levels of ownership: regional government, municipal government and private owners.

The regional sewer system is organized into Metro Vancouver’s four sewerage areas: Fraser Sewerage Area, Lulu Island West Sewerage Area, North Shore Sewerage Area and Vancouver Sewerage Area. Metro Vancouver provides wastewater treatment and major wastewater conveyance as the receiver of municipal wastewater, while municipalities operate sewerage collection works that connect the regional system to wastewater sources. Private sewers connect wastewater sources on private property to the municipal and regional systems through private sewer laterals. Together, the two local government systems (Metro Vancouver and municipal) represent over half the total length of sewer pipes in the region.

This ownership structure is illustrated by Figure 1 which also provides the estimated lengths of sewer falling under each tier of ownership. The lengths of municipal sewers and number of service connections are shown in Table 1.

---

4 Semi-combined sewers were first identified in a 2014 study examining I&I allowances and further investigated in 2016 to determine if there is an easy method to identify them as they are considered I&I sources (Metro Vancouver, 2016). The approach recommended in the 2016 study is being evaluated by Burnaby, North Vancouver City and Surrey in 2017 to determine whether the methodology is useful in I&I management programs.

5 Private sewer laterals are estimated to be about 80% of the total laterals, where the remaining 20% of laterals are generally confined to public rights-of-way and are considered public laterals. Overall lateral length is estimated from an average length of 16 metres and the total number of sanitary sewer connections as reported by municipalities in the Biennial Report (Metro Vancouver, 2017b).
Table 1 Lengths of Sewers and Number of Sewer Connections by Municipality (Metro Vancouver, 2017b)

<table>
<thead>
<tr>
<th></th>
<th>Sanitary Sewer (km)</th>
<th>Combined Sewer (km)</th>
<th>Total Sewers (km)</th>
<th>Sanitary Service Connection</th>
<th>Combined Service Connection</th>
<th>Total Service Connection</th>
<th>Estimated San. Lateral Length† (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burnaby</td>
<td>610</td>
<td>49</td>
<td>659</td>
<td>33,035</td>
<td>3,439</td>
<td>36,474</td>
<td>529</td>
</tr>
<tr>
<td>Coquitlam</td>
<td>485</td>
<td>-</td>
<td>485</td>
<td>25,272</td>
<td>-</td>
<td>25,272</td>
<td>404</td>
</tr>
<tr>
<td>Delta</td>
<td>478</td>
<td>-</td>
<td>478</td>
<td>30,100</td>
<td>-</td>
<td>30,100</td>
<td>482</td>
</tr>
<tr>
<td>Langley City</td>
<td>85</td>
<td>-</td>
<td>85</td>
<td>3,812</td>
<td>-</td>
<td>3,812</td>
<td>61</td>
</tr>
<tr>
<td>Langley Township</td>
<td>302</td>
<td>-</td>
<td>302</td>
<td>14,794</td>
<td>-</td>
<td>14,794</td>
<td>237</td>
</tr>
<tr>
<td>Maple Ridge</td>
<td>301</td>
<td>-</td>
<td>301</td>
<td>15,566</td>
<td>-</td>
<td>15,566</td>
<td>249</td>
</tr>
<tr>
<td>New Westminster</td>
<td>36</td>
<td>148</td>
<td>184</td>
<td>1,453</td>
<td>6,082</td>
<td>7,535</td>
<td>23</td>
</tr>
<tr>
<td>North Vancouver City</td>
<td>124</td>
<td>-</td>
<td>124</td>
<td>6,781</td>
<td>-</td>
<td>6,781</td>
<td>108</td>
</tr>
<tr>
<td>North Vancouver Dist.</td>
<td>380</td>
<td>-</td>
<td>380</td>
<td>21,499</td>
<td>-</td>
<td>21,499</td>
<td>344</td>
</tr>
<tr>
<td>Pitt Meadows</td>
<td>46</td>
<td>-</td>
<td>46</td>
<td>3,122</td>
<td>-</td>
<td>3,122</td>
<td>50</td>
</tr>
<tr>
<td>Port Coquitlam</td>
<td>182</td>
<td>-</td>
<td>182</td>
<td>11,030</td>
<td>-</td>
<td>11,030</td>
<td>176</td>
</tr>
<tr>
<td>Port Moody</td>
<td>107</td>
<td>-</td>
<td>107</td>
<td>7,334</td>
<td>-</td>
<td>7,334</td>
<td>117</td>
</tr>
<tr>
<td>Richmond</td>
<td>469</td>
<td>-</td>
<td>469</td>
<td>31,565</td>
<td>-</td>
<td>31,565</td>
<td>505</td>
</tr>
<tr>
<td>Surrey</td>
<td>1,578</td>
<td>-</td>
<td>1,578</td>
<td>83,342</td>
<td>-</td>
<td>83,342</td>
<td>1,333</td>
</tr>
<tr>
<td>Vancouver</td>
<td>665</td>
<td>651</td>
<td>1,315</td>
<td>47,038</td>
<td>38,203</td>
<td>85,241</td>
<td>753</td>
</tr>
<tr>
<td>West Vancouver</td>
<td>336</td>
<td>-</td>
<td>336</td>
<td>12,680</td>
<td>-</td>
<td>12,680</td>
<td>203</td>
</tr>
<tr>
<td>White Rock</td>
<td>82</td>
<td>-</td>
<td>82</td>
<td>4,540</td>
<td>-</td>
<td>4,540</td>
<td>73</td>
</tr>
<tr>
<td>UEL</td>
<td>12</td>
<td>3</td>
<td>15</td>
<td>272</td>
<td>100</td>
<td>372</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>6,276</td>
<td>851*</td>
<td>7,127</td>
<td>353,235</td>
<td>47,824</td>
<td>401,059</td>
<td>5,652†</td>
</tr>
</tbody>
</table>

*This value has alternately been estimated as 1,035 km which reflects differences in municipal classification of separation work.
†Based on estimated average 16 m lateral length (both public and private) and includes only sanitary sewer connections.

Sewer Maintenance and I&I Management

In Metro Vancouver’s I&I Management Template, Kerr Wood Leidal Associates (2011) defines three tiers of I&I management: Tier 1 consists of managing mainline sewers and lateral connection interfaces;
Tier 2 consists of managing sewer laterals within public rights-of-way; and Tier 3 is the management of sewer laterals on private property.

Although municipal governments undertake sewer inspection and maintenance programs that benefit the identification and reduction of I&I in their sewers (Tiers 1 and 2), the owners of private sewer laterals seldom undertake similar programs (Tier 3). Private sewer lateral maintenance is generally carried out only in responses to local blockages, lateral failures or other operational problems.

Furthermore, the absence of Tier 3 I&I management is one explanation offered (Metro Vancouver, 2014, pp. 24-25) as to why municipal I&I management programs are not always able to reduce I&I rates to meet the region-wide allowance of 11,200 L/ha·d; others are “illicit” cross-connections to sanitary sewers and the legacy of “permitted” cross-connections in semi-combined sewers (Metro Vancouver, 2016, pp. 8-10).

Funding and prioritizing local governments programs to identify and reduce I&I (whether Tier 1 or 2) are often done in consideration of other local drivers and priorities. Irrespective, I&I reduction programs are part of long-term, ongoing sewer operations and maintenance strategies. Annual budgets for municipal sanitary sewer condition evaluation and rehabilitation are summarized in Table 2. In 2015 and 2016, approximately $3.6 million was spent annually by GVS&DD members to assess the condition of their sanitary sewers, and $12.4 and $16.6 million were spent each year rehabilitating municipal sewers. These costs do not include specific I&I management work which may have been accounted for separately from the two program categories in Table 2.

Regional and municipal sewer condition evaluation programs support Tier 1 I&I management programs. Evaluating the municipal budgets reported in Table 2 with the sewer system extents provided by Table 1, results in the comparison of unit costs shown by Figure 2. In general, around $0.40/m was allocated annually for municipal sewer condition evaluation in 2015 and 2016.

**Assessing Impacts and Risks of I&I**

Excessive I&I is considered by Metro Vancouver to be the I&I that is greater than the current I&I allowance of 11,200 L/ha·d. Excessive I&I consumes trunk sewer capacity, requires extra energy for pumping and treatment, and can increase the likelihood of sanitary sewer overflows (SSOs) and sewer backups. I&I related overflows, either SSOs or sewer backups, pose risks to the public health, utility workers and the environment. I&I management is a challenge for many utilities. The Water Environment Federation (2016, pp. 1-2) reports that 27% of all SSOs in the United States are due to I&I.

While not believed to be an issue in this region, excessive I&I due to a lack of municipal sewer inspection and maintenance may leave a municipality liable for sewer backup damages under certain circumstances.
### Table 2 Annual Municipal Budgets for Sewer Asset Evaluation and Rehabilitation (Metro Vancouver, 2017b)

<table>
<thead>
<tr>
<th>Sanitary Sewer Condition Evaluation Program (dollars annually)</th>
<th>Sewer System Rehabilitation Program (dollars annually)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Burnaby</td>
<td>$552,000</td>
</tr>
<tr>
<td>Coquitlam</td>
<td>476,000</td>
</tr>
<tr>
<td>Delta</td>
<td>120,000</td>
</tr>
<tr>
<td>Langley City</td>
<td>40,000</td>
</tr>
<tr>
<td>Langley Township</td>
<td>92,700</td>
</tr>
<tr>
<td>Maple Ridge</td>
<td>51,750</td>
</tr>
<tr>
<td>New Westminster</td>
<td>100,000</td>
</tr>
<tr>
<td>North Vancouver City</td>
<td>50,000</td>
</tr>
<tr>
<td>North Vancouver Dist.</td>
<td>250,000</td>
</tr>
<tr>
<td>Pitt Meadows</td>
<td>209,800</td>
</tr>
<tr>
<td>Port Coquitlam</td>
<td>44,000</td>
</tr>
<tr>
<td>Port Moody</td>
<td>—</td>
</tr>
<tr>
<td>Richmond</td>
<td>200,000</td>
</tr>
<tr>
<td>Surrey</td>
<td>838,000</td>
</tr>
<tr>
<td>Vancouver</td>
<td>300,000</td>
</tr>
<tr>
<td>West Vancouver</td>
<td>197,800</td>
</tr>
<tr>
<td>White Rock</td>
<td>45,000</td>
</tr>
<tr>
<td>UEL</td>
<td>—</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$3,567,050</strong></td>
</tr>
</tbody>
</table>

* This work is generally covered through the combined sewer separation program

---

**Figure 2 Comparison of Annual Budgets for Sanitary Sewer Condition Evaluation Programs (Metro Vancouver, 2017b)**
Research published by Sandink (2007, p. 3) reports that Ontario Sewer and Watermain Construction Association concluded that a municipality may be found liable in negligence for sewer backups due to failing infrastructure if:

- It failed to have an infrastructure inspection system in place;
- It failed to ensure the system was reasonably maintained; its employees (or agents) were careless in constructing, inspecting and maintaining the system, or;
- If it failed to respond to complaints in a timely manner (e.g., if a flood or sewer backup occurred due to slow response time by a city crew).

Furthermore, unmitigated RDI&I rates are expected to increase I&I rates as the reoccurrence of severe rainfall is anticipated to increase with climate change. The impacts of severe rainfall are described by the Institute for Catastrophic Loss Reduction as follows:

"Severe rainfall and associated basement flooding are leading causes of damage to Canadian homes... resulting in hundreds of millions of dollars in insured and uninsured losses. Numerous factors, including increasing urbanization, issues associated with age, design and construction of infrastructure and climate change are expected to increase urban flood risk in many parts of Canada over the coming decades. Inflow and infiltration (I&I) is also an ongoing concern in many municipalities, as it both increases sewer backup risk and contributes quantities of excess stormwater to wastewater treatment systems, reducing capacity, increasing operating costs and increasing risk of bypasses."

(Kyriazis, Zizzo, & Sandink, 2017, p. 1)

In the Metro Vancouver region, the primary impacts of excessive I&I are extra pumping and treatment costs, loss of pipe conveyance capacity, and wet weather overflows to receiving waterbodies. Sewer backups and basement flooding due to excessive I&I have not been identified by GVS&DD member municipal staff as a common occurrence (Kiyonaga, 2015). Therefore, cost effectively reducing the likelihood of overflows to waterbodies, conserving sewer and treatment capacity and avoided pumping and treatment costs are currently the primary benefits from managing excessive I&I in the Metro Vancouver region.

While the physical I&I impacts are easily described, the cumulative financial impact costs have been difficult to accurately estimate. Cost estimates of preferred I&I mitigation strategies are often compared against the costs to convey and treat higher levels of I&I; these are then used to inform I&I...

---

6 Analysis by GHD (2018, pp. 36-40) on the Collingwood Sanitary Trunk sewer determined that I&I associated with the 1:5-year return storm frequency will increase due to climate change.
management policies. This is a consistent approach among most North American utilities where excessive I&I is managed only if it is less costly than increasing conveyance and treatment capacity (Water Environment Federation, 2016, p. 14). This approach is illustrated by Figure 3.

![Figure 3 Cost-Benefit Rationale for I&I Management: Convey and Treat (Left) vs I&I Management (Right) (AECOM, 2013, p. 32)](image)

This cost-benefit approach was applied to the Fraser, Lulu Island West and North Shore Sewerage Areas during the development of the LWMP in the late 1990s. Analysis determined the preferred I&I strategies are to target priority basins with the greatest RDI&I for rehabilitation as this provides the best value for each dollar spent (Metro Vancouver, 2014, pp. 41-45). The strategy of targeted I&I management was reaffirmed in 2014 as part of the I&I allowance evaluation (Metro Vancouver, 2014, p. 35).

**I&I Management Cost Effectiveness**

Quantifying the costs of sewer backups and benefits of I&I mitigation was attempted by the Institute for Catastrophic Loss Reduction. Examination of the Greater Toronto Area using lifecycle analyses indicates that steady ongoing investment in I&I reduction over a 50 year window would be positive and cost effective (Kesik, 2015, pp. 9-11).

However, identifying generic thresholds for cost effective I&I management that can be applied among different cities is challenging and may not be useful due to the uniqueness of each sewer catchment. While benefits are most easily identified as treatment and conveyance cost reduction, the costs of overflows remain difficult to generalize and estimate. Consequently, the urgency to aggressively reduce I&I rates seldom materializes unless I&I rates are exceedingly high or I&I induced overflows are

---

7 Net present value analysis and capacity upgrade scenarios were examined with respect to the appropriate I&I allowances and strategies (Metro Vancouver, 2014, pp. 41-46, 52-61). As well, cost-benefit analysis was developed for different tiers of I&I management effort (AECOM, 2013).

8 While the costs of overflows may be accounted under “other” costs as described by Figure 3, their value depends on the site specifics of where the overflow has occurred as well as the magnitude and duration of the overflow. Furthermore, the cost-benefits of I&I mitigation are unique to each sewer system (Water Environment Federation, 2016, p. 14)
causing frequent environmental or property impacts. As well, the unit costs of I&I removed are generally lower for systems with exceedingly high I&I rates as they generally benefit significantly from mainline and manhole rehabilitation as compared to systems with chronic I&I that may require significant private lateral remediation. Extrapolating a generalized relationship is not useful given the wide variability in costs and reductions; this is evident by Figure 4 which shows significant variability between case studies.

![Figure 4 Cost-Effectiveness Comparison Curve for RDII U.S. Case Studies, (Merrill et al., 2003, pp. ES-3 to ES-4)](image)

In multi-level utilities, the benefits of I&I management are not always directly apparent, nor are costs and benefits necessarily shared evenly at all levels of ownership. The I&I reduction benefits to Metro Vancouver’s sewer system with respect to avoided SSOs and reduced conveyance treatment costs have been difficult to quantify at the regional level, let alone at the municipal level. While the impacts of high I&I from private laterals are borne collectively by municipalities through the GVS&DD, I&I mitigation efforts to address municipal and private lateral I&I are undertaken independently by each municipal.

This can lead to a misalignment of regional and municipal interests as illustrated by the following extracted from a City of Surrey I&I management plan:

---

9 US dollars adjusted to Canadian dollars at a factor of C$1.20 to US$1.00.
“The City has invested nearly $5M over the past years with limited measureable [I&I] improvements where significant amounts of infrastructure could have been replaced. The historical program was focused on fixing cracks and joints with grouting which does not treat the problem for the long-term as I&I levels have been proven to continue to increase with pipe age.

In such case, there is limited incentive to do more at present as the City is currently not seeing savings or benefits from the work performed in respect to charges paid to Metro Vancouver, particularly when the MV charges are based on dry weather flows.

When the future capital projects such as the expansion of MV’s Annacis WWTP (estimated to be $450M) are taken into consideration the benefit / cost ratio increases but the optimum point remains close to Tier 1 and quickly diminishes towards Tiers 2 and 3.”

(AECOM, 2013, p. iii)

The I&I plan prepared by AECOM (2013) highlights a common challenge: when GVS&DD members develop I&I management strategies, the supporting analysis represents only the municipality’s perspective and can have difficulty taking into account the municipal share of the regional costs to convey, store and treat excess I&I. Specifically, the regional costs to manage excessive I&I are divided among its members based on dry weather (25th percentile) flow and do not reflect the different, individual municipal levels of contributing I&I. Consequently, the current cost allocation methodology does not recognize municipal I&I reduction progress when allocating regional treatment and conveyance costs as only dry weather flows are considered.

Commitments in the ILWRMP include changing the sewerage area cost allocation to be based on 75th percentile of flow to take I&I into account. In developing a supporting process to enable this change, work by the REAC LWSC examined whether cost allocation based on the 75th percentile flow would be more equitable and offer better incentives to member municipalities to reduce excessive I&I. However, it was determined that problematic I&I induced SSOs occur closer to the 95th percentile flow and not at the 75th percentile flow. While the 75th percentile flow would provide some incentives to reduce groundwater infiltration, incentives for reducing the amounts of rainwater inflow responsible for SSOs may be better achieved by using a flow peaking surcharge. The current Metro Vancouver sewer billing meter is configured to provide data for 25th percentile (dry weather) cost allocation. To move to wet weather cost allocation, new flow monitors would need to be installed, some upgraded while others operated at a higher level of effort to provide data to enable reliable 75% percentile cost allocation. As a

---

10 Metro Vancouver’s cost allocation is among sewerage area members and is based upon 25th percentile (dry weather) flow for the Fraser Sewerage Area, property assessments for the Vancouver Sewerage Area or pre-set percentages for the North Shore Sewerage Area. The Lulu Island [West] Sewerage Area is 100% City of Richmond.
result, further work developing 75\textsuperscript{th} percentile flow cost allocation methodology was deferred at the request of the REAC LWSC\textsuperscript{11}.

Measuring and Comparing I&I

Consistent methodologies allow comparison of I&I rates among catchments and between storm events; however, a standardized methodology for measuring I&I has not been accepted among wastewater professionals. The most commonly used methodologies for calculating I&I in the Metro Vancouver region are the Envelope Method and RTK Method\textsuperscript{12}. Each methodology has its advantages and disadvantages with respect to complexity, data requirements and accuracy. In Metro Vancouver’s Inflow and Infiltration Management Plan Template (Kerr Wood Leidal Assoc., 2011), the Envelope Method is recommended as the preferred methodology.

The Envelope Method was introduced to the GVS&DD and its members around 2002, and is used by most GVS&DD members to determine peak hourly I&I normalized to 1:5-year return rainfall event. Comparison by Soong & Bell (2013) found that the RTK Method better represents the sources of RDI&I and noted that it can be used to model the dynamic response of the sewer system to rainfall events.

When comparing the two methodologies for study catchments in Coquitlam, Soong & Bell (2013) found the relationship between the results derived from the two methods varied and concluded that the RTK Method estimates higher I&I rates if catchment resolution is more discrete, whereas the Envelope Method estimates higher I&I if the catchment resolution is less discrete.

An extensive list of other methods for estimating I&I was created by Hey, Jönsson, & Mattsson (2016, pp. 4-5) and is included in Appendix C. Each of these methods has its unique advantages and disadvantages, with some methods being suited to identifying GDI&I. In a comparison of different I&I estimation methods (Weidelener, Krampe, Birkner, & Bosseler, 2007), the Moving-Minimum Method was found to be the simplest in determining system I&I and generally resulted in values between the estimates derived using the Minimum Night-time Flow Method (consistently low range) and the Difference Water Consumption Method\textsuperscript{13} (consistently high range). However, none of the methods described by Hey, Jönsson, & Mattsson (2016) or Weidelener et al. (2007) appear to normalize I&I estimates to a common rainfall return frequency.

Furthermore, work by GHD (2018) indicates that rainfall intensity is likely to increase significantly due to climate change and will result in higher-I&I generating storms becoming more frequent. Therefore, in

\textsuperscript{11} This evaluation work was undertaken by the REAC LWSC in 2010.

\textsuperscript{12} Metro Vancouver also estimate I&I at its permanent sewer flow meter sites using a first principle approach (Metro Vancouver, 2014, pp. 8-9). These estimates are not normalized to the 1:5-year rainfall return period.

\textsuperscript{13} This method is described by Weidelener, et al. (2007) as the Jahresschmutzwassermethode and is based on comparing measured wet weather flow to sewer flow which is derived from metered drinking water consumption. It is not included in the list developed by Hey, Jönsson, & Mattsson (2016).
the long-term, the advantage of using the Envelope Method to compare normalized catchment I&I rates and I&I mitigation will diminish as the rainfall intensities for given return periods increase.

**Data and I&I Estimation**

A common challenge for both methodologies is ensuring sufficient data is accurately collected to estimate I&I rates. For example, observed variability before and after I&I mitigation for catchments in Surrey show some catchments where I&I increased post-remediation while others showed I&I reductions (Metro Vancouver, 2017b, pp. 350-352). Table 3 shows similar variability in the City of North Vancouver, and Table 4 shows I&I rates grouped by Tier for mainline and lateral remediation for three catchments in Cloverdale, Surrey. Both Tables show peak hourly I&I flows normalized for the 1:5-year return storm event.

*Table 3 Year-to-year Variability of I&I Rates for City of North Vancouver Catchments (Metro Vancouver, 2017b, p. 242)*

<table>
<thead>
<tr>
<th>Catchment</th>
<th>Normalized I&amp;I Rates (L/ha·d)</th>
<th>2009/2010</th>
<th>2012/2013</th>
<th>2015</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st and St Davids</td>
<td></td>
<td>118,100</td>
<td>—</td>
<td>90,200</td>
<td>136,800</td>
</tr>
<tr>
<td>3rd and Queensbury</td>
<td></td>
<td>—</td>
<td>85,200</td>
<td>49,700</td>
<td>65,874</td>
</tr>
<tr>
<td>6th and Forbes</td>
<td></td>
<td>70,500</td>
<td>—</td>
<td>30,500</td>
<td>52,200</td>
</tr>
<tr>
<td>East Keith</td>
<td></td>
<td>—</td>
<td>131,300</td>
<td>90,800</td>
<td>—</td>
</tr>
</tbody>
</table>

*Table 4 Changes in I&I Pre- and Post Catchment Remediation (AECOM, 2013, pp. 8a-8b)*

<table>
<thead>
<tr>
<th>Catchment</th>
<th>Normalized I&amp;I Rates (L/ha·d)</th>
<th>Before Remediation</th>
<th>Tier 1 &amp; 2 Mitigation</th>
<th>Tier 3 Mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cloverdale 1 (29 ha)</td>
<td></td>
<td>17,517</td>
<td>13,396</td>
<td>13,641</td>
</tr>
<tr>
<td>Cloverdale 2 (13 ha)</td>
<td></td>
<td>23,825</td>
<td>48,697</td>
<td>29,938</td>
</tr>
<tr>
<td>Cloverdale 3 (23 ha)</td>
<td></td>
<td>21,060</td>
<td>34,160</td>
<td>24,315</td>
</tr>
</tbody>
</table>

Such variability may be due to errors in data collection, equipment calibration, the absence of significant rain events during flow monitoring, or changes in catchment characteristics. Irrespective of the causes, accurately determining I&I is challenging as additional time, costs, quality control and analysis may be required to ensure useful data is collected and I&I meaningfully estimated. Furthermore, errors in I&I estimates lead to misrepresentation and misunderstanding of the benefits of I&I reduction programs.

**Wet Weather Peaking Factors**

In addition to directly estimating catchment I&I, wet weather peaking is another parameter that can be used to assess the relative magnitude of I&I. York Region (2011, p. 47) uses wet weather peaking factors as one of its criteria to identify whether catchment I&I is a low, medium or high priority: wet weather peaking factors

---

14 The weather of 2015 included summer drought conditions and heavy winter and autumn rains which resulted in greater than the typical number of SSO events when compared to prior years.
peaking factors below 4 are considered low priority, between 4 to 6 are the medium priority, while wet weather peaking factors above 6 are considered high priority. Water New Zealand (Carne & Le, 2015a, p. 33) recommends a peaking factor of 5 as the indicator that I&I remediation is required. Neither of these peaking factors are normalized to any particular rainfall return frequency.

Section 44 of the BC Municipal Wastewater Regulations (MWR) sets a maximum wet weather peaking factor of two times average dry weather flow for 1:5-year return flow for sanitary sewer systems as measured at the wastewater treatment plant. Local governments with peaking factors greater than this limit are required to develop and implement liquid waste management plans that will either bring wet weather peaking within this limit or mitigate the effects.

The highest Metro Vancouver wet weather peaking factors observed for the Annacis Island and Lions Gate WWTPs are greater than the twice average dry weather flow threshold defined under the Municipal Wastewater Regulations. Only the NW Langley and Lulu Island WWTPs are consistently under the twice average dry-weather threshold. The relationship of the wastewater treatment plants as well as key pump stations are shown for the peak annual event by Figure 5 and Figure 6.

If York Region’s peaking factor criteria are applied to these Figures, then all Sewerage Areas except the North Shore would be ranked low priority; the North Shore would be a medium I&I priority. However, these Figures show the most extreme annual peaking factor and include return periods greater than the MWR threshold of 1:5-years. This may explain why there are no trends or patterns evident for either Annacis Island or Lions Gate WWTPs with respect to their peaking factors: the peaking factors provided are the result of different rainfall durations, intensities and event return frequencies.

---

15 The wet weather peaking factors shown in Figure 5 and Figure 6 are for the most extreme I&I in the recording period (and include events greater than 1:5-year return period) and are calculated as the maximum hourly flow of the maximum flow day divided by the 25th percentile of average daily flow for the year. The 25th percentile of average daily flow is used to represent dry weather flow.

16 The Iona Island WWTP treats mostly combined sewage and consequently is not comparable. Peaking factors are calculated based on the maximum hourly flow on the annual maximum flow day divided by the 25th percentile of daily annual flow for the year. These may be the result of rainfall from storms with greater than 1:5-year return frequencies.

17 One possible exception is the Tilbury Forcemain. This may be due to improved wet weather leachate controls at the Vancouver Landfill, or be due to increased dry weather flows relative to unchanged peak wet weather flows.
Figure 5 Wet Weather Peaking Factors for Annacis Is WWTP and Tributaries

Figure 6 Wet Weather Peaking Factors for NW Langley, Lulu Is and Lions Gate WWTPs plus North Shore Tributaries
I&I Sources
Within the Metro Vancouver region, I&I are generally attributed to rainwater inflow from cross-connections to drains and downspouts, or groundwater infiltration through pipe defects. I&I may also enter sanitary sewers through manhole lids and other defects. I&I may originate in all three groups of sewer ownership, with private sewer laterals having been identified as significant sources of excessive I&I since the 1990s (US Environmental Protection Agency, 1990, p. iv; Greater Vancouver Regional District, 2002, p. 30). Three of five of Metro Vancouver’s WWTPs respond quickly to rainfall: Annacis Island, Lions Gate, and Iona Island. While the system tributary to the Iona Island WWTP is still predominantly combined sewer, the systems tributary to Annacis Island WWTP and the Lions Gate WWTP are not. RDI&I is believed to be significant in the catchments tributary to the Annacis Island and Lions Gate WWTPs as shown by Figure 7.

Sufficient cross-connections and other inflow mechanisms into these systems have yet to be identified and mitigated. While previous studies emphasize the significant role that private-side inflow is likely having on the liquid waste system (Metro Vancouver, 2014, pp. 21, 27; Metro Vancouver, 2016, p. 41), other wet weather inputs also need to be quantified and addressed as part of complete I&I management strategies. Tools such as CCTV inspections, flow monitoring, and smoke and dye testing continue to be essential to identifying I&I either as part of an asset management program or as part of a dedicated I&I program.

Figure 7 Flow Response to Precipitation for Metro Vancouver WWTPs (Metro Vancouver, 2017a)
**Sewer Degradation and Defects**

Inspection programs are the core to maintaining mainline and lateral sewer pipe integrity and eliminating cross-connections. It is well established that defects and holes in mainline sewers, manholes and connection interfaces allow I&I into the sewer system. Estimates of the associated I&I rates are shown in Table 5.

<table>
<thead>
<tr>
<th>Description of Inflow Stream</th>
<th>L/s</th>
<th>L/d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slow Drip</td>
<td>0.001</td>
<td>82</td>
</tr>
<tr>
<td>Fast Drip</td>
<td>0.002</td>
<td>163</td>
</tr>
<tr>
<td>Steady Dribble</td>
<td>0.004</td>
<td>338</td>
</tr>
<tr>
<td>1.6 mm Stream</td>
<td>0.018</td>
<td>1,525</td>
</tr>
<tr>
<td>Drinking Fountain Stream</td>
<td>0.032</td>
<td>2,724</td>
</tr>
<tr>
<td>6.4 mm Stream</td>
<td>0.035</td>
<td>3,051</td>
</tr>
<tr>
<td>12.7 mm Stream (Garden Hose)</td>
<td>0.315</td>
<td>27,240</td>
</tr>
</tbody>
</table>

While I&I rates for small defects can be modest, they can represent significant I&I flow if numerous throughout a catchment basis.

**Manholes Covers as I&I Sources**

Manholes are sometimes overlooked as important I&I sources even though they can contribute significant I&I (Toronto Water, 2018, p. 3). Manhole lid bolt holes and road grading that directs runoff towards manholes are potential RDI&I inputs that can be addressed through the plugging of manhole cover bolt holes, installing manhole cover gaskets, manhole repairs and better road grading. One set of estimated inflows for different size manhole bolt holes and different depths of standing water over the manhole cover are shown in Table 6.

<table>
<thead>
<tr>
<th>Depth of Water Over Manhole Cover (mm)</th>
<th>Flow Through Cover Seal (No Gasket)</th>
<th>Flow Through Single 38 mm Ø Bolt Hole in the Cover</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L/s</td>
<td>L/d</td>
</tr>
<tr>
<td>1.6</td>
<td>0.63</td>
<td>54,480</td>
</tr>
<tr>
<td>6.4</td>
<td>0.76</td>
<td>65,380</td>
</tr>
<tr>
<td>13</td>
<td>0.88</td>
<td>76,270</td>
</tr>
<tr>
<td>25</td>
<td>1.07</td>
<td>92,620</td>
</tr>
<tr>
<td>102</td>
<td>1.45</td>
<td>125,300</td>
</tr>
</tbody>
</table>

The research cited by Telzlaff (2010) is based on published values determined through experiments by Meyer & Warren (1976). This work determined that RDI&I rates can be very large and require only a small amount of standing water over a manhole cover. In contrast, more recent work by Mustaffa et al.
(2006) suggest substantially lower, but still significant inflow can occur through manhole cover bolt holes. These results are provided in Table 7. Furthermore, an inflow value of 0.17 L/s (when the depth of water is 50 mm over a 19mm bolt hole) is recommended by the Commonwealth of Massachusetts (2017, p. 38) for sewer I&I and is more similar to the values determined using the methodology of Mustaffa et al. than the results of Meyer & Warren.

Table 7 Estimated Inflow Rates Through Manhole Bolt Holes (Mustaffa, Rajaratnam, & Zhu, 2006)

<table>
<thead>
<tr>
<th>Depth of Water Over Manhole Cover (mm)</th>
<th>Flow Through Single 19 mm Ø Bolt Hole in the Cover</th>
<th>Flow Through Single 38 mm Ø Bolt Hole in the Cover</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L/s</td>
<td>L/d</td>
</tr>
<tr>
<td>1.6</td>
<td>0.03</td>
<td>2,670</td>
</tr>
<tr>
<td>6.4</td>
<td>0.06</td>
<td>5,350</td>
</tr>
<tr>
<td>13</td>
<td>0.09</td>
<td>7,620</td>
</tr>
<tr>
<td>25</td>
<td>0.12</td>
<td>10,560</td>
</tr>
<tr>
<td>102</td>
<td>0.25</td>
<td>21,340</td>
</tr>
</tbody>
</table>

In addition to I&I through manhole covers, defects in manhole structures can also allow I&I to enter sewers. Table 5 can be used to assign flow rates to different observed inflow characteristics. Although manhole I&I can be significant, it is highly variable due to the uniqueness and condition of each manhole. Manhole I&I can theoretically contribute to I&I rates well in excess of regional I&I allowance of 11,200 L/ha∙d. To illustrate this and translate the observations in Table 5 and Table 7 into areal I&I rates, the following hypothetical scenarios are presented: 18

Scenario 1: Number of Manholes and Magnitude of Inflow
If a city block is approximately 1.0 ha in area and serviced by a sanitary sewer and 1 manhole, then the I&I rate for one 12.7 mm diameter inflow stream could equal 27,240 L/ha∙d. If such conditions were persistent throughout the broader catchment area, then the I&I allowance would be exceeded.

Scenario 2: Number of Manholes and Magnitude of Inflow
Alternately, for a different city block 1.2 ha in area and serviced with multiple sewer branches and five manholes, but experiencing only steady drips and dribbles of I&I in each manhole, manhole I&I could be 1,354 L/ha∙d: much lower than the regional I&I allowance.

Scenario 3: Standing Water on Manhole Lids
Scenario 3: In wet weather, I&I through manhole gasketed rims and bolts holes might be expected to mimic drips and dribbles and result in minimal inflow rates of 82 to 652 L/ha∙d and would not be an I&I management concern. However, if manholes were situated in wheel ruts or other depressions, inflow

---

18 Inflow rates are provided by Telzlaff (2010). The block area and the number of manholes per block are highly variable. The area is a rounded average of one block in Vancouver and one in Burnaby. Lots on the 3100-Block West 15th Avenue, Vancouver cover 1.02 ha, contain 22 dwellings, and are serviced with one manhole. Lots on the 6300-Block Halifax Avenue, Burnaby cover 1.25 ha, contain 19 dwellings, and are serviced with 5 manholes. The regional I&I allowance is 11,200 L/ha∙d (Metro Vancouver, 2014, p. 35)
could be significant. Upwards of 10,680 L/d could enter through a manhole’s four bolt holes if the manhole were submerged in just 1.6 mm of water\textsuperscript{19}.

This suggests that a few problematic manholes could be major I&I sources for some catchments, but also highlights some of the challenges in identifying key I&I sources if the I&I is originating from just a few locations. The lack of manhole lid sealing around their frames can add further manhole I&I.

**Pipe Materials**

Materials used for municipal and regional sewer mains include brick, concrete, vitrified clay, asbestos-cement and PVC. Currently, PVC is the most commonly used for pipe diameters 450 mm and smaller, while concrete is commonly used for sewers greater than 500 mm in diameter. Vitrified clay and asbestos cement are considered to be brittle pipe materials. In the Metro Vancouver region, only the City of Vancouver continues to use vitrified clay pipe for constructing new sewers with diameters between 200 mm and 300 mm. While asbestos cement pipe is no longer used in new construction, there are still significant areas serviced using this legacy pipe material. For example, in the North Shore Sewerage Area, the District of North Vancouver was serviced in 1960s primarily with asbestos-cement pipe, while the older sewers of the City of North Vancouver were serviced using primarily vitrified clay pipe. The deterioration of asbestos-cement pipe materials and vitrified clay pipe joint packing are suspected to be significant factors contributing to the high I&I rates observed on the North Shore.

**Connection Interfaces and Trenches**

Underground linear infrastructure that are the sewers, waterlines and utility ducts servicing communities create an extensive French drain system when trench backfill and pipe bedding are permeable materials. Permeable utility trenches drain their service area, conveying rainwater runoff and groundwater to the lowest trench points. As sanitary sewer trenches are typically constructed lower than other utility trenches, the other trenches will drain to the sanitary sewer and cause sanitary sewer pipes, joints, tie-ins and laterals to become submerged in trench groundwater — I&I will then enter sanitary sewers through any open defect. (US Environmental Protection Agency, 1990, pp. 2-6, 2-7, 2-12). Figure 8 shows how utility trenches create a linked French drain network; however, this illustration is incomplete as it does not include the full lengths of the utility connections on private property or trenches from other utilities such as gas and telecom.

\textsuperscript{19} Using the orifice relationship provided by Mustaffa \textit{et al.} (2006).
Private Laterals

The structural condition of private sewer laterals is generally unmanaged until there is a sewer backup. Furthermore, I&I from private laterals has been found to account for the majority of a catchment’s total I&I (Wastewater Treatment Division, 2004; Kerr Wood Leidal, 2008; Metro Vancouver, 2014). Some pipe materials historically used for laterals, such as Orangeburg (No-Corrode) pipe, age poorly and are likely to fail.

Property demolition and redevelopment often results in the old sewer laterals being abandoned but not necessarily removed; municipal sewer bylaws typically set lateral severance requirements such as capping and plugging. Well-functioning sewer bylaws appear to prevent significant I&I from severed laterals (Toronto Water, 2018). Furthermore, pipe deterioration, poor lateral construction, and drainage cross-connections are believed to be the primary reasons for elevated private lateral I&I (Kerr Wood Leidal Assoc., 2011).

Related to private lateral cross-connections are semi-combined sewers which are essentially sanitary sewers with combined service laterals20.

---

20 Semi-combined sewers are sanitary sewers with sanitary laterals that receive foundation drainage from buildings (Metro Vancouver, 2014, pp. 16-18; Metro Vancouver, 2016, p. 9)
Semi-combined Sewers
Semi-combined sewers were constructed in some older neighbourhoods in the Metro Vancouver region, but the extents of such systems are not known. These sewers were once common in new construction across Canada. In Greater Vancouver, they are believed to be limited to older service connections for portions of the sanitary sewer system in Burnaby, North Vancouver City, Vancouver and possibly White Rock (Metro Vancouver, 2016, p. 41). Estimates of potential I&I rates from private laterals with cross-connected drainage or semi-combined laterals range were estimated to be around 0.1 L/s to 0.2 L/s (Metro Vancouver, 2016, pp. 33, 35, 37, 39). Applying these estimates to the lot configurations of Scenarios 1 and 2 (page 20), I&I rates for semi-combined sewers could range from 131,000 L/ha·d to 373,000 L/ha·d. While this range seems high when compared to the 16% increase in design flows allocated for foundation drains connected to sanitary sewers as recommended by Rawn et al. (1953, p. 99), it aligns closely with the 126,000 to 166,000 L/ha·d range of I&I recommended in Brampton’s design criteria (Region of Peel, 2009, p. 4) for semi-combined sewer I&I allowances.21

Mimicking Sources
When conducting flow monitoring to estimate I&I rates, some permitted discharges may mimic I&I and contribute to higher I&I estimates if they are not accounted for during data analysis. These sources include discharges of landfill leachate, contaminated ground and surface waters, and industrial cooling and process water.

Landfill Leachate
Figure 9 shows the locations of current and historical landfills in the Metro Vancouver region. While only the Vancouver Landfill in Delta is still in operation, many historical landfills continue to discharge leachate to sanitary sewers. The success of the landfill closure plans, caps and groundwater management determines the long-term leachate flows being conveyed to the sewer systems.

21 Applying Scenario 1, 22 dwellings over 1.0 ha and Scenario 2, 19 dwellings per 1.25 ha per page 17 of this report with the unit rates of 0.2 L/s·ha and 0.08 L/s per foundation drain
Controlling Inflow and Infiltration in the Metro Vancouver Area

March 12, 2019

Figure 9 Current and Historical Municipal Landfills in the Metro Vancouver Region
While not all historical landfills are connected to the sanitary sewer system, three landfills continue to generate significant leachate and discharge flows to sanitary sewers through permits. Their permitted daily discharges to sanitary sewer are 45,000 m³/d from the Vancouver Landfill (active), 5,030 m³/d from the Coquitlam Landfill (closed) and 4,400 m³/d from the Premier Street Landfill (closed). Other landfills have smaller discharge rates on the order of 500 m³/d or less. Irrespective of size, landfill leachate discharges to sanitary sewers can give the impression that a catchment’s I&I is greater than it actually is by the leachate contributing to additional wet weather flows.

Contaminated Groundwater and Runoff
There are two types of contaminated water that may be permitted to discharge to sanitary sewers: contaminated surface runoff from industrial operations, and contaminated groundwater. Groundwater may be from site remediation or construction dewatering. Irrespective of source, permits are evaluated and issued by Metro Vancouver (and City of Vancouver) for discharges to sanitary sewers when discharge to storm sewers are not possible. Discharges are authorized through a permit, often with wet weather flow restrictions or prohibitions.

In 2016, a total of 6,700 m³/d of groundwater was permitted to be discharged to the sanitary sewers for all Metro Vancouver sewerage areas22. However, this total is high for any given day as the actual permitted flow varied among sewerage areas and by month as permits are issued and cancelled.

Industrial Process Water Discharges
Certain industrial processes may continuously discharge process water which may be misinterpreted as groundwater I&I. However, it is not believed that significant continuous discharges presently occur in the region’s sanitary sewer network to cause this type of misinterpretation.

Sewer System Regulations
The federal and provincial governments use the Fisheries Act and the BC Environmental Management Act to set wastewater collection and treatment performance requirements. Provincial legislation, which includes the Community Charter, the Vancouver Charter, the Local Government Act, the Greater Vancouver Sewerage & Drainage District Act, and the Environmental Management Act, gives local governments specific abilities to fund, build, operate and regulate wastewater systems for all three tiers of ownership.

The provincial government also issues Municipal Wastewater Regulations (MWR) which require the development of a Liquid Waste Management Plan to address chronic I&I in complex sewer systems. Liquid Waste Management Plans (LWMPs) are regulatory instruments enabled under the Environmental Management Act, (Sect. 44) and approved by the Minister of Environment. Local governments are required to implement approved LWMPs.

---

22 The smallest permitted discharge was 5 m³/d (0.17 L/s) located in the Vancouver Sewerage Area and the largest 2,592 m³/d (30 L/s) located in the Lulu Island West Sewerage Area.
The Sheltair Group et al. (2008, pp. 9-10) identify that the Community Charter (Sect. 8) states that one of the purposes of municipalities is providing services for community benefit, and specifically:

8 (3) A council may, by bylaw, regulate, prohibit and impose requirements in relation to the following: (a) municipal services (b)...

Furthermore, the Sheltair Group et al. (2008, pp. 9-10) point to the Community Charter (Sect. 69) as providing municipalities with additional authority to manage private sewer laterals. However, Section 69 does not explicitly address the roles of the subsequent non-builder owners of private sewers and it is likely that Section 69 is more applicable to new construction and permitted renovation. Section 69 is as follows:

69 A council may, by bylaw, do one or more of the following:

(a) in relation to drainage and sewerage works provided by persons other than the municipality,

(i) regulate their design and installation, and

(ii) require property owners to connect their buildings and structures to the works in the manner specified in the bylaw;

(b) impose requirements on persons undertaking the construction of works to

(i) maintain the proper flow of water in a stream, ditch, drain or sewer in the municipality, or

(ii) reclaim or protect part of the land mass of the municipality from erosion by any cause; Section 69(b)

Therefore, through bylaws and policies, local governments have the ability to set regulations to regulate the discharge of liquid wastes to sewers systems as well as the construction of new sewer connections. Sewer use bylaws and other source control measures are used to regulate the quality and quantity of non-domestic wastewater discharges to public sewers. Local government building permits and bylaws are used to regulate sewer connection construction and workmanship. While inspection is used to monitor and promote bylaw compliance, self-inspection by the builder can result in very high I&I rates in new construction (Robinson & Sandink, 2017).

Liquid Waste Management Plan Requirements

The current LWMP for Metro Vancouver and its GVS&DD members is the Integrated Liquid Waste and Resource Management Plan (ILWRMP). It was approved by the GVS&DD Board and member councils in 2010 and the BC Minister of Environment in 2011. As a regulatory instrument, it supersedes the Liquid Waste Management Plan which was approved by the Minister of Environment in 2002. Furthermore, the actions and commitments of the 2002 LWMP approved by the GVS&DD and endorsed by member
municipal councils were neither rescinded nor withdrawn as part of their approvals of the new LWMP in 2010.

In the 2002 LWMP, an I&I allowance of 11,200 L/ha∙d was introduced as the I&I target for the GVS&DD and its members. Policy P8 defines the I&I allowance such that:

“...the average daily infiltration and inflow will not exceed 11,200 litres per hectare per day as a result of a storm with less than a five year return period...”

(Greater Vancouver Regional District, 2002, p. 29)

Also in the 2002 LWMP, member municipal councils committed that:

“...Repair and replacement programs will be established based on targets set for sanitary sewer overflow reduction and the severity of infiltration and inflow relative to the design allowance of 11,200 litres per hectare per day...”

(Greater Vancouver Regional District, 2002, p. 30)

The current LWMP’s (ILWRMP) strategy towards I&I continues to rely on GVS&DD members to develop and implement I&I management plans that identify and target priority catchments with the objective of reducing I&I to 11,200 L/ha∙d as measured at Metro Vancouver’s trunk sewers (Metro Vancouver, 2011, pp. 15,16; Metro Vancouver, 2014, p. 35). A review of the I&I allowance was completed by the REAC LWSC in 2014, and it recommended maintaining the 11,200 L/ha∙d I&I allowance and its re-evaluation in 2018 (Metro Vancouver, 2014, p. 35).

New Sewer and Lateral Construction

Municipalities, through the Community Charter and the Local Government Act, enact bylaws that can set local sewer design and construction requirements. The BC Plumbing Code sets requirements for sanitary sewer and drainage requirements within buildings. Quality control of new construction is ensured through municipal inspection and permit programs. Work completed by Metro Vancouver and its members in the mid-1990s evaluated how changes to new construction could help reduce I&I. It found that the most obvious change would be increasing inspections to ensure that new construction meets specifications, with a further recommendation to standardize the level of inspection on all sewer construction, from the house to the wastewater treatment plant (Greater Vancouver Regional District, 1995a, pp. 2, 30). These findings match similar findings by Robinson & Sandink (2017) who found that poor construction practices in Ontario are the main causes of excessively high I&I in new construction.

23 A definition for the I&I allowance has generally been that 11,200 L/ha∙d represents the peak hourly flow that occurs over a 24 hour period for 1:5-years return frequency storms for all rainfall durations. This would correspond with how I&I estimated using the Envelope Method. However, the wording of the 2002 LWMP is somewhat ambiguous as the I&I allowance could be interpreted as an average daily flow rate of 11,200 L/ha∙d meaning peak hourly I&I could be much higher.
Their investigation determined that when inspection and testing of new works were incomplete, tests omitted, or defects were not recognized, elevated I&I was often found in the finished construction.

The sewer construction and inspection recommendations made by Metro Vancouver and its members in 1995 are contained in Appendix D.
Costs & Managing Excessive I&I

The costs of managing excessive I&I and SSOs are not well documented in the local context. Comparisons between the costs of adding additional sewer system capacity and targeted I&I management were undertaken by Metro Vancouver in the late 1990s (Metro Vancouver, 2014). While this work determined that targeted I&I management programs are more cost effective than treating and conveying excessive I&I, the costs of I&I related overflows impacts were not determined.

Wet Weather Overflows

Climate Change

Work by the Institute for Catastrophic Loss Reduction (Sandink, 2007, pp. 1,3,4) summarizes estimates of sewer backup costs from storm events in Alberta and Ontario. While these estimated costs are associated with extreme rainfall events and are not representative of typical current I&I overflow and related sewer backup costs, Sandink (2007, p. 1) notes that by 2070, storms with currently a 1:100 year return period may occur more frequently at a 1:10 to 1:15 year return frequencies due to climate change. Analysis by GHD (2018, p. C28) anticipate similar increases in extreme rainfall frequency for Metro Vancouver by 2100. Comparison of old and new IDF curves by the District of North Vancouver shows increasing frequency of high intensity rainfall which roughly corresponds to the previous 1:5-year return period becoming a 1:2 year return period (Rooney, 2018). The reasons behind these particular observed changes are not presently known as they may be due to other factors such as climate oscillation. However, in the long-term I&I is expected to increase as a result of climate change unless significant improvements are made to address the integrity of sanitary sewer networks.

An estimate of the potential I&I impacts from climate change on sanitary sewer overflows was done for Metro Vancouver by GHD (GHD, 2018). As part of their evaluation, updated IDF curves representing climate scenarios for 2050 and 2100 were developed and applied to the Collingwood Sanitary Trunk Sewer. Modelling of the increased rainfall intensity determined that current levels-of-service would decline as future rainfall intensity was found to result in higher I&I rates. Although the costs to upsize infrastructure to maintain current level-of-service could be mitigated during capacity upgrades needed to accommodate future population and demand growth, the I&I allowance would need to increase unless I&I was more aggressively controlled. GHD’s findings are similar to those reported by Sandink who concluded that climate change will exacerbate current I&I problems and will result in more numerous overflows unless RDI&I inflow sources are significantly reduced.

Sanitary Sewer Overflows

Under the ILWRMP Metro Vancouver and its members have committed to reducing the occurrence of SSOs so that wet weather overflows do not occur from storms associated with a return frequency of less than 1:5-years\(^2\). To reduce the likelihood of SSOs, Metro Vancouver has constructed one SSO

\(^{24}\) (Metro Vancouver, 2011, p. 17)
containment storage tank in Cloverdale to reduce peak wet weather flows and is planning to construct additional SSO containment storage tanks. These tanks mitigate the likelihood of SSOs in areas of the regional conveyance system which are receiving chronically excessive I&I. In the long-term, the use of SSO containment storage is an expensive option to manage SSOs as it does not reduce quantity of I&I or the costs of conveying and treating excessive rainwater or groundwater and requires investment in the construction and maintenance of substantial structures. Costs for SSO containment tanks are estimated to be approximately $3,400/m³ which results in each facility costing on the order of tens of millions of dollars to build.

Determining the costs of SSO events is challenging as costs vary by location and are specific to the types of impacts and how they may be monetized. While post-overflow clean-up is typically required for SSOs to land, SSOs to creeks or the Fraser River generally do not receive similar remediation. Typical remediation costs following an SSO are on the order of $700 for a vacuum truck and crew, plus staff time and follow-up environment assessment. Including administrative costs, a typical SSO costs around $5,000 per event. Impacts affecting reputation, trust, nuisance and the environment are difficult to monetize and therefore difficult to consider in cost-benefit analyses.

Work for Surrey by AECOM (2013, p. 33) suggests that managing I&I has an optimal threshold and produces diminishing benefits efforts once that threshold is crossed. Evaluation of the costs and benefits of addressing overflows in Surrey’s Robson Creek area determined that Tier 2 I&I mitigation was the most cost-effective level of effort for I&I management; for other catchments without a history of overflows, Tier 1 mitigation was recommended. In AECOM’s study, programs to reduce private-side I&I (Tier 3) were not considered cost-effective.

Sewer Back-ups
The Institute for Catastrophic Loss Reduction has observed that sewer backups are becoming costlier. This is partly because basement usage and the value property located in basements subject to backups have both increased. Insurance payouts for a 2005 storm in the Greater Toronto Area was $247 million, while severe rain in 2013 caused almost $1 billion in damages. Kesik (2015, pp. 11, 12) found that the average value of individual claims due to basement flooding from sewer backup is reported between $15,000 and $19,000.

However, the underlying factors behind for sewer backups in Ontario are different than in British Columbia. The legacy of large networks of semi-combined sewers and the comparably flatter topography of Ontario, combined with increasing extreme rainfall intensity and severe storms, have caused sewer backups to become an issue of growing concern in Ontario. Whereas, in the Lower

---

25 The Cloverdale SSO Containment Tank is approximately 7,000 m³ whereas the proposed Katzie SSO Containment Tank is being proposed as 20,000 m³.

26 Sec. 744, Local Government Act, indemnifies local governments and local boards against nuisance claims for damage and flooding caused by sewers and drainage facility failure, malfunction or break down. Therefore, local governments and local boards are not responsible for the cost of damage to private property under such circumstances.
Mainland, the extents of legacy semi-combined sewers, steeper topography and less severe high intensity rainfall may explain why sewer backups due to I&I do not presently appear to be increasing in the Lower Mainland. This may change as rainfall patterns change and its intensity increases due to climate change.

I&I Mitigation

Experience

Metro Vancouver’s GVS&DD members undertake their own I&I management programs, and often prioritize for investigation of the sewer catchments with suspected high I&I. Therefore, I&I estimates are not indicative for all municipal catchments. Furthermore, through the ILWMP, members committed to complete and implement their I&I management plans (Metro Vancouver, 2011, p. 16). A survey of members’ I&I management plans in 2014 determined that their plans varied significantly among each other in both scope and complexity with municipal-wide I&I management plans not having been developed by all members. Instead, members have generally focussed on what are suspected to be their greatest I&I areas through a series of catchment specific I&I studies, and focussed I&I mitigation resources accordingly.

Most municipalities use the Envelope Method to calculate peak hourly associated with a 1:5-years rain event I&I rates as it provides a standardized estimate of I&I, and therefore, permits catchment-to-catchment comparison and long-term tracking. This permits comparison of catchment I&I rates as shown by Figure 10.

Not all GVS&DD members have distinct I&I management programs. Some members undertake I&I mitigation through their asset management programs which are focussed on ensuring the integrity of sewer mains and are similar to Tier 1 I&I management.

Even though I&I rates vary significantly through the region, newer catchments and communities without basements appear to have lower I&I rates. An explanation for this has yet to be satisfactorily established: the era of construction and the absence of storm sewers resulting in the connection of foundation drainage have been put forward as possible explanations (Metro Vancouver, 2016, pp. 8-10).

Prioritizing I&I Mitigation

Metro Vancouver’s I&I Plan Template contains a methodology to assist with the development I&I management program priorities (Kerr Wood Leidal Assoc., 2011, pp. 5.4-5.8). However, this methodology provides only high level guidance and provides limited direction on how the specifics of catchment prioritization. In contrast, a prioritization approach was developed by the Regional Municipality of York using multi-category criteria to prioritize sewer catchments for I&I management programs. Table 8 contains these criteria with the highest score for each category being used to assign
Figure 10 Inflow and Infiltration Reported by GVS&DD Members up to 2017
the priority to each sewer catchment (York Region, 2011, p. 17). Catchments are then assessed to determine I&I sources according to their I&I priorities. I&I mitigation options are then identified and in turn prioritized based on cost benefit, criticality, risk of failure, expected lifecycle and performance improvements, environmental impacts, social implications, plant performance, and operation and maintenance cost savings (York Region, 2011, pp. 18-19)

<table>
<thead>
<tr>
<th>Key Factors for Prioritization</th>
<th>Prioritization Ranges and Colour Coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instantaneous Peaking Factor</td>
<td>Low (Green)</td>
</tr>
<tr>
<td>PF = (Flow Peak/Flow Average)</td>
<td>4 ≤ PF &lt; 6</td>
</tr>
<tr>
<td></td>
<td>PF ≥ 6</td>
</tr>
<tr>
<td>RDI&amp;I per Pipe Area (L/d·mmØ·km)</td>
<td>RDI&amp;I &lt; 280</td>
</tr>
<tr>
<td></td>
<td>280 ≤ RDI&amp;I &lt; 560</td>
</tr>
<tr>
<td></td>
<td>RDI&amp;I ≥ 560</td>
</tr>
<tr>
<td>Percent of Rain Entering System</td>
<td>C_v &lt; 5%</td>
</tr>
<tr>
<td></td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>C_v ≥ 5%</td>
</tr>
<tr>
<td>York Region (Town) Peak I&amp;I Flow (L/ha·d)</td>
<td>I&amp;I &lt; 21,600</td>
</tr>
<tr>
<td></td>
<td>21,600 ≤ I&amp;I &lt; 30,240</td>
</tr>
<tr>
<td></td>
<td>I&amp;I ≥ 30,240</td>
</tr>
</tbody>
</table>

### I&I Reduction and Asset Remediation

GVS&DD members’ efforts to identify and reduce I&I have had mixed success. This may be in part due to most programs being limited primarily to Tier 1 and 2, and seldom including Tier 3 private-side I&I remediation. AECOM reports that Tier 1 remediation in Surrey typically resulted in around a 29% I&I decrease resulting in an average rate of 21,400 L/ha·d while Tier 2 efforts typically yielded a 39% reduction in I&I, and Tier 3 efforts only achieved a 60% I&I reduction. While AECOM’s reduction of 29% compared well with Boyland & Wesimiller’s Tier 1 mitigation results shown in Table 9, AECOM’s Tier 3 results and maximum I&I reduction threshold are inconsistent with the I&I reductions achieved following aggressive foundation drain disconnection pilot studies in London, Ontario (Kovacs, Guilbault, & Sandink, 2014, pp. 50-53): this pilot work reduced I&I to near zero. Both AECOM’s and Boyland & Wesimiller’s results support a generalized Tier 1 threshold for I&I reduction of roughly twice the regional I&I allowance (22,400 L/ha·d). However, AECOM’s figures are based on an average pre-remediation I&I rate of 31,550 L/ha·d. AECOM concluded that 29% of I&I can be controlled by addressing mainline sewer defects and cross-connections (Tier 1), an additional 10%

---

27 Mainline and service connection interface were remediated as part of Tier 1 (AECOM, 2013, p. 21)

28 The pilot studies in London disconnected known drainage cross-connections which were permitted under old servicing standards (Chambers, 2013). AECOM’s limit of an additional 21% reduction through Tier 3 work may be more representative of the difficulties in identifying unknown cross-connections as sumps and pee-traps reduce the effectiveness of smoke-testing.
more I&I can be controlled by managing public-side lateral defects (Tier 2), and a further 21% of I&I can be controlled by managing I&I on private property (Tier 3). The result is that 40% of I&I cannot be practically controlled which equates to 12,620 L/ha·d — close to the regional I&I allowance of 11,200 L/ha·d — based on an average pre-remediation I&I rate.

Table 9 Tier 1 I&I Remediation Results for Burnaby (Boyland & Weismiller, 2011)

<table>
<thead>
<tr>
<th>Catchment</th>
<th>Initial I&amp;I (L/ha·d)</th>
<th>Remediated I&amp;I (L/ha·d)</th>
<th>Reduction in I&amp;I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forglen</td>
<td>49,700</td>
<td>23,400</td>
<td>52.9%</td>
</tr>
<tr>
<td>Royal Oak</td>
<td>44,000</td>
<td>25,500</td>
<td>42.0%</td>
</tr>
<tr>
<td>Newcombe</td>
<td>33,800</td>
<td>27,500</td>
<td>18.7%</td>
</tr>
<tr>
<td>Brentwood*</td>
<td>122,300</td>
<td>68,800</td>
<td>43.7%</td>
</tr>
<tr>
<td>Malvern</td>
<td>46,000</td>
<td>29,600</td>
<td>35.7%</td>
</tr>
<tr>
<td>Sperling</td>
<td>38,100</td>
<td>23,890</td>
<td>37.3%</td>
</tr>
<tr>
<td>Copley**</td>
<td>96,900</td>
<td>92,200</td>
<td>0.49%</td>
</tr>
<tr>
<td>South-Slope 2</td>
<td>67,800</td>
<td>40,400</td>
<td>40.4%</td>
</tr>
</tbody>
</table>

*The Brentwood catchment was never serviced with semi-combined sewers but is suspected of having significant private-side drainage cross-connections to address groundwater and surface water drainage issues (Metro Vancouver, 2016, p. 39).
**The Copley catchment is suspected of being serviced with semi-combined sewers (Metro Vancouver, 2016, p. 39).

Although Burnaby’s Tier 1 I&I remediation (Table 9) did not achieve the 11,200 L/ha·d regional I&I target in any of its catchments, its program was successful in removing significant I&I in all areas except for the semi-combined Copley catchment. Burnaby’s average Tier 1 I&I reduction was 39% (excluding semi-combined catchments), which is 10% greater than the reduction reported by AECOM and matched AECOM’s Tier 2 I&I reduction rates. As I&I reductions are only approximations due to errors introduced by rainfall and flow monitoring, the actual differences between the results of these two studies may be larger or smaller.

Private Lateral Management

Since the 1990s, reducing I&I originating from private sewer laterals has been identified as an essential component of effective I&I control (US Environmental Protection Agency, 1990, p. iv). The magnitude of I&I originating from private laterals varies with each catchment. King County estimates private sewers and laterals are responsible for between 50% and 95% of all I&I (Wastewater Treatment Division, 2004, p. 1; Lampard, 2003). This may be due to factors which include ubiquitous lack of maintenance on private laterals, the challenge to local governments in overseeing all do-it-yourself repairs and private property sewer works, and improvements in plumbing standards over the decades.

In the 2002 LWMP, GVS&DD members committed to including the management of private lateral I&I as part of their overall commitment to reduce I&I rates to the regional allowance of 11,200 L/ha·d (Greater Vancouver Regional District, 2002, pp. 29-30). The I&I Management Template classifies private lateral I&I management as Tier 3 I&I management. While GVS&DD members committed to undertake targeted

---

29 see “Data and I&I Estimation”, page 13 of this report
Tier 3 I&I management as part of the 2002 LWMP, most members have not undertaken targeted Tier 3 I&I management programs.

Municipalities have the ability to regulate the management and repair of private sewer laterals (Sheltair Group & Westcoast Environmental Law, 2008); however, only a few neighbourhood specific programs have been undertaken in Greater Vancouver to address private-side I&I. Although these programs yielded significant I&I reductions30, widespread private lateral inspection and maintenance programs are not occurring in the region. Where lateral inspection and repair/rehabilitation work have occurred, they have mostly been focussed on the public section of the laterals as part of municipal mainline I&I programs – Tier 1 and Tier 2 programs.

Private laterals essentially remain unmanaged with respect to inspection and repair/rehabilitation. As such, property owners and tenants rely on plumbers and municipal crews to address “surprise” blockages. The rate and nature of these blockages are not well documented.

Discussions with the City of Surrey indicated that about 54% of 485 private lateral blockages between 2012 and 2015 may be associated with the laterals being in such poor repair that they failed31. Prior to failure, cracked and misaligned laterals can contribute significant amounts of ongoing groundwater infiltration: this only become problematic for property owners when lateral blockages occur. Cross-connections do not generally contribute to lateral failure conditions and therefore seldom present a problem to homeowners and are easy to overlook. Consequently, cross-connections are less likely to present themselves as problems to property owners.

**Combined Laterals & Lateral Cross-connections**

Estimates of private lateral I&I rates are summarized in Table 10. Applying these rates to 25% of the lots in Scenario 2 (see page 20) with just foundation drain cross-connected results in I&I estimates between 46,000 L/ha·d (based on 0.14 L/s per lot) to 124,800 L/ha·d (based on 0.38 L/s per lot).

In 2016, a methodology was developed to identify and prioritize neighbourhoods for I&I investigation based upon characteristics such as era of construction, storm sewer servicing and the presence of basements or semi-basements (Metro Vancouver, 2016). With respect to this methodology, the City of Burnaby (Weismiller, 2018) has found the misalignment between storm sewer and sanitary sewer servicing dates useful to flag and check for potential cross-connections. Furthermore, roof downspouts cross-connections identified through smoke testing are now supplemented by a review of available record drawings to gain insight on any potential foundation drain cross-connections. An initial observation is that combined laterals connected to sanitary sewers are not believed to be widespread.

---

30 Targeted private lateral rehabilitation work was undertaken by the District of West Vancouver in 2003 for 37 properties and was able to reduce I&I rates by 69% (Kerr Wood Leidal, 2008), while work by the District of North Vancouver in 2013 was able to reduce I&I by about 47% (Carroll, 2014).

31 These blockages were reported for categories due to tree roots, pipe or lid failure, and rocky debris (Kiyonaga, 2015)
### Table 10 Comparison of Estimated Private-Side I&I Rates

<table>
<thead>
<tr>
<th>Private-side I&amp;I Cross-connection Source</th>
<th>Estimate Rate (L/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storm Sump Pump</td>
<td>0.19 to 0.38*</td>
</tr>
<tr>
<td></td>
<td>0.19 to 0.63**</td>
</tr>
<tr>
<td>Foundation Drain</td>
<td>0.19 to 0.38*</td>
</tr>
<tr>
<td></td>
<td>0.19 to 0.63**</td>
</tr>
<tr>
<td></td>
<td>0.14 to 0.24†</td>
</tr>
<tr>
<td>Roof Downspouts</td>
<td>0.19*</td>
</tr>
<tr>
<td></td>
<td>0.38 to 0.63**</td>
</tr>
<tr>
<td>Driveway Drains</td>
<td>0.19*</td>
</tr>
<tr>
<td></td>
<td>0.19 to 0.63**</td>
</tr>
<tr>
<td>Stairway Drain</td>
<td>0.03 to 0.06*</td>
</tr>
<tr>
<td></td>
<td>0.38 to 0.63**</td>
</tr>
<tr>
<td>Lateral Joint and Material Defects</td>
<td>0.01 to 0.03**</td>
</tr>
<tr>
<td>General Private-side Sources</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.50‡</td>
</tr>
</tbody>
</table>

* (Commonwealth of Massachusetts, 2017, pp. 38,39)
** (Water Environment Federation, 2016, p. 28)
† (Metro Vancouver, 2016, pp. 33, 35, 37, 39)
‡ (Carroll, 2014, p. 5)

### Sewer Lateral Certification

As private laterals seldom receive inspection and condition assessment until after there has been a sewer back-up, a lateral certification program is anticipated to benefit local governments through I&I source identification and I&I reduction in addition to property owners by identifying laterals in need of repair prior to potential sewer back-ups.

In the development of the ILWRMP, real estate transfer was identified as a process suitable to trigger the lateral inspection and certification of the condition of private sewer laterals. Under this strategy, it is assumed that chronic I&I is the result of either illegal cross-connections, poor lateral construction or deterioration in the lateral materials. While research has correlated increasing I&I rates with lateral age (Kerr Wood Leidal, 2008), it is believed that this correlation also reflects the era of construction which may have tolerated higher I&I rates, had different construction standards, or required combined private laterals (Metro Vancouver, 2014, pp. 16, 17).

Lateral condition certification programs are used in some jurisdictions in the United States, and appear to be primarily an outcome of consent decrees. For example, as a result of consent decrees, 24 of 101 local governments around the San Francisco Bay Area require private lateral certification at the time of property transfer as a mechanism to reduce chronic sewer overflows (Miller & Muller, 2017). In the municipalities of the East Bay Metropolitan Utilities District (EBMUD), lateral certification is required when properties sell, undertake renovations greater than US$100,000, or change water meter sizes (Dinsmore, 2016). In 2012, approximately 16,000 homes were reported to have certified private laterals. All houses are anticipated to be certified by 2045-2050 (Carne & Le, 2015b, pp. 63-64). In some jurisdictions, private laterals can no longer be certified and are required to be replaced once they exceed a mandated age threshold, such as 50 years (City of San Mateo, 2017).
A similar program by the New York State Environmental Conservation Department requires time-of-sale private lateral certification for public sewer systems with excessive I&I. Two examples are the Town of Cheektowaga which requires private lateral certification for all properties prior to their sale, and the Town of Amherst which only requires private lateral certification for properties serviced prior to 1975.

Time-of-sale lateral certification requires municipal administrative processes to track property transactions and implement certification. Furthermore, the roles of real estate boards in time-of-sale certification need to also be defined. Municipal administrative processes could be relatively simple such as correlating property title changes with a lateral certification database. Alternately, lateral sewer certification could form part of the property disclosure statement at the time of a property’s listing for sale and therefore form part of the sales agreement. Real estate boards are important stakeholders for all time-of-sale lateral certification processes and should need to be involved in the development of any time-of-sale lateral certification process.

Work by Sheltair Group & Westcoast Environmental (2008) and Pinna Sustainability (2012) determined that local governments in British Columbia have the necessary authority and mandates to require certification of private sewer laterals. Therefore, a time-of-sale lateral certification program similar to EBMUD’s is currently possible for Metro Vancouver members through a bylaw. A model bylaw for time-of-sale lateral certification based on work by the Sheltair Group & Westcoast Environmental Law (2008) is provided in Appendix E and could form the basis of a harmonized region-wide strategy to reduce private-side I&I. An example of a private lateral certification application and form is provided in Appendix F using the Town of Cheektowaga.

Another mechanism for private lateral certification is to trigger lateral certification by renovation and building permits. A challenge with this approach is that it certifies only the laterals associated with the very limited number of properties under renovation, and it may be circumvented if renovation work falls below the value threshold that triggers building permits. It is however worthwhile to include a renovation trigger as part of another lateral certification process to ensure better coverage.

An alternative to time-of-sale lateral certification is to promote lateral inspection and condition certification as means to obtain “discounted” sewer utility fees. Such a program would establish a system of dual sewer fees. It does not require coordination with real estate boards and instead incentivizes private lateral condition inspection and maintenance. This approach recognizes that certified laterals, which have been determined to not be sources of excessive I&I, are of lesser financial risk and cost to the operation of the public sewer system than uncertified laterals. However, the incremental costs to local government that result from uncertified laterals would need to be rationalized and estimated so that a system of dual sewer fees would be reasonable. At the same time, the difference between the certified and uncertified lateral sewer fees needs to be sufficient to incentivize sewer lateral maintenance. Such an approach could be included as part of municipal sewer utility fees bylaws. Jurisdictions where this approach is used have not be identified.
Conclusions & Recommendation

Conclusion
First identified in the early 1990s, excessive I&I continue to be problematic, impacting the GVS&DD’s sewerage systems. The costs of conveying and treating excessive I&I in the regional system as well as mitigating associated SSOs are borne by GVS&DD members either directly or indirectly.

In developing the LWMP, member municipalities committed to reducing and managing I&I originating from both public and private sewers as part of a strategy to maintain the capacity and investment value of existing infrastructure. While I&I management initiatives were started by all members following approval of the 2002 LWMP, the results of I&I management programs have since been highly variable in mitigating excessive I&I, and overall, I&I reductions have not been achieved as envisioned by the LWMP.

Chronic I&I induced sanitary sewer overflows must be eliminated to address regulatory expectations. The options before GVS&DD members to manage excessive I&I continue to be 1) investing in the inspection and maintenance of public-side and private-side sewer assets, 2) investing in additional wet weather storage, and/or 3) investing in additional conveyance and treatment capacity for the regional sewerage system.

While there are many factors which can explain the shortfall in I&I reductions, the general reasons appear to result from I&I management efforts being low-priority municipal programs, and therefore underfunded, and private laterals remaining essentially unmanaged. The absence of well articulated and clear municipally-focussed business cases linking the needs and benefits of controlling I&I with the costs to municipalities may help with funding priority.

It is recognized that I&I management will remain a dynamic ongoing process with both short-term and long-term objectives. Prioritizing remediation budgets and efforts to high I&I catchments will provide essential short-term gains which should free-up sewer capacity and thereby reduce the occurrence of overflows. Similarly, by using improved materials and different operations and maintenance practices, members may reduce the amount of rainwater inflow entering through manhole lids and frames. Furthermore, consistent and thorough inspection practices for new construction, both private-side and public-side are critical to preventing long-term I&I problems.

Private-side sewer laterals continue to be unmanaged in the region and these are believed to contribute significant amounts of I&I to the public sewer systems. As a result, only about half of the sanitary sewer system is actively managed by local governments. Local governments have the mandate and authority to manage private laterals. Full sewer system management requires administrative resources and political commitment to manage I&I from private laterals. Chronic, excessive I&I in other North American jurisdictions have led to the development of private lateral inspection and repair including the use of time-of-sale private lateral inspection and certification as a mechanism to reduce private-side I&I.
With respect to developing I&I management plans, the use of the Envelope and RTK Methods appear to be appropriate and valid techniques that allow for comparison of estimated I&I and appear to be the only I&I estimation techniques that can “normalize” variations in rainfall intensity to a common return frequency. Although the accuracies of these methods are sensitive to the quality of rainfall and flow monitoring data used in their generation, the overall magnitudes of I&I estimated using these methods consistently identify catchments that have excessively high I&I. Therefore, their use is very beneficial in directing and prioritizing I&I mitigation work whereas the benefits of their use in tracking long-term I&I trends and effectiveness of catchment specific I&I programs will depend on the quality of data collected.

Considering that the tools and know-how to control and manage I&I have been available to GVS&DD members for several decades, the primary challenge facing local governments in controlling I&I appears to be related to municipal prioritization and the disconnected costs of unmitigated I&I on the regional sewer system.

**Recommendations**

At their February 20, 2019 meeting, the REAC LWSC committee endorsed the following recommendations to REAC to address excessive I&I in the regional sanitary sewer system:

1. That GVS&DD members continue to use the Envelope Method or the RTK Method to estimate sewer catchment I&I.
2. That by July 2019, GVS&DD members review their I&I management plans to contribute and develop a regional (Metro Vancouver-wide) list of municipally prioritized and targeted catchments that may be contributing to excessive I&I.
3. That by December 2019, GVS&DD members and Metro Vancouver evaluate members’ inspection practices for the new construction of sewers and public and private laterals and identify recommendations for improvements to bylaws, policies and procedures that will reduce I&I in new construction.
4. That by December 2019, GVS&DD members and Metro Vancouver identify suitable strategies for sewer lateral I&I management based on local work and North American case studies.
5. That by July 2020, GVS&DD members and Metro Vancouver identify guidelines for annual municipal sewer programs needed to address excessive I&I in prioritized and targeted catchments.
6. That by July 2020, GVS&DD members develop implementation options for private lateral I&I management to reduce excessive I&I.
7. That by December 2020, GVS&DD members and Metro Vancouver establish a coordinated strategy and implementation timeline for municipal I&I management priorities that will reduce the occurrence of wet weather SSOs and prioritize members’ I&I reduction efforts.
8. That by December 2020, GVS&DD members and Metro Vancouver develop a public education strategy and program blueprint to support private lateral I&I management.
References


Controlling Inflow and Infiltration in the Metro Vancouver Area


http://www.amherst.ny.us/govt/govt_dept.asp?dept_id=dept_10&div_id=div_12&menu_id=menu_02

http://www.tocny.org/Departments/InflowInfiltrationTimeofSaleInspections.aspx

http://www.tocny.org/Portals/0/Departments/InflowandInfiltration/2017%20II%20Application%20and%20Inspection%20Form.pdf


Wastewater Treatment Division. (2004). *Pilot Project Report: Regional Infiltration and Inflow Control Program*. King County, Department of Natural Resources and Parks. Seattle: King County.


https://www.york.ca/wps/wcm/connect/yorkpublic/7311896a-b49e-41e7-9927-86d3db6f0dc1/Inflow_and_Infiltration_Reduction_Strategy.pdf?MOD=AJPERES
Appendix A: Inflow and Infiltration Reduction Program Recommendations

This summarizes the 1995 recommendations from the work done by Metro Vancouver and its members on I&I reduction (Greater Vancouver Regional District, 1995c, pp. 16-18). Detailed recommendations for new sewer construction are reproduced in Appendix E.

[Sewer System Evaluation Surveys] SSES Work Group Recommendations

The following are the recommendations contained in the SSES Work Group report.

Flow Monitoring:
- Choose flow monitoring sites with consideration given to hydraulic characteristics and safety concerns.
- Choose appropriate flow monitoring equipment for the site and intended application.
- Calibrate the equipment before installation, where possible.
- Verify the operation of the equipment after installation.
- Maintain the equipment on a regular basis.
- Choose an appropriate duration of monitoring – the Work Group suggests a minimum of two months for I/I studies.
- Use a 5-minute data interval for data collection.
- Produce a “Flow Monitoring Site Report” for each flow monitoring site.
- Transfer flow monitoring data between the District and municipalities in a standard format.

Rainfall Monitoring:
- Produce a “Rain Gauge Site Report” for each rain gauge installation.
- Collect and store rain data time-stamped to one second accuracy or in one-minute totals.
- Transfer rainfall data between the District and municipalities in a standard format.
- Follow AES guidelines as closely as possible when selecting rain gauge locations and equipment, and performing operation and maintenance and quality assurance procedures.

Video Inspections:
- Establish an objective defect rating system for video inspections for use by all member municipalities.

Manhole Inspections:
- Standardize manhole inspection procedures and rating systems.
I/I Analysis Work Group Recommendations

The following are the recommendations contained in the I/I Analysis Work Group report.

- The I/I analysis methods described herein be adopted for all I/I studies undertaken in the region. Any I/I studies performed by or for municipalities within the region would, therefore, be reported upon in the same way.
- Subcatchments within separate sewerage areas should be compared according to their relative I/I potential using volumes, the ratio of PWWF to ADWF, exceedance probability of average maximum DWF and response to storm events.
- The District should use the hydrograph separation techniques described above for the analysis of flow monitoring data collected over the past winter.
- The District should further investigate the method of estimating GWI based on 85% of the average minimum dry weather flow.
- Seasonal variations in the groundwater level should be accounted for by adjusting the DWF pattern.
- Antecedent moisture conditions should be considered using an approach similar to the U.S. Soil Conservation Service.
- The method of expressing RDI/I volume as a percentage of the rainfall that falls on a subcatchment should be used to compare I/I response to storms on an event by event basis.
- The Flow and Rain Database would be a valuable tool for storing and managing the large amount of data for both current and future I/I analysis.
- GIS would facilitate comparisons of I/I contributions on the basis of subcatchment attributes.
- The current I/I analysis methodology should be improved as new information from the coming winter’s monitoring program becomes available.

New Construction Work Group Recommendations

The following are the recommendations contained in the New Construction Work Group report.

- Colour-code sanitary and storm sewers and laterals to avoid cross-connections.
- Standardize the level of inspection and testing on all aspects of sewer construction, including laterals, so that existing specifications on materials and installation methods are correctly followed.
- Ensure that inspectors are familiar with the products and their uses.
- Investigate developing and implementing a training program for sewer construction inspectors.
- Require certified inspection certificates for critical items such as infiltration testing.
- Introduce new materials (that can reduce I/I) into the Master Municipal Specifications, and include recommendations on when to use them.
- Standardize I/I design allowances throughout the GVRD.
Appendix B: Liquid Waste Management Plan Requirements for I&I Management

2002 Liquid Waste Management Plan I&I Management Policies and Commitments
(Greater Vancouver Regional District, 2002, pp. 8, 29‐31)

*Maintain Infrastructure and Stretch Capacity*
The present sewerage infrastructure within the region (District, municipal, and private) has a replacement value in the order of $12 billion. It is a critical asset that must be maintained so that it can provide adequate service, minimize risk of spills and avoid expensive future expenditures resulting from deferred maintenance and repairs.

The sanitary sewer system currently experiences a fairly high level of wet weather inflow and infiltration of rainwater because of system deterioration. This results in the overloading of existing trunk sewers and treatment plants with capacity being reached well in advance of what the need would be if their use were confined to sanitary sewage. Consistent and prudent investment in maintenance and rehabilitation can stretch system capacity, thereby delaying expensive capital expenditure, and reducing the frequency of emergency spills and overflows.

Capacity can also be stretched by demand management programs that encourage households, businesses and industries to conserve water and reduce wastewater flows and loads discharged to the sewer system, thus postponing the need for costly capital investments. Examples include industrial pre‐treatment, best management practices, codes of practice and public education programs.

*Focus Effort to Maximize Environmental Benefit Per Dollar Spent*
Priority should be given to initiatives and projects that will provide the maximum cost‐benefit for the human and natural environment. These must be considered within the affordability framework in relation to alternative investments in transportation, drinking water, solid waste and other fields that will produce environmental and human health benefits. Only after these aspects have been fully considered should attention shift to which entity of local government has the jurisdictional responsibility for implementing and paying for projects and programs.

*Separate Sanitary Sewer Systems*

*Policies*

P8. Infrastructure Management
The District and its member municipalities will establish sewer system infrastructure management programs that will maintain the regional trunks and interceptors, the municipal collection system, and the private service laterals in a state of good repair. The objective will be to ensure the sustainability of the collection system so that expensive repair and rehabilitation is not deferred to future generations...
and that the average daily infiltration and inflow will not exceed 11,200 litres per hectare per day as a result of a storm with less than a five year return period.

**P9. Basic Sanitary Sewer Service Capacity**
The District will establish a basic level of service capacity for all District sanitary sewers that provides for the conveyance of measured dry weather flows plus a wet weather allowance for infiltration and inflow of 11,200 litres per hectare per day, such that the hydraulic grade lines do not exceed established safe operating levels.

**P10. Sanitary Sewer Overflow Documentation and Targets**
The District will document all sanitary sewer overflows from the collection system under its jurisdictions and determine the cause of overflow. The District and its member municipalities will establish targets for sanitary sewer overflow reduction as part of their sewer system infrastructure management programs to target reduction and long term elimination of wet weather sanitary sewer overflows caused by storms of less than a five year return period. Areas experiencing high growth and chronic sanitary sewer overflows with associated health or environmental risks will receive the highest priority for elimination of sanitary sewer overflows.

**Commitments**

**C19. Infrastructure Management**
The District and its member municipalities will establish ongoing sanitary sewer system evaluation programs to determine the condition of the regional trunk sewerage system, the municipal sewerage system, and private property service laterals. As required, legislative and legal authority will be sought to address infiltration and inflow originating from private property service laterals. These evaluation programs will be ongoing and determine the condition of the entire sewer system over a 20 year time cycle. The District and its member municipalities will develop and apply a consistent approach to sewer system evaluation surveys.

Repair and replacement programs will be established based on targets set for sanitary sewer overflow reduction and the severity of infiltration and inflow relative to the design allowance of 11,200 litres per hectare per day.

**C20. New Construction Objectives**
The District and its member municipalities will review engineering standards and guidelines for new sewer construction with the objective of ensuring a high standard for new construction to Liquid Waste Management Plan minimize future infiltration and inflow problems.
(Metro Vancouver, 2011, pp. 15-17, 24)

Metro Vancouver will:

Action 1.1.6 – Develop a template to guide the preparation and implementation of inflow and infiltration management plans as part of broader asset management plans and to support sanitary sewer overflow reduction strategies.

Action 1.1.7 – Work with the real estate industry and their regulators, and the municipalities to develop and implement a process for the inspection and certification of private sewer laterals being in good condition as a required component of real estate transactions within Metro Vancouver.

Action 1.1.8 – Develop and implement inflow and infiltration management plans that identify reduction strategies and timelines to ensure wet weather inflow and infiltration are within targeted levels.

Action 1.1.9 – Work with municipalities to review historical data and adjust as necessary the average inflow and infiltration allowance for regional trunk sewers and wastewater treatment plants, and develop associated target allowances for municipal sewer catchments associated with a 1:5-year return frequency storm event for sanitary sewers to a level that ensures environmental and economic sustainability.

Action 1.1.10 – Review progress in reducing inflow and infiltration every four years.

Action 1.1.11 – Enhance enforcement of sewer use bylaw prohibition against the unauthorized discharge of rainwater and groundwater to sanitary sewers.

Action 1.3.2 – Maintain trunk sanitary sewer capacity for dry weather sewerage conveyance levels plus the Metro Vancouver target inflow and infiltration allowance; as necessary upgrade trunk sewer systems to maintain hydraulic gradelines and safe operating levels which have been established based on measured flow.

Action 3.1.2 – Create incentives to reduce inflow and infiltration by adjusting Tier 1 sewerage cost allocation formulae within each sewerage area from an average dry weather flow basis (25th percentile) to average wet weather flow (75th percentile) with appropriate
adjustments for combined sewerage areas. Tier 2 cost allocation would remain unchanged.

**Municipalities will:**

**Action 1.1.18** Develop and implement inflow and infiltration management plans, using the Metro Vancouver template as a guide, to ensure wet weather infiltration inflow and infiltration volumes are within Metro Vancouver’s allowances as measured at Metro Vancouver’s flow metering stations.

**Action 1.1.19** Enhance enforcement of sewer use bylaw prohibition against the unauthorized discharge of rainwater and groundwater to sanitary sewers.

**Action 3.1.6** Assess the performance and condition of municipal sewerage systems by: (a) inspecting municipal sanitary sewers on a twenty year cycle; (b) maintaining current maps of sewerage inspection, condition and repairs; and (c) using the Metro Vancouver “Sewer Condition Reporting Template Standard Report, November 2002” as a guide to ensure a consistent approach to sewer system evaluation and reporting.

**Action 3.1.8** Develop and implement asset management plans targeting a 100-year replacement or rehabilitation cycle for municipal sewerage infrastructure and provide copies of such plans to Metro Vancouver.
Appendix C: Methods for Estimating Inflow and Infiltration

The following is a summary of different methodologies used to estimate I&I.

*Table 11 Summary of Methodologies to Estimate I&I (Hey, Jönsson, & Mattsson, 2016, pp. 4-5)*

<table>
<thead>
<tr>
<th>Method</th>
<th>Type</th>
<th>Short Description</th>
<th>Advantages (+) and Disadvantages (-)</th>
</tr>
</thead>
</table>
| Triangle             | Flow rate method   | Measures total daily flow (minimum 21 days) and ranks in ascending order of magnitude to create an S-curve | + includes both wet and dry-weather flow days  
+ simple and widely used  
- large variation in results                                                                                                                                                                                                 |
| Moving-minimum       | Flow rate method   | Measures total daily flow and determines temporal variation of I&I                | + simple and widely used  
- large variation of results                                                                                                                                                                                                                                                                     |
| Dry weather flow     | Flow rate method   | Measures flow hydrograph on dry-weather days                                      | + simple and widely used  
- neglects days with storm inflow  
- inaccurate results                                                                                                                                                                                                                     |
| Minimum night-time flow | Flow rate method | Measures night-time flow, assuming most flow due to groundwater                  | - mainly based on hydrograph  
- applicable only to residential flow                                                                                                                                                                                                                                                                |
| Density average      | Flow rate method   | Not determined                                                                     | Not determined                                                                                                                                                                                                                      |
| Stable water isotope | Tracer method      | Uses direct natural tracer such as stable isotope composition of local drinking water (proxy for sewage) and local groundwater (proxy for infiltrating water) | + allows direct calculation of infiltration ratios  
+ robustly produces accurate results  
+ suitable for routine application on catchment or sub-catchment scale  
- requires comprehensive hydrologic and hydrogeological study  
- costly  
- certain boundary conditions have to be satisfied, ex. only one source of wastewater and one source of infiltration water                                                                                                                                 |
| Pollutant time-series| Tracer method      | Measures infiltrating waters based on time series of wastewater flow, pollutant concentration is measured at a single point in the system using automatic on-line device with high temporal resolution | + uses automatically operating in-line device  
+ robustly produces accurate results  
- costly  
- requires a minimum amount of wastewater for the device to operate                                                                                                                                                                     |
<table>
<thead>
<tr>
<th>Method</th>
<th>Type</th>
<th>Short Description</th>
<th>Advantages (+) and Disadvantages (-)</th>
</tr>
</thead>
</table>
| Ammonium concentration         | Tracer method               | Analyze ammonium concentration of grab samples and relate to expected concentration in undiluted sanitary wastewater. Too much I&I is assumed when ammonium concentration is below a set value, for instance 20 mg N/L. | + quick and simple  
+ uses natural tracer in wastewater  
- equipment for analyzing ammonium in field                                                                                   |
| Nitrogen and phosphorous       | Tracer method               | Analyze total nitrogen and phosphorous concentration of composite samples and relate to concentrations in sanitary wastewater. | + I&I can be accurately quantified  
- time consuming sampling and analysis  
- equipment for sampling                                                                                                           |
| Distributed temperature        | Detection/localization      | Locate sources of I&I using fibre-optic cables installed in the sewer to record high temperatures at specific time and location. | + this technique is based on a proven technology  
+ easy to use and does not require access to private property  
+ allows detection to foul water discharges to storm sewer and vice versa  
+ accurate measurements with high spatial and temporal resolution  
- more advanced equipment is needed  
- costly  
- time-consuming                                                                                                                     |
| Stevens-Schultzbach            | Empirical method            | Measures groundwater infiltration or base infiltration using empirical relationship between average daily sanitary flow and minimum daily flow | + good estimate of base infiltration  
+ verified as most accurate empirical method  
- applicable only to residential flow                                                                                               |
| Minimum flow factor            | Empirical method            | Uses average daily flow to determine minimum daily flow in relationship to basin size, based on published minimum flow factors | Not determined                                                                                                             |
| Mathematical modelling         | Not determined              |                                                                                  | - labour intensive  
- requires loads of data and longer monitoring period                                                                          |
Appendix D: Findings and Recommendations for New Sewer Construction

These findings are reproduced from work done by Metro Vancouver and its members on I&I reduction and new sewer construction practices developed from the 1995 work on I&I reduction.

Table 12 Recommendations from the I&I New Construction Task Group (Greater Vancouver Regional District, 1995a, pp. 30-34)

<table>
<thead>
<tr>
<th>Category</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Redevelopment or Resale of Private Property</td>
<td></td>
</tr>
<tr>
<td>• Review the condition of private service laterals upon sale or redevelopment of a house or business</td>
<td></td>
</tr>
<tr>
<td>• Require that the purchaser or redeveloper replace defective private service laterals</td>
<td></td>
</tr>
<tr>
<td>• Upgrade private service laterals, where required, upon issuance of a building permit.</td>
<td></td>
</tr>
<tr>
<td>Materials</td>
<td></td>
</tr>
<tr>
<td>Mainline Pipe</td>
<td></td>
</tr>
<tr>
<td>• Use non-brittle pipe</td>
<td></td>
</tr>
<tr>
<td>• Colour-code sanitary and storm pipe to avoid cross-connections</td>
<td></td>
</tr>
<tr>
<td>• Include colour-coded pipe in the MMS</td>
<td></td>
</tr>
<tr>
<td>• Choose pipe materials that minimize the number of pipe joints, where possible</td>
<td></td>
</tr>
<tr>
<td>• Investigate means of ensuring quality control from foundries and suppliers</td>
<td></td>
</tr>
<tr>
<td>Service laterals</td>
<td></td>
</tr>
<tr>
<td>• Inspect during backfilling</td>
<td></td>
</tr>
<tr>
<td>• Monitor new and old subdivisions for service lateral contribution to I/I</td>
<td></td>
</tr>
<tr>
<td>• Use different colour/size of pipe for sanitary and storm sewer connections</td>
<td></td>
</tr>
<tr>
<td>Manholes</td>
<td></td>
</tr>
<tr>
<td>• Introduce pre-fabricated manholes including pre-lined PVC channel and benching, one metre long inlet/outlet pipe, and a flexible pipe joint to the manhole into the MMS</td>
<td></td>
</tr>
<tr>
<td>• Introduce rubber boot-seal type pipe/manhole connections into the MMS</td>
<td></td>
</tr>
<tr>
<td>• Introduce fibreglass and polyethylene manholes into the MMS</td>
<td></td>
</tr>
<tr>
<td>• Include guidelines for the specification of these in the MMS</td>
<td></td>
</tr>
</tbody>
</table>
Fittings

- Pipe fittings should comply with CSA B182 and ASTM D3034-89 standards, and other standards depending on the product
- Install pipe fittings according to the manufacturer’s specifications and the MMS
- Use the correct size, material, and gasket
- Ensure that installation personnel are familiar with the products and their uses and the manufacturer’s installation guide
- Do not use single strap saddles
- Use “inserta” tees only when there are no other feasible alternatives. When “inserta” tees are used, take great care to ensure that the surrounding soils and fill are adequately compacted to minimize settlements
- Ensure that the surrounding soils and fill are adequately compacted to minimize settlements
- Stamp an arrow on the tee pointing in the direction of flow
- Install tees properly with respect to their prefabricated 2% slope
- Double strap saddle wyes and saddle tees are acceptable fittings provided they are made specifically for the pipe being connected to (i.e., correct size, material, and gasket).
- Wyes and tees with hub connections are acceptable fittings as long as the connecting pipe is properly beveled
- PVC wyes pre-cast into concrete pipe should have a bell end
- Use a flexible boot type connection 450 mm away from the actual lateral connection

Sanitary Sewer Design Practices

- Design locations of joints carefully
- Design transitions between flexible and non-flexible pipe adequately
- Ensure information on material type transition is distributed more efficiently to designers
- Consider using rubber boot-type seals at manholes
- Use wyes at lateral connections
- Avoid inside drop lateral connections to manholes wherever possible (i.e., use outside drops)
- Where possible, avoid designing lateral connections directly to manholes; connect to the mainline pipe instead
- Consider future flow monitoring requirements when designing manholes

Construction Methods

Compaction

- Introduce depths for soil testing into the MMS
- Use 19 mm diameter crush gravel (not pit-run sand) for the pipe zone bedding
- Investigate ways to alleviate the concern of compaction testing personnel regarding the safety of entering a trench

Pipe Covering Practices

- Ensure proper inspection

Service laterals

- Construct to same standard as mainline sewer pipe
- Review practice for what portion of work a certified plumber is required

Video inspection

- Video inspect at time of construction completion and one year later
## Inspections

<table>
<thead>
<tr>
<th>General</th>
<th>Regionally, standardize frequency of testing and site visits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public Inspections</td>
<td>Allow only properly trained personnel to inspect sewer construction</td>
</tr>
</tbody>
</table>
| Private Inspections | Ensure standards are equivalent to public facilities  
                        | Standardize frequencies of site visits |
| Inspector’s Training | Investigate the adequacy of existing training programs for sewer construction inspectors  
                        | Require inspectors’ training |
| Construction Guarantee | Require that the developer’s engineer provide a sealed letter of declaration for construction completion. Make the requirement standard across the region. |
| Inspection Certificates | Require certified inspection certificates for critical items such as infiltration testing |

## Performance Testing

- Standardize testing methods across the region
- Upgrade water testing standards for PVC to reflect new pipe technology
- Create a standardized testing manual, and update it for new materials
- Investigate developing standardized specifications for joint by joint air testing for use with sewer reconstruction testing (concrete pipe)

## Codes And By-Laws

- Use a watertight manhole cover when it is located in a low-lying area, gutter, or swale, or anywhere else that could result in surface water readily entering it
- Develop a by-law that allows a municipality to both disconnect inappropriate connections and enforce stiffer fines for illegal connections

## I/I Allowances

- Standardize I/I design allowances throughout the GVRD

## Water Conservation

- Encourage water conservation efforts
- Use simple-to-install low water-use products
- Research and educate on the benefits of reducing water use
Appendix E: Model Bylaw for the Maintenance and Repair of Private Sanitary Sewer Laterals

This Appendix contains a copy of a model bylaw drafted by Metro Vancouver. Alternative model sewer lateral bylaws and approaches have been developed by the Institute for Catastrophic Loss Reduction by Kyriazis, Zizzo, & Sandink (2017, pp. 24-36), and by the Sheltair Group & Westcoast Environmental Law (2008, pp. 58-74).
BYLAW NO. _____, 2016
FOR THE MAINTENANCE AND REPAIR OF
PRIVATE SANITARY SEWER LATERALS

WHEREAS the Council of [municipality] has regulatory authority over sewers and drains and deems it in the public interest to regulate the maintenance, operation and function of private sanitary sewer laterals;

AND WHEREAS such regulation improves the integrity and efficient operation and function of the municipal sewer system, and reduces and prevents sewage overflows caused by inflow and infiltration,

NOW THEREFORE, the Council of [municipality], in open meeting assembled, ENACTS AS FOLLOWS:

PART 1 - INTERPRETATION

CITATION

1. This bylaw may be cited for all purposes as the Private Sanitary Sewer Lateral Maintenance Bylaw No. _____, 2016.

DEFINITIONS

2. The following definitions apply:

   (a) “Building Inspector” means the person assigned the responsibility of Chief Building Inspector or Building Inspector or his authorized designate or representative.

   (b) “Bylaw Enforcement Officer” means the person assigned the responsibility of bylaw compliance and enforcement or his authorized designate or representative.

   (c) “Cleanout” means a device installed on a sewer lateral to provide access for the purposes of routine flushing, rodding, cleaning and other maintenance, inspection and diagnostic purposes.

   (d) “City” means the [municipality].

   (e) “Council” means the Council of the [municipality].

   (f) “Director of Engineering” means the person assigned the responsibility of City Engineer, or his authorized designate, assistants or representatives.

   (g) “Financial Officer” means the person assigned the responsibility of financial administration, or his authorized designate, assistants or representatives.
(h) “Infiltration” means groundwater, rainwater, surface runoff or snowmelt that enters a municipal wastewater collection system from a Sewer Defect.

(i) “Inflow” means groundwater, rainwater, surface runoff or snowmelt that enters a municipal wastewater collection system from connections to roof leaders; surface, foundation and other drains; manhole covers; and direct connections to storm or combined sewers.

(j) “Infiltration Exemption” means a certificate issued by the Director of Engineering that specifically authorizes Infiltration discharges to a Private Sanitary Sewer Lateral.

(k) “Inflow Exemption” means a certificate issued by the Director of Engineering that authorizes Inflow discharges to a Private Sanitary Sewer Lateral.

(l) “Licenced Plumber” means a plumber who has received accreditation in that trade pursuant to the Interprovincial Standards (Red Seal) Program.

(m) “Notice of Non-Compliance” means a written notice which advises an Owner of the failure to comply and the obligation to comply with the bylaw.

(n) “Owner” means the registered owner of a real property estate in fee simple.

(o) "Plumbing Fixture” includes any toilet, urinal, wash basin, sink, bath tub, shower, or other plumbing apparatus on private property that directly or indirectly conveys Sewage to the Sanitary Sewer Main.

(p) “Private Sanitary Sewer Lateral” means the privately owned underground pipe that conveys Sewage from a building or structure to the Public Sanitary Sewer Lateral at the property line.

(q) “Public Sanitary Sewer Lateral” means publicly owned pipe and fittings that convey sewage and connect a property, at or near the private property line, to the Sanitary Sewer Main.

(r) “Sanitary Sewer Lateral Certificate” means a certificate issued by the Director of Engineering evidencing the property’s compliance with the bylaw.

(s) “Sanitary Sewer Main” means publicly owned sewer pipe that conveys Sewage and is located on public property and to which the Private Sanitary Sewer Lateral is directly connected or connected via a Public Sanitary Sewer Lateral.

(t) "Sewage" includes waters carrying industrial and sanitary wastes from residences, business buildings, institutional and industrial establishments, and swimming pool water.

(u) “Sewer Defect” includes, but is not limited to cracked, broken or faulty pipes, pipe joints, sewer lateral connections, or manhole walls; rodent holes; or missing pipe portions which allow debris and groundwater to enter into the municipal wastewater collection system.

APPLICATION

3. This bylaw shall apply to all properties that receive sanitary sewer service from the [municipality].
NOTICE

4. A person shall be deemed to have received any notice delivered to that person by mail on the same day of the week, in the calendar week following mailing, as the day of the week on which the document was mailed or, if that day is a Saturday or holiday, on the next day that is not a Saturday or holiday.

PART 2 – PRIVATE SEWER LATERAL INSPECTION AND MAINTENANCE

REQUIRED MAINTENANCE STANDARD

5. An Owner of real property containing a Private Sanitary Sewer Lateral shall at the Owner’s expense maintain the Private Sanitary Sewer Lateral to the required maintenance standard.

6. The required maintenance standard for a Private Sanitary Sewer Lateral shall be as follows:
   (a) Clear of all obstructions, deposits, debris, tree roots and other solids which may impede the flow or obstruct the conveyance of Sewage;
   (b) Uniform and without sags, and shall be free of any Sewer Defect which may allow the introduction of Infiltration or debris into the Municipal wastewater collection system or that result in the discharge of Sewage onto property;
   (c) Have Cleanouts installed in accordance with sections 10 through 12 that permit the cleaning of the entire lateral. All Cleanouts shall be securely sealed with a proper cap at all times; and
   (d) Have all Inflow disconnected from the Private Sanitary Sewer Lateral and re-routed or connected in accordance with the City’s standards, except when an Inflow Exemption is issued by the Director of Engineering in accordance with section 13.

7. An Owner must maintain the Private Sanitary Sewer Lateral from the private property line to the building.

8. The City must maintain the Public Sanitary Sewer Lateral at the City’s expense.

9. If flushing or rodding of a Private Sanitary Sewer Lateral is required to remove an obstruction caused solely by a defect in the Public Sanitary Sewer Lateral, the City shall be solely responsible for the cost of removing the obstruction.

CLEANOUTS REQUIRED

10. Each Private Sanitary Sewer Lateral shall have a Cleanout located in the City right-of-way or easement.

11. Each Private Sanitary Sewer Lateral shall also have a privately maintained Cleanout installed in accordance with the Division B, Part 7 of the BC Building Code [citation of applicable sections required], as amended.
12. A person may Install Cleanouts under this Part at any time with applicable permits, but shall not be required until a Sanitary Sewer Lateral Certificate is required pursuant to any of Parts 3 or 4 of the bylaw.

UNAUTHORIZED DISCHARGES AND EXEMPTIONS

13. A person shall not discharge or permit to be discharged anything other than Sewage into the municipal wastewater collection system except as authorized by an Inflow Exemption or an Infiltration Exemption.

ENTRY AND TESTING BY CITY

14. The Director of Engineering may periodically perform tests or inspections to confirm the integrity and proper function of the Municipal wastewater collection system.

15. Testing and inspection methodology may include smoke testing, dyed water testing, air testing, hydraulic testing, closed circuit television inspection, and other testing or inspection techniques approved by the Director of Engineering.

16. The Director of Engineering may at reasonable times and on giving reasonable notice to the Owner, enter any property for the purposes of ascertaining whether the regulations of this bylaw are being observed.

17. The Director of Engineering may reasonably shorten the notice period for entry:

   (a) If the Director of Engineering is conducting an investigation in response to a complaint, or

   (b) If Sewage is exposed on the property in a manner that creates a potential health hazard.

18. A person commits an offence under this bylaw if they obstruct entry, tests or inspections by the Director of Engineering.

PART 3 – CERTIFICATE REQUIRED

IDENTIFIED DEFECT

19. The Director of Engineering may provide the Owner with written notice of a Sewer Defect identified in a Private Sanitary Sewer Lateral as a result of testing or inspection conducted by the City.

20. Subject to section 22, an Owner in receipt of a written notice of a Sewer Defect shall within 120 days of receipt of the notice obtain a Sanitary Sewer Lateral Certificate in accordance with Part 4.

21. If the identified Sewer Defect is such that Sewage is exposed on the property or there is a potential health hazard, an Owner must:

   (a) Stop the discharge immediately;
(b) Remediate the site not later than 24 hours after the Owner has notice of the exposed sewage; and
(c) Within 14 days of receipt of the notice obtain a Sanitary Sewer Lateral Certificate in accordance with Part 4.

CONSTRUCTION, RENOVATION OR NEW CONNECTION

22. Subject to section 23, an Owner shall completely replace the existing Private Sanitary Sewer Lateral with a new Private Sanitary Sewer Lateral and obtain a Sanitary Sewer Lateral Certificate in accordance with Part 4 if:
   (a) A new house or building is constructed on the property;
   (b) An existing house or building that is not already connected to a Private Sanitary Sewer Lateral requires a connection to the sewer system; or
   (c) An existing house or building is renovated and the estimated construction value is more than $100,000 and the work involves:
      (i) extensive excavation work,
      (ii) enlargement of the plumbing system by adding two or more fixtures, or
      (iii) results in increased demand upon the existing sewer system after renovations are complete.

23. If the existing Private Sanitary Sewer Lateral was built less than 25 years prior and meets the approval of the Director of Engineering, an Owner conducting construction or renovation work described in Section 21(c) shall obtain a Sanitary Sewer Lateral Certificate in accordance with Part 4.

24. The City may refuse to issue a building or occupancy permit to any Owner who fails to comply with this Part.

COMMERCIAL, STRATA AND MULTI-FAMILY DWELLINGS

25. An Owner of commercial or industrial use properties, strata, or multi-unit dwellings having four or more units shall obtain a Sanitary Sewer Lateral Certificate in accordance with Part 4 by December 31, 2018 and every ten years thereafter.

26. The Director of Engineering shall send Owners notice of their obligation to comply with the bylaw.

27. Any failure by the City to provide the notice described in Section 25 does not relieve an Owner of his obligation to comply with the bylaw.

NEIGHBOURHOOD PROGRAM NOTICE

28. The Director of Engineering may establish a Neighbourhood Program requiring Owners of real property in neighbourhoods identified by the Director of Engineering to obtain Sanitary Sewer Lateral Certificates.
29. The Director of Engineering may deliver to an Owner a notice of a Neighbourhood Program requiring a Sanitary Sewer Lateral Certificate requiring the Owner to obtain a Sanitary Sewer Lateral Certificate in accordance with Part 4.

30. An Owner who receives a notice of a Neighbourhood Program requiring a Sanitary Sewer Lateral Certificate shall within 120 days of receipt of the notice obtain a Sanitary Sewer Lateral Certificate in accordance with Part 4.

CHANGE OF OWNERSHIP OF PROPERTY

31. For the purposes of this Part a Change of Ownership means:

   (a) The property is sold outright pursuant to an “arm’s length agreement”, or

   (b) The property is inherited by someone other than a surviving spouse, who is neither a resident of the property, nor on property title.

32. As of December 31, 2017 for residential use real property containing three or fewer dwelling units, within 120 days after a Change of Ownership or a change of name associated with a Change of Ownership is entered in the City’s property tax records, an Owner shall obtain a Sanitary Sewer Lateral Certificate.

33. If the City becomes aware of any inquiry, information or evidence that suggests a Change of Ownership may or may have already occurred, the Director of Engineering shall deliver a notice to an Owner advising the Owner of his requirement under this Part to obtain a Sanitary Sewer Lateral Certificate.

34. If the Director of Engineering fails to provide a notice pursuant to section 33, it does not relieve an existing Owner or a new Owner of the obligation to obtain a Sanitary Sewer Lateral Certificate.

35. An Owner shall disclose to a prospective new Owner the requirements of this bylaw and the compliance status of the real property in question.

36. Upon a Change of Ownership, the new Owner shall be responsible for compliance with this Part, regardless of any disclosure or failure to disclose on the part of the prior Owner.

PART 4 - SANITARY SEWER LATERAL CERTIFICATE PROCEDURE

REQUIREMENTS FOR CERTIFICATE

37. An Owner subject to Part 4 shall obtain a Sanitary Sewer Lateral Certificate for the property.

38. Unless an Owner is able to produce the evidence described in section 44 (c) (ii), the Owner shall, in accordance with sections 39 through 43, first complete an inspection and any necessary repairs and post-repair inspection by a Qualified Inspector.
QUALIFIED INSPECTION

39. An Owner shall at his own expense arrange to have the Private Sanitary Sewer Lateral inspected by a Qualified Inspector in accordance with testing procedures prescribed by the Director of Engineering.

40. For the purposes of this Part:

   (a) “Qualified Inspector” means a Licensed Plumber equipped and able to perform inspections to confirm the integrity and proper function of the Private Sanitary Sewer Lateral, and equipped and able to carry out repair work.

   (b) “Inspection Report” means a report in a form prescribed by the Director of Engineering detailing the results of all inspection, repair work and post-repair inspection on the Private Sanitary Sewer Lateral, and signed by the Qualified Inspector who conducted the inspection and repair work.

SEWER LATERAL WORK

41. If an Inspection Report or a notice of defect delivered by the Director of Engineering reveals a Sewer Defect in a Private Sanitary Sewer Lateral, an Owner shall at his own expense repair or replace the Private Sanitary Sewer Lateral as necessary to meet the required maintenance standard described in Part 2.

42. An Owner shall first obtain from the City Engineering or Building Department a permit to conduct the repair or replacement work.

43. An Owner who has inspected, repaired or replaced a Sewer Defect in the Private Sanitary Sewer Lateral in compliance with Part 4 shall obtain from the Qualified Inspector an Inspection Report which will be filed by the Owner with the City as proof of compliance.

SANITARY SEWER LATERAL CERTIFICATE

44. The Director of Engineering may issue a Sanitary Sewer Lateral Certificate to an Owner who provides to the Director of Engineering the following items:

   (a) An Application for Sanitary Sewer Lateral Certificate in the prescribed form;

   (b) The required fee; and

   (c) Either of:

      (i) an Inspection Report, duly signed by the Qualified Inspector who performed the inspection and any repair work in accordance with sections 39 through 43 of this Part, and acceptable to the Director of Engineering; or

      (ii) records of a permit or evidence acceptable to the Director of Engineering, sufficient to prove that the Private Sanitary Sewer Lateral on the property
(1) was installed less than 25 years before the date of the application, or

(2) sustained significant repairs less than 10 years before the date of the application that the Director of Engineering at his sole discretion deems sufficient to reasonably expect the proper functioning of the Private Sanitary Sewer Lateral for a period of 10 years after issuance of a Sanitary Sewer Lateral Certificate.

45. The Director of Engineering shall consider the Inspection Report or other records or evidence pursuant to section 44 (c) (ii), and if the Director finds them to be satisfactory evidence of the Owner’s compliance, shall issue a Sanitary Sewer Lateral Certificate.

46. If the Director of Engineer finds the Inspection Report or other records or evidence to not be satisfactory, the Director of Engineering may require:

(a) City staff to perform an inspection to verify the Private Sanitary Sewer Lateral’s compliance with the required maintenance standard, and

(b) The Owner to carry out repairs or replacement work to bring the Private Sanitary Sewer Lateral into compliance with the required maintenance standard.

47. The Director of Engineering may waive the requirement for an Owner to affect a repair or replacement to a Private Sanitary Sewer Lateral and issue a Sanitary Sewer Lateral Certificate with an Infiltration Exemption for the Owner’s property, if he determines that compliance is not feasible.

48. The Director of Engineering may waive the Inflow disconnection requirement of section 6 (d) of the Required Maintenance Standard and issue a Sanitary Sewer Lateral Certificate with an Inflow Exemption for the Owner’s property if he determines there is no nearby municipal storm sewer, drain, ditch, stream, water body or other means to feasibly receive Inflow.

49. A Sanitary Sewer Lateral Certificate shall be effective for the following periods of time:

(a) A period of 10 years after acceptance by the Director of Engineering of an Inspection Report, or other records or evidence pursuant to section 45 for an existing Private Sanitary Sewer Lateral; or

(b) A period of 25 years after acceptance by the Director of Engineering of an Inspection Report for the replacement of the Private Sanitary Sewer Lateral.

PART 5 - FINANCIAL

FEES

50. The Director of Engineering may establish and collect fees in respect of:

(a) Issuance of a permit to conduct work involving repairs and/or replacement of a Private Sewer Lateral;
(b) Inspection or re-inspection of a Private Sanitary Sewer Lateral by City staff; (c) Issuance of a Sanitary Sewer Lateral Certificate; and (d) Recovery of costs in respect of any other administrative process required to implement this bylaw.

FINANCIAL ASSISTANCE

51. The City may establish a Private Sanitary Sewer Lateral financial assistance program in the nature of a no-interest loan program, to assist Owners with the costs of repairing or replacing a defective Private Sanitary Sewer Lateral.

52. The City shall not grant a loan unless:

(a) The Owner signs an agreement to repay the loan plus the lien registration costs in full, by way of five equal annual installments collected as property taxes;

(b) The loan principal will be secured by a lien registered against the property’s title in the Land Title Office; and

(c) The agreement requires the full balance of the loan to become immediately due and payable to the City upon any change in Ownership of the Property, as defined by section 31 and if unpaid, due and collectable as property taxes in arrears.

53. An Owner may apply for assistance from the program by filing an application with the Director of Engineering in the form prescribed by the Director of Engineering.

54. The Director of Engineering may determine eligibility for financial assistance on the basis of financial inability to pay for required repairs.

55. If an Owner complies with the application requirements, the Director of Engineering may authorize the Owner to receive financial assistance under the program.

PART 6 - FAILURE TO COMPLY

OFFENCE AND PENALTIES

56. The Director of Engineering, the Chief Building Inspector, or the Bylaw Enforcement Officer may enforce the provisions of this bylaw.

57. On becoming aware of an Owner’s non-compliance with this bylaw, an authorized enforcement officer may deliver a Notice of Non-Compliance to the Owner.

58. An Owner shall comply with the bylaw within 30 days of issuance of a Notice of Non-Compliance, or be liable to enforcement action.

59. The Director of Engineering may at his discretion extend the time period for compliance.

60. Each day that a violation occurs or continues constitutes a separate offence.
61. Costs incurred by the City to effect repairs required to bring a defaulting Owner’s Private Sanitary Sewer Lateral into compliance with the bylaw shall be a debt of the Owner owed to the City.

62. This debt will be due and payable 30 days after the date on which the expenses were incurred and if unpaid on the due date will be deemed taxes in arrears and may be so entered on the tax roll by the collector. Debts due may be recovered as a lien against the property.

63. Any financial assistance provided to an Owner by the City, or any repair or replacement of a defaulting Owner’s Private Sanitary Sewer Lateral by the City pursuant to section 17 of the Community Charter, as amended, are at the sole risk and cost of the Owner only.

64. The City shall assume no liability for providing financial assistance, or for effecting repair or replacement work and shall be immune from any claim by the Owner or any other person that arise as a result of providing the financial assistance or effecting the repair or replacement.

PART 7 – REVIEW

REVIEW

65. The Director of Engineering shall gather data and deliver to Council an annual report summarizing the actions that have resulted from the adoption of the bylaw, assessing the effectiveness of those actions, and making recommendations on any other priority actions needed to address Private Sanitary Sewer Lateral maintenance.

READ A FIRST TIME this ___ day of _____, 2016.

READ A SECOND TIME this ___ day of _____, 2016.

READ A THIRD TIME and passed by the Council this ___ day of _____, 2016.

READ A FINAL AND TIME this ___ day of _____, 2016.

MAYOR

_____________________________

CITY CLERK

_____________________________
Appendix F: Example Private Lateral Inspection Certification Application Form

The document is produced by the Town of Cheektowaga, New York is one example of a lateral certification application. Lateral certification is required prior to the sale of property in Cheektowaga.

33 (Town of Cheektowaga, 2017)
TOWN of CHEKTOWAGA
Inflow and Infiltration
Application and Inspection Form

Applications will not be processed unless all fees are paid at the time of filing the application

☐ Residential Property (single building up to three [3] units) $100.00 inspection fee.
☐ Commercial Property Total number of buildings on property ______ $150.00 inspection fee per building.

Date of Application ____________________ Amount Paid ____________________
Received By ____________________ Permit No. ____________________

APPLICANT to COMPLETE the PINK PORTION ONLY!

☐ Owner or ☐ Agent ____________________ must be present at the time of inspection.

Residential Property
☐ Owner Occupied   ☐ Rental   ☐ Single Family   ☐ Duplex   ☐ Multiple Apartments   ☐ Townhouse

Commercial Property
☐ Industrial   ☐ Warehouse   ☐ Mercantile   ☐ Hotel   ☐ Office   ☐ Institutional   ☐ Restaurant

Applicant’s Name ____________________ Daytime Phone No. ____________________ Call Phone No. ____________________
legal Address of Installation ____________________ Cheektowaga, NY 14 ____________________ 1/20 ______________

Closing Date ____________________

Property Owner’s Name ____________________ Daytime Phone No. ____________________ Call Phone No. ____________________

Property Owner’s Address ____________________ City ____________________ State ____________________ Zip code ____________________

INSPECTION OBSERVATIONS

Date of inspection: ______/_____/______ Time: _____:_____ ☐ am ☐ pm Inspected By: ____________________

Exterior Inspection

DOWNSPOUTS ☐ YES ☐ NO total # discharging below grade ______ total # discharging above grade ______
method of discharge ☐ on ground ☐ to sanitary sewer ☐ to storm sewer ☐ bubbler system ☐ unknown

LAWN/YARD CLEAN-OUT ☐ YES ☐ NO number ______ locations ______

LAWN FRESH AIR INLET ☐ YES ☐ NO material: ☐ plastic ☐ cast iron ☐ other ______
☐ replace broken or missing cap ☐ replace cracked or broken riser ☐ low lying trap (visible)
☐ unknown or buried must be raised above grade or sealed at grade ☐ air inlet thru building wall

COMMERCIAL PROPERTY ☐ parking lot receivers ☐ yard drains ☐ catch basins ☐ roof drains

EXTERIOR INSPECTION RESULTS

☐ No Corrections Required ☐ Corrections Required ☐ Re-inspection Required ☐ Dye Test Required

See reverse side for comments and or recommendations to correct any noted issues

TOWN of CHEKTOWAGA
Office of Building and Plumbing Inspections
275 Alexander Avenue Cheektowaga NY 14211
Controlling Inflow and Infiltration in the Metro Vancouver Area

March 12, 2019

INTERIOR INSPECTION

BASEMENT  □ YES □ NO  □ visible hung on wall, height above floor _____ □ not visible buried under floor

SUMP PUMP □ YES □ NO

method of discharge: □ to sanitary sewer □ to storm sewer □ exterior grade □ bubblor system □ unknown

BASEMENT KITCHEN □ YES □ NO number of: food prep sinks _____ dishwashers _____

method of discharge: □ to sanitary sewer □ to storm sewer □ exterior grade □ bubblor system □ unknown

LAVATORY FACILITIES □ YES □ NO hand wash sinks _____ water closets _____ showers or bath tubs _____

method of discharge: □ to sanitary sewer □ to storm sewer □ exterior grade □ bubblor system □ unknown

LAUNDRY TRAY □ YES □ NO

method of discharge: □ to sanitary sewer □ to storm sewer □ exterior grade □ bubblor system □ unknown

FLOOR DRAIN □ YES □ NO number of floor drains _____ location(s) ______________

method of discharge: □ to sanitary sewer □ to storm sewer □ exterior grade □ bubblor system □ unknown

INTERIOR INSPECTION RESULTS

□ No Corrections Required □ Corrections Required □ Re-Inspection Required □ Dye Test Required

REQUIRED CORRECTION FOR VIOLATIONS

□ It is required that all downsprouts from the dwelling be disconnected from the existing drainage system which is currently connected to the Town sanitary sewer system. As these connections are in violation of the Sewer Law of the Town of Cheektowaga, and immediate response to correct this violation is required to avoid any future legal action which may be filed against you.

□ It is required that the sump pump be disconnected from the existing sewer system which is currently connected to the Town sanitary sewer system. As this connection is in violation of the Sewer Law of the Town of Cheektowaga, an immediate response to correct this violation is required to avoid any future legal action which may be filed against you.

□ It is required that the sump pump discharge be relocated from the existing stationary tube in the basement. As this connection is in violation of the Sewer Law of the Town of Cheektowaga, an immediate response to correct this violation is required to avoid any future legal action which may be filed against you.

□ It is required that the existing floor drain be properly connected to the sanitary sewer or sealed to eliminate further inflow from the perimeter drainage system and/or ground water. As this connection is in violation of the Sewer Law of the Town of Cheektowaga, an immediate response to correct this violation is required to avoid any future legal action which may be filed against you.

□ It is required that all parking lot drains, yard drains and catch basins be disconnected from the existing drainage system which is currently connected to the Town sanitary sewer system. As these connections are in violation of the Sewer Law of the Town of Cheektowaga, an immediate response to correct this violation is required to avoid any future legal action which may be filed against you.

RECOMMENDATIONS FOR THE ELIMINATION OF WATER INFILTRATION

▪ It is recommended that a control valve be installed if the existing floor drain is connected to the sanitary sewer to eliminate any future sanitary sewer backups.
▪ It is recommended that a sump pump be installed to prevent and eliminate ground water from entering the basement area.
▪ Consult a professional to address any further water infiltration concerns.
▪ It is recommended that water discharged from roof downsprouts and the sump pump be directed away from the

NOTES

Page 69 of 69
End of Document