FINAL REPORT

Pinecrest Creek Cumulative Impacts Study

Summary Report

Ottawa, Ontario

Presented to:

Darlene Conway, P.Eng.
Senior Project Manager
Asset Management Branch

City of Ottawa

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<tr>
<td>TP</td>
<td>Total Phosphorus</td>
</tr>
<tr>
<td>TSS</td>
<td>Total Suspended Solids</td>
</tr>
<tr>
<td>Zn</td>
<td>Zinc</td>
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EXECUTIVE SUMMARY

In February 2016 the City of Ottawa (the City) commissioned Morrison Hershfield Limited (MHL), J.F. Sabourin and Associates Inc. (JFSA), and JTB Environmental Systems (JTBES) to undertake a Cumulative Impacts Study (CIS) for Pinecrest Creek. The CIS was required by the National Capital Commission (NCC) prior to implementation of the Baseline/Woodroffe Stormwater Management Retrofit Pond (B/W Pond), a priority project identified in the Pinecrest Creek/Westboro Stormwater Management Retrofit Study (JFSA, 2011) which was one of 17 projects that comprise the Ottawa River Action Plan (City of Ottawa, 2010).

In 2013 NCC staff had accepted the B/W Pond in principle, subject to the following conditions:

- That the cumulative effects of all anticipated major projects on the Pinecrest Creek corridor and adjacent NCC lands be investigated and addressed in a comprehensive manner;
- That the City commit to the implementation of retrofit measures beyond the “end-of-pipe” including retrofits within the right-of-way and at the lot level throughout the Pinecrest Creek subwatershed (as recommended in the P/W Study); and
- That it be demonstrated the proposed pond design will have significant positive benefits for the open space corridor and will maintain a recreational pathway link through this area.

The B/W Pond will treat uncontrolled runoff from some 435 ha of existing development. It will also offset SWM requirements (quantity control) for the proposed Baseline Station to be reconstructed with the implementation of Stage 2 Ottawa Light Rail Transit (OLRT).

The purpose of the CIS was to evaluate the cumulative impacts of development projects and City SWM retrofit projects on the hydrologic/hydraulic regime (peak flows and flood levels), water quality, and fluvial geomorphology (erosion and sedimentation) of Pinecrest Creek (the Creek).

The primary objectives of the CIS were as follows:

1. Identify and quantify the cumulative impacts on Pinecrest Creek of the following projects:
   - Baseline Road / Woodroffe Avenue SWM Retrofit Pond (B/W Pond);
   - SWM Retrofit Projects on City properties and within City rights-of-way (to 2037);
   - Stage 2 Ottawa LRT and Related Projects;
   - Baseline Road Bus Rapid Transit (BRT) Development (East and West);
   - MTO Highway 417 Widening (from Maitland Avenue to Highway 416); and
   - Planned development and redevelopment within the subwatershed (to 2031).

2. Identify appropriate measures to mitigate any (negative) cumulative impacts.

This CIS was completed in consultation with the NCC, Rideau Valley Conservation Authority (RVCA), Ministry of the Environment, Conservation and Parks (MECP), and the City of Ottawa.
The cumulative impacts assessment was based on a comparison of quantitative results from hydrologic/hydraulic and water quality modelling and a fluvial geomorphic assessment of the Creek. The analyses looked at Existing (2015) and Future (2027, 2037) Conditions scenarios. Future Conditions scenarios fell under two categories: uncontrolled (without SWM controls) and controlled (with SWM controls). Future development and SWM retrofit projects were subcategorized as being implemented in either the Interim (2027) or Ultimate (2037) time frame. Storm events (2- to 100-year design storms) and watershed response (peak flows, runoff volumes, flood levels) were simulated. Continuous (1967-2007) hydrologic simulations were completed for use in erosion and water quality analyses. Hydrologic/hydraulic modelling was completed with PCSWMM and HEC-RAS software. Water quality modelling was completed with PCSWMM using a methodology adapted from the draft *Eastern Subwatersheds SWM Retrofit Study* (MHL, 2018). The fluvial geomorphic functioning was assessed using a geomorphology model and erosion threshold analysis that determines the number of hours for which critical discharges are exceeded.

When implemented with SWM controls, Future (2027, 2037) Conditions peak flows are lower than Existing (2015) Conditions peak flows for the 2- to 100-year events. This reduction, primarily attributed to the B/W Pond, is seen for the full length of the Creek from the SWM pond outlet to the Ottawa River Parkway Pipe (ORPP) inlet. Peak flows and flood levels were modelled at key locations along the Creek, the ORPP, and spill to the Sir John A. MacDonald (SJAM) Parkway.

The B/W Pond and other SWM controls eliminate the spill to the Parkway during the higher frequency events (2-year return period events and smaller). This flow reduction translates to a reduction in flood depths on the Parkway of approximately 0.3m in a 100-year event. Peak flows and depths on the SJAM Parkway are reduced for all modelled storm events when comparing Future Conditions to Existing Conditions, pointing to a net reduction in flood risk to the Parkway. Key hydrologic and hydraulic results are presented in Table E-1.

*Table E-1: Summary of hydrologic and hydraulic modelling results Existing (2015) Conditions, Future Interim (2027) Conditions, and Future Ultimate (2037) Conditions (after JFSA Table 5-9)*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Event</th>
<th>Existing (2015)</th>
<th>Interim (2027)</th>
<th>Ultimate (2037)</th>
</tr>
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<tr>
<td>Peak Flow Upstream of ORPP Inlet (m³/s) (PCSWMM)</td>
<td>2-year</td>
<td>29.82</td>
<td>22.27</td>
<td>22.02</td>
</tr>
<tr>
<td></td>
<td>5-year</td>
<td>35.19</td>
<td>29.18</td>
<td>29.07</td>
</tr>
<tr>
<td></td>
<td>100-year</td>
<td>51.69</td>
<td>37.39</td>
<td>37.25</td>
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<tr>
<td>Peak Parkway Flow (m³/s) (HEC-RAS)</td>
<td>2-year</td>
<td>1.43</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5-year</td>
<td>4.39</td>
<td>0.57</td>
<td>0.51</td>
</tr>
<tr>
<td></td>
<td>100-year</td>
<td>23.11</td>
<td>7.77</td>
<td>7.62</td>
</tr>
<tr>
<td>Peak Water Level at ORPP Inlet (m) (HEC-RAS)</td>
<td>2-year</td>
<td>67.16</td>
<td>65.61</td>
<td>65.59</td>
</tr>
<tr>
<td></td>
<td>5-year</td>
<td>67.31</td>
<td>67.09</td>
<td>67.07</td>
</tr>
<tr>
<td></td>
<td>100-year</td>
<td>67.69</td>
<td>67.52</td>
<td>67.51</td>
</tr>
<tr>
<td>Depth along Parkway at Carling Ave (m) (HEC-RAS)</td>
<td>2-year</td>
<td>0.36</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>5-year</td>
<td>0.52</td>
<td>0.27</td>
<td>0.26</td>
</tr>
<tr>
<td></td>
<td>100-year</td>
<td>0.90</td>
<td>0.63</td>
<td>0.63</td>
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</table>

*The 2027 and 2037 simulation results showed no spill to the Parkway for the 2-year event. Model results for the 12-hour SCS storm (City of Ottawa, 2012).*
The water quality results show that in-stream average concentrations and loadings of all five pollutants simulated (TSS, TP, E. coli, Copper and Zinc) are reduced for Future Conditions. This reduction is driven by an increase in SWM controls with the B/W Pond providing the majority of the water quality improvement. The Future Ultimate conditions include additional retrofit LIDs compared to the Future Interim Conditions that provide further water quality benefit. A summary of water quality results is presented in Table E-2.

Table E-2: Existing (2015) Conditions annual average pollutant concentrations and reduction in annual average pollutant concentrations from Existing Conditions to Future Interim (2027) and Ultimate (2037) Conditions at key locations (after JFSA Tables 6-5, 6-8, and 6-9)

<table>
<thead>
<tr>
<th>Location</th>
<th>Cu  mg/L</th>
<th>E. Coli counts/100 mL</th>
<th>TP  mg/L</th>
<th>TSS mg/L</th>
<th>Zn  mg/L</th>
</tr>
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<tbody>
<tr>
<td>Woodroffe Avenue</td>
<td>0.021</td>
<td>33,334</td>
<td>0.189</td>
<td>133.3</td>
<td>0.061</td>
</tr>
<tr>
<td>Iris Road</td>
<td>0.020</td>
<td>31,650</td>
<td>0.188</td>
<td>132.1</td>
<td>0.057</td>
</tr>
<tr>
<td>ORPP Outlet</td>
<td>0.020</td>
<td>31,322</td>
<td>0.186</td>
<td>131.1</td>
<td>0.056</td>
</tr>
<tr>
<td>Ottawa River</td>
<td>0.020</td>
<td>31,278</td>
<td>0.186</td>
<td>131.3</td>
<td>0.055</td>
</tr>
<tr>
<td><strong>Interim (2027) Conditions – Reduction in concentrations from Existing Conditions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Woodroffe Avenue</td>
<td>52%</td>
<td>63%</td>
<td>48%</td>
<td>72%</td>
<td>59%</td>
</tr>
<tr>
<td>Iris Road</td>
<td>25%</td>
<td>30%</td>
<td>21%</td>
<td>33%</td>
<td>26%</td>
</tr>
<tr>
<td>ORPP Outlet</td>
<td>15%</td>
<td>19%</td>
<td>13%</td>
<td>21%</td>
<td>16%</td>
</tr>
<tr>
<td>Ottawa River</td>
<td>14%</td>
<td>18%</td>
<td>12%</td>
<td>20%</td>
<td>15%</td>
</tr>
<tr>
<td><strong>Ultimate (2037) Conditions – Reduction in concentrations from Existing Conditions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Woodroffe Avenue</td>
<td>52%</td>
<td>63%</td>
<td>48%</td>
<td>72%</td>
<td>59%</td>
</tr>
<tr>
<td>Iris Road</td>
<td>25%</td>
<td>30%</td>
<td>21%</td>
<td>34%</td>
<td>26%</td>
</tr>
<tr>
<td>ORPP Outlet</td>
<td>17%</td>
<td>19%</td>
<td>15%</td>
<td>23%</td>
<td>17%</td>
</tr>
<tr>
<td>Ottawa River</td>
<td>16%</td>
<td>18%</td>
<td>14%</td>
<td>22%</td>
<td>16%</td>
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</table>

Due to on-site SWM controls, some development projects will not negatively impact the Creek. In comparison, negative impacts from other projects such as Baseline LRT Station and Baseline BRT will rely on mitigation provided by the B/W Pond. The B/W Pond (and other projected SWM retrofit projects) are expected to provide an overall net benefit to the Creek for flood risk, water quality, and erosion from the upstream end of the daylit portion (north of Baseline Road) to its outlet at the Ottawa River.

The erosion impacts analysis indicates that under Future Conditions, the B/W Pond, in combination with the projected SWM retrofits, greatly reduces the exceedance of most erosion thresholds and therefore erosion itself in the reach immediately downstream of the Pond. Although the B/W Pond is attenuating the highest and most erosive flows, the discharge during the drawdown period is enough to produce the velocities required to transport particles of 5 mm or finer, which could mean a loss of finer-grained materials in the Creek if a natural supply of fines is not available. Key results are presented in Table E-3 and show the percent increase or decrease in threshold exceedance hours from existing to future conditions for each critical discharge for the most upstream (5060) and the most downstream (1177) cross-sections analyzed.
Changes to the runoff response of the Pinecrest Creek subwatershed as a result of the B/W pond and other projects will result in changes to the Creek’s geomorphic function. This will introduce a new period of adjustment. Within 20 to 40 years, the Creek, which is currently in a stage characterized by channel widening, will transition to a period of stabilization and deposition, followed ultimately by a new stability. During this stabilization process, the Creek is expected to experience bank failures, however, the Creek corridor is sufficiently wide to allow for adjustment during the transition. Direct intervention during this stage is not recommended unless there is a risk to public safety, property, or infrastructure but it is not possible to accurately predict when such risks might arise. Risks can be managed via a monitoring program throughout the Creek corridor. A detailed monitoring plan for the Creek will be developed by the City, in consultation with the NCC, in 2019. The plan will be implemented by the City in parallel with, and subsequent to, the future projects and development, in particular the B/W Pond.

Figure E-1 below provides a summary of historical and active erosion areas on Pinecrest Creek. Erosion Sites #1, #2 and #3 were originally identified in the fluvial geomorphology study as part of the detailed design of the B/W Pond and were identified in the study herein as the current areas of erosion concern. Restoration Sites #8, #9, and #10 were identified in the 2007 restoration study by the NCC, however their implementation was not prioritized at the time and consequently not undertaken. The status of each of the erosion areas based on the current study herein is as follows:

- Erosion Site #1 (upstream of Iris Street) was not included in the erosion analysis herein as it will be eliminated with the future channel realignment at Iris Street as part of Stage 2 OLRT.
- Erosion Site #2 (downstream of the Queensway) will continue to be affected by toe erosion, however it is expected to be at a decreased frequency and magnitude, allowing for more opportunity to intervene if risk to the adjacent informal pathway develops.

- Erosion Site #3 (downstream of Erosion Site #2) will experience a decrease in exceedances of its critical erosion threshold. In summer 2018, erosion undercutting of the east bank resulted in the toppling of a large tree, creating a barrier to flow and accumulation of debris, which may exacerbate erosion. The NCC has been alerted to the issue and to the recommendation for tree removal as soon as possible.

- In the same reach as Erosion Site #3, proposed works at Restoration Site #8 are not required now that the undercut tree and bank have collapsed, and given the planned SWM retrofits.

- Downstream, Restoration Site #9, which includes an eroding bank with toppling trees near the multi-use pathway, no longer presents an issue now that the bank has stabilized and, as with Restoration Site #8, will benefit from implementation of the SWM retrofit projects.

- Restoration Site #10, located within the Creek reach downstream of the Baseline Road outfall, will be addressed with the armour stone wall removal and bank regrading works associated with the B/W Pond to be implemented with Stage 2 OLRT.

Restoration works were identified in the 2007 restoration study for Transitway culverts #1 and #2 and for the Iris Street culvert. In 2015, accumulated sediment in culvert #1 (furthest upstream on Transitway) was cleaned out and a low flow channel introduced. Restoration works have not been undertaken at the other culverts (although the Iris Street culvert will be removed with the channel realignment required for Stage 2 OLRT). Based on a 2016 assessment of culvert crossings, the current fluvial geomorphology study has identified no additional fluvial concerns other than previously noted nor risks to culvert function from fluvial processes.

Implementation of the planned SWM controls and SWM retrofits will result in an overall net benefit to the Creek in terms of peak flows, flood levels, water quality, and fluvial geomorphology and will mitigate negative impacts associated with the future projects and development identified herein to 2037. Apart from the removal of a fallen tree at Erosion Site #2, no further interventions are required at this time. The development of a detailed long-term monitoring plan is recommended prior to implementation of the B/W Pond that will capture the full length of the remaining open channel, including the remaining erosion areas of concern, remaining restoration sites, and infrastructure near/within the Creek including culverts, pathways and outfalls.
Figure E-1: Summary of Erosion Sites along Pinecrest Creek

[Map showing various locations along Pinecrest Creek with erosion sites marked]

Legend
- Storm Outfalls
- Culverts
- Recreational Pathways
- Pinecrest Creek
- Informal Pathway
- Channel Realignment (To be implemented with Stage 2 DLIPT)
- Restoration Sites*
- Culvert Works
- Erosion Sites

* Restoration Sites 9, 10 and 16 shown on this figure were developed in the NCC Pinecrest Creek Restoration Plan (TRES, 2007)
1. INTRODUCTION

In February 2016, the City of Ottawa retained Morrison Hershfield Limited (MHL), J.F. Sabourin and Associates Inc. (JFSA), and JTB Environmental Systems (JTBES) to undertake a Cumulative Impacts Study (CIS) of Pinecrest Creek.

The overall purpose of the CIS is to evaluate the cumulative impacts of development projects and other City SWM retrofit projects on the flow regime (flows and flood levels), water quality, and fluvial geomorphology (erosion and sedimentation) of Pinecrest Creek (the Creek).

This Summary Report presents key findings from the analyses completed as part of the CIS. Section 1 provides the background. Section 2 summarizes the approach and methodology for the hydrologic/hydraulic, erosion, and water quality analyses. Section 3 presents the results for existing and future conditions. Section 4 discusses the impacts that are anticipated to occur as a result of the planned projects. Finally, Section 5 describes the benefits expected from the proposed SWM controls for various development projects and retrofit SWM projects planned for the long-term by the City, and identifies any additional measures required to mitigate impacts.

1.1 Background

On February 24, 2010, Ottawa City Council adopted the Ottawa River Action Plan (ORAP). Two key objectives of ORAP were to:

i. Maintain a healthy aquatic ecosystem, with a focus on addressing challenges presented by existing development and infrastructure; and

ii. Optimize recreational use and economic development of the Ottawa River, with a focus on reducing beach closures.

To help achieve these objectives, ORAP stated that the impacts of uncontrolled stormwater runoff must be addressed.

The Pinecrest Creek/Westboro Stormwater Management (SWM) Retrofit Study (P/W Study) was one of 17 separate projects that comprise ORAP. It identified a long-term plan of SWM retrofit projects, outreach efforts, and monitoring programs aimed at mitigating the historical impacts of development on the Creek and the local reach of the Ottawa River. Ottawa City Council endorsed the P/W Study on October 26, 2011.

One of the priority projects identified through the P/W Study (JFSA et al., 2011) was the implementation of a new retrofit SWM pond to be located on National Capital Commission (NCC) property at the northeast corner of Baseline Road and Woodroffe Avenue (the B/W Pond) that would treat approximately 435 hectares of primarily urban residential area upstream that currently flows uncontrolled to the Creek.

Prior to completion of the P/W Study, a separate assessment outlined subwatershed-specific SWM criteria for a number of imminent and future projects in the Pinecrest/Centrepointe SWM Criteria Study (JFSA et al., 2010). These criteria (referred to herein as the Pinecrest Creek SWM criteria) were later updated for application to all future projects and developments in the
P/W Study area in the *SWM Guidelines for the Pinecrest Creek/Westboro Area* (JFSA, Draft 2012).

When underground storage was proposed at Baseline Station as a SWM option to provide quantity control that would adhere to the Pinecrest Creek SWM criteria for the future Southwest Transitway (SWTW) Extension, the B/W Pond was identified as a more holistic solution that would provide significant benefits to the Creek while compensating for the quantity control requirements of the station. Discussions with NCC staff led to the preparation of the *Feasibility Study for a Surface Stormwater Management Facility at Baseline Road and Woodroffe Avenue* (JFSA et al., 2015). The draft results of this study, presented to NCC staff in March 2013, demonstrated that implementation of the B/W Pond could offset the required SWM quantity control needed to meet Pinecrest Creek SWM criteria for the 14.4 ha drainage area including the proposed SWTW Extension and upgraded Baseline Station, in lieu of underground storage. Uncontrolled runoff from the SWTW Extension would ultimately discharge downstream of the B/W Pond through a new outfall to Pinecrest Creek between Woodroffe Avenue and Iris Street. Quality control for the SWTW Extension and upgraded Baseline Station would have to be provided on–site.

Following the construction of the new outfall (not yet commissioned) in 2011, the preparation of the Feasibility Study in 2015, and NCC’s conditional acceptance of the B/W Pond in 2014, City Council approved the functional design of the Stage 2 Ottawa Light Rail Transit (OLRT) in July 2015 and authorized staff to begin the procurement process for the Stage 2 LRT project. This was to include the extension of the Confederation Line West to Baseline Station. Council’s decision would result in direct conversion of Baseline Station to BRT/LRT rather than remain a BRT station on an interim basis. As such, conversion of the station, including the commissioning of the outfall built in 2011, became part of the Stage 2 OLRT project.

NCC staff had accepted the B/W Pond in principle, subject to the following conditions:

- That the **cumulative effects** of all anticipated major projects on the Pinecrest Creek corridor and adjacent NCC lands be investigated and addressed in a comprehensive manner;

- That the City commit to the **implementation of retrofit measures** beyond the “end-of-pipe” including retrofits within the right-of-way and at the lot level throughout the Pinecrest Creek subwatershed (as recommended in the P/W Study); and

- That it be demonstrated the proposed **pond design will have significant positive benefits** for the open space corridor and will maintain a recreational pathway link through this area.

With NCC’s conditional acceptance of the B/W Pond conceptual design, the required CIS commenced in conjunction with the Municipal Class Environmental Assessment (Class EA) ‘Schedule B’ for the pond. Both studies were needed to inform the Preliminary Engineering (PE) for Stage 2 OLRT now that Baseline Station would be converted to an LRT Station under Stage 2 OLRT. To ensure that the CIS and the EA were delivered in conjunction with the Preliminary Engineering schedule, these assignments were awarded in early 2016 to the study consultant team under the direction of Capital Transit Partners 2 (CTP2), the consortium tasked with completing the PE and procurement of Stage 2 OLRT.
The Class EA Study was posted to the Environmental Registry of Ontario in June 2017. A request for a Part II Order was received in August 2017 but denied by the Minister later that year, enabling the project to move forward.

Because the B/W Pond was needed to offset the SWM requirements for Baseline LRT Station, the detailed design assignment for the pond was also included in the scope of work of Stage 2 OLRT. The design was undertaken by CTP2 (including MHL et al.) and subconsultants (JFSA, JTBES) in consultation with the public, NCC, RVCA and other regulatory partners, and completed in January 2018. Final design and construction of the B/W Pond will be completed with the implementation of Stage 2 OLRT scheduled to occur between 2019 and 2023. Federal Land Use, Design, and Transaction Approval (FLUDTA) of the B/W Pond was granted by the NCC on July 16, 2018.

At the final CIS Technical Advisory Committee (TAC) meeting on June 26, 2018, the NCC confirmed that the FLUDTA for Stage 2 OLRT was not dependent on the completion of the CIS. However, the CIS was referenced in the Memorandum of Understanding (MOU) between the City and NCC. Any mitigation measures required by the CIS will need to be implemented by the City at a time that is mutually agreeable to the City and NCC. The City agreed to remain in consultation with the NCC with regards to the timeline of implementation of mitigation measures and projects.

1.2 Previous Studies

A number of background studies related to Pinecrest Creek were reviewed as part of the current study including:

- Pinecrest Creek Restoration Plan (JTBES et al., 2007)
- Impacts of wet weather flow on Westboro Beach and the Ottawa River (Baird & Associates, 2002; 2004; 2008)
- Pinecrest Creek 2010 Monitoring Report (JTBES, 2011)
- Ottawa River Action Plan (City of Ottawa, 2010)
- Pinecrest/centrepointe SWM Criteria Study (JFSA et al., 2010)
- Pinecrest Creek/Westboro Stormwater Management Retrofit Study (JFSA, 2011)
- Stormwater Management Guidelines for the Pinecrest Creek / Westboro Area (JFSA, Draft 2012)
- Feasibility Study for a Surface Stormwater Management Facility at Baseline Road and Woodroffe Avenue (JFSA, 2015)
- Baseline Road/Woodroffe Avenue Pinecrest Creek Stormwater Management Pond Design Brief (MHL et al., 2017)
1.3 Pinecrest Creek SWM Criteria

The Pinecrest Creek SWM criteria were developed to mitigate the impacts of infill and redevelopment projects on Pinecrest Creek and the local reach of the Ottawa River. The subwatershed-specific criteria were first outlined in the Pinecrest/Centrepointe SWM Criteria Study (JFSA et al, 2010) and were later updated in the SWM Guidelines for the Pinecrest Creek/Westboro Area (JFSA, Draft 2012).

The draft criteria for projects and developments draining to Pinecrest Creek are summarized in Table 1 below. The criteria require that infill and redevelopment projects in the subwatershed retain on-site the first 10 mm of rainfall, detain runoff from the next 15 mm of rainfall to 5.8 L/s/ha for erosion protection, and control the 100-year peak flows to 33.5 L/s/ha for flood protection. The water quality requirement of 80% TSS removal can be achieved in part with the retention of the first 10 mm of rainfall.

Table 1: Pinecrest Creek SWM Criteria (JFSA, Draft 2012)

<table>
<thead>
<tr>
<th>Soil Infiltration Characteristic</th>
<th>Runoff Volume Reduction</th>
<th>Water Quality (TSS Removal)</th>
<th>Water Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Flooding</td>
</tr>
<tr>
<td><strong>Discharging upstream of Ottawa River Parkway Pipe (ORPP) inlet</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>soil infiltration &gt; 1mm/hr</td>
<td>On-site retention of 10mm rainfall</td>
<td>On-site 80% TSS removal</td>
<td>More stringent of 33.5 L/s/ha (1:100 yr) or Sewer Design Guideline</td>
</tr>
<tr>
<td>soil infiltration &lt; 1mm/hr</td>
<td>Best effort based on opportunity</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Discharging directly to the Ottawa River Parkway Pipe (ORPP)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>soil infiltration &gt; 1mm/hr</td>
<td>On-site retention of 10mm rainfall</td>
<td>On-site 80% TSS removal</td>
<td>More stringent of 33.5 L/s/ha (1:100 yr) or Sewer Design Guideline</td>
</tr>
<tr>
<td>soil infiltration &lt; 1mm/hr</td>
<td>Best effort based on opportunity</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1.4 Study Objectives

In addition to the B/W Pond and other SWM retrofit measures recommended in the P/W Study to be implemented over the coming decades, a number of upcoming transportation projects and future developments are anticipated to have impacts on the Creek (listed below).

Accordingly, the primary objectives of the CIS are as follows:

3. Identify the cumulative impacts on Pinecrest Creek of the following:
   - Baseline / Woodroffe SWM Retrofit Pond (B/W Pond);
   - SWM Retrofit Projects on City properties and within City rights-of-way (projected to 2037);
• Stage 2 OLRT;
• MTO Highway 417 Widening;
• Baseline BRT Development; and
• Planned development and redevelopment within the subwatershed (to 2031).

4. Identify appropriate measures to mitigate any (negative) cumulative impacts.

1.5 Study Area

The study area for the CIS comprises the Pinecrest Creek subwatershed and the Pinecrest Creek system within it (Figure 1). The Pinecrest Creek system, located in the City’s west end, is a tributary to the Ottawa River, and is composed of the remaining open channel and the Ottawa River Parkway Pipe (ORPP), which is the enclosed section of Pinecrest Creek and its overland flow to the Sir John A. MacDonald Parkway (the SJAM Parkway.)

Pinecrest Creek is a small “flashy” stream within an urbanized subwatershed that has long been adjusting to uncontrolled urban runoff and the resulting high peak flows and erosion potential.

1.6 Consultation

A Technical Advisory Committee (TAC) was convened with the NCC, Rideau Valley Conservation Authority (RVCA), Ministry of the Environment, Conservation and Parks (MECP), and the City of Ottawa. Three TAC meetings were held throughout the study process. The minutes of the TAC meetings are provided in Appendix A.

Specific consultation goals included:

• Consultation with stakeholders on the study process, steps, and tasks;

• Presentation of the results of the hydrology, hydraulics, water quality, and erosion cumulative impacts assessments; and

• Consultation with the TAC on the proposed mitigation measures.
Figure 1: The Pinecrest Creek System and Subwatershed, Study Area (after JFSA Figure 1-1)
2. APPROACH AND METHODOLOGY

2.1 General Approach

The purpose of the CIS is to identify and quantify the cumulative effects of a number of City of Ottawa projects and future development in the Pinecrest Creek subwatershed area. These projects include a future SWM retrofit pond at Baseline Road and Woodroffe Avenue, planned SWM retrofits throughout the watershed, the Stage 2 OLRT and associated projects with impacts in the Pinecrest Creek corridor and subwatershed, Baseline Road BRT, Highway 417 widening, and projected development within the Official Plan horizon (2031).

The cumulative effects of these projects and future development on the Creek’s peak flows and runoff volumes, water levels, water quality, and erosion processes were assessed with the intent of identifying appropriate mitigation measures where required.

The cumulative impacts assessment is primarily based on a comparison of quantitative results from hydrologic/hydraulic, and water quality modelling, as well as a fluvial geomorphic assessment of the Creek. However, consideration was also given to the direct impact of projects, such as a future channel realignment associated with the Stage 2 LRT at Iris Street. The approaches for the various analyses are summarized in Sections 2.4, 2.5, and 2.6 below and are documented in detail in Appendix B and Appendix C.

The analyses looked at existing conditions and a range of future conditions to represent various possible degrees of development and SWM control implementation. The scenarios are summarized in Section 2.3.

2.2 Data

Documentation and data review were on-going throughout most of the study duration. Data requirements for the study generally included: completed studies and studies underway in parallel to the CIS (see Section 1.2 above), GIS and other digital data from the City, and planning and design data for projects, future development, and SWM controls.

A list of main studies consulted as part of the CIS is provided in Section 1.2, with complete references provided in Section 6. The complete list of studies consulted for the Hydrology, Hydraulics, and Water Quality Report is provided in the reference section of Appendix B.

The City provided topographic and land use GIS data, LiDAR, rain gauge data, stream flow data, field survey data, trunk sewer monitoring data, and water quality data. This data is used in the hydrologic and hydraulic subwatershed models.

The City also provided information on the extent (footprint), implementation schedule, and SWM controls and related information for the Stage 2 OLRT, the Baseline Road BRT, and planned development within the subwatershed.
2.3 Modelling Scenarios

As part of the current study, existing conditions peak flows and water levels were compared to various future conditions scenarios. The existing conditions scenario serves as a benchmark against which other scenarios were compared in order to assess the cumulative impacts of future development and mitigation measures.

Future scenarios fall under two categories: uncontrolled and controlled (see Table 2). The uncontrolled category includes scenarios without SWM controls that, when compared with existing conditions, serve to measure the impacts of proposed developments when these are implemented without SWM controls. Storm events (2- to 100-year design storms) and watershed response (peak flows, runoff volume, etc.) were modelled for uncontrolled scenarios, however continuous hydrologic simulations were not completed for these scenarios.

The future controlled scenarios were intended to measure impacts of proposed developments implemented with SWM controls, and evaluate the need for additional mitigation measures, such as additional SWM controls, retrofits, or in-stream restoration works. Storm events (2- to 100-year design storms) and watershed response (peak flows, runoff volume, etc.) were simulated for these scenarios. Continuous hydrologic simulations for use in erosion and water quality analyses were also completed. Subcatchments where SWM controls will be implemented under Future (Interim and Ultimate) Conditions are shown in Figure 2.

Development and SWM retrofit projects are subcategorized as being implemented in either the Interim (2027) or Ultimate (2037) time frame.

Table 2: Modelling Scenarios

<table>
<thead>
<tr>
<th>Existing Conditions</th>
<th>Future Uncontrolled Conditions</th>
<th>Future Controlled Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Existing (2015)</td>
<td>• Uncontrolled Future Interim</td>
<td>• Controlled Future Interim</td>
</tr>
<tr>
<td></td>
<td>(2027) Conditions</td>
<td>(2027) Conditions</td>
</tr>
<tr>
<td></td>
<td>• Uncontrolled Future Ultimate</td>
<td>• Controlled Future Ultimate</td>
</tr>
<tr>
<td></td>
<td>(2037) Conditions</td>
<td>(2037) Conditions</td>
</tr>
<tr>
<td></td>
<td>• Uncontrolled Future Interim</td>
<td>• Controlled Future</td>
</tr>
<tr>
<td></td>
<td>(2027) Conditions + B/W Pond</td>
<td>Ultimate (2037) Conditions</td>
</tr>
<tr>
<td></td>
<td>• Uncontrolled Future Ultimate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2037) Conditions + B/W Pond</td>
<td></td>
</tr>
</tbody>
</table>

2.3.1 Future Conditions Scenarios

In addition to the B/W Pond and other SWM measures recommended in the P/W Study to be implemented over the coming decades, a number of upcoming City projects and development projects are anticipated to have impacts on the Creek, including Stage 2 OLRT, MTO widening of Highway 417, Baseline Road BRT, and development within the subwatershed. The projects and SWM controls that characterize each timeframe (2027 and 2037) are summarized here and described in greater detail in Section 5.2 of Appendix B.

Table 3 lists the simulated SWM controls for each future project and how they meet the Pinecrest Creek SWM criteria for runoff volume/erosion control, flood control, and water quality (refer to Section 1.3 for SWM Criteria details). Future SWM retrofit project locations are shown on Figure 3 and future development project locations are shown on Figure 4.
Table 3: Development Projects and SWM Controls simulated for Future Interim (2027) and Ultimate (2037) Conditions (after JFSA Tables 5-1 and 6-3 in Appendix B)

<table>
<thead>
<tr>
<th>Development Projects</th>
<th>SWM Controls</th>
<th>10 mm retention</th>
<th>25 mm detention</th>
<th>100-year detention</th>
<th>Water Quality</th>
<th>Year implemented</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stage 2 OLRT Related Projects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline Station</td>
<td></td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>OGS</td>
<td>2027</td>
</tr>
<tr>
<td>LRT Track (ballast)</td>
<td></td>
<td>LID</td>
<td>LID</td>
<td>LID</td>
<td>BR</td>
<td>2027</td>
</tr>
<tr>
<td>Queensview Station / Track</td>
<td></td>
<td>–</td>
<td>–</td>
<td>Storage</td>
<td>IT</td>
<td>2027</td>
</tr>
<tr>
<td>Pinecrest Station to Queensview Station</td>
<td></td>
<td>–</td>
<td>–</td>
<td>Storage</td>
<td>IT</td>
<td>2027</td>
</tr>
<tr>
<td>Lincoln Fields Bus Station</td>
<td></td>
<td>Dep. Stor.</td>
<td>–</td>
<td>Storage***</td>
<td>IT</td>
<td>2027</td>
</tr>
<tr>
<td><strong>Proposed Development Projects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Algonquin CCE**</td>
<td></td>
<td>Dep. Stor.</td>
<td>–</td>
<td>Storage</td>
<td>BR</td>
<td>2015</td>
</tr>
<tr>
<td>Archives and Library</td>
<td></td>
<td>LID</td>
<td>Storage</td>
<td>Storage</td>
<td>IT</td>
<td>2015</td>
</tr>
<tr>
<td>East Baseline BRT</td>
<td></td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>2027</td>
</tr>
<tr>
<td>West Baseline BRT</td>
<td></td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>2037</td>
</tr>
<tr>
<td>HWY 417 Widening</td>
<td></td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>2027</td>
</tr>
<tr>
<td>IKEA Mall*</td>
<td></td>
<td>Dep. Stor.</td>
<td>Storage</td>
<td>Storage</td>
<td>IT</td>
<td>2037</td>
</tr>
<tr>
<td>Lincoln Fields Mall*</td>
<td></td>
<td>Dep. Stor.</td>
<td>Storage</td>
<td>Storage</td>
<td>IT</td>
<td>2037</td>
</tr>
<tr>
<td>Priscilla Mall*</td>
<td></td>
<td>Dep. Stor.</td>
<td>Storage</td>
<td>Storage</td>
<td>IT</td>
<td>2037</td>
</tr>
<tr>
<td><strong>CTC Redevelopment (subcatchment names)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>“CTC_4”</td>
<td></td>
<td>Dep. Stor.</td>
<td>Storage</td>
<td>–</td>
<td>IT</td>
<td>2037</td>
</tr>
<tr>
<td>“HG8X2_2”*</td>
<td></td>
<td>Dep. Stor.</td>
<td>Storage</td>
<td>–</td>
<td>IT</td>
<td>2037</td>
</tr>
<tr>
<td>“CTC_1”</td>
<td></td>
<td>Dep. Stor.</td>
<td>Storage</td>
<td>–</td>
<td>IT</td>
<td>2037</td>
</tr>
<tr>
<td>“CTC_3”</td>
<td></td>
<td>Dep. Stor.</td>
<td>Storage</td>
<td>–</td>
<td>IT</td>
<td>2037</td>
</tr>
<tr>
<td>“CTC_2”</td>
<td></td>
<td>Dep. Stor.</td>
<td>Storage</td>
<td>Storage</td>
<td>OGS</td>
<td>2015</td>
</tr>
<tr>
<td><strong>Proposed SWM Retrofit Projects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B/W Pond</td>
<td></td>
<td>Storage</td>
<td>Storage</td>
<td>Storage</td>
<td>WP</td>
<td>2027</td>
</tr>
<tr>
<td>ROW Retrofit LID</td>
<td></td>
<td>LID</td>
<td>LID</td>
<td>LID</td>
<td>BR</td>
<td>2027 + 2037</td>
</tr>
<tr>
<td>Lot Level Retrofit LID</td>
<td></td>
<td>LID</td>
<td>LID</td>
<td>LID</td>
<td>BR/IT</td>
<td>2027 + 2037</td>
</tr>
</tbody>
</table>

*Redevelopment projects referred to as “2031 intensification projects”

**Design report for Algonquin CCE (Centre for Construction Excellence) (Delcan, 2010) indicates that the 25 mm retention control was not explicitly provided due to orifice size limitations.

*** LIDs are proposed at Lincoln Fields Station for flood control, however specific design details were not available. Therefore, detention volume was simulated as a storage node.

Dep. Stor. - Denotes using depression storage volume in PCSWMM to simulate the 10 mm runoff volume reduction.

Storage - Denotes using a storage node in PCSWMM to simulate detention (quantity control).

LID - Denotes using the ‘LID Tool’ in PCSWMM. Refer to JFSA Table 5-1 footnotes for details.

BR, IT, OGS, and WP - Denotes the removal rates applied for bioretention, infiltration trench, oil grit separator, and wet pond, respectively. Refer to JFSA Table 6-3 footnotes for details.
Future Interim (2027) Conditions

The Future Interim (2027) Conditions scenario includes the following development and transit projects and SWM controls:

1. **Baseline Road / Woodroffe Avenue SWM Retrofit Pond**: A SWM Pond with a contributing drainage area of 435 ha of primarily residential development that currently drains uncontrolled to Pinecrest Creek. Detailed (90%) design of the pond was completed in December 2017 by Capital Transit Partners 2 (CTP2, Owner’s Engineers for Stage 2 OLRT). Construction, which will be undertaken with Stage 2 OLRT, is anticipated to be complete by 2023.

2. **SWM Retrofit Projects**: Proposed lot-level and right-of-way (ROW) retrofit sites were identified in a memo from the City entitled *Pinecrest Creek Cumulative Impact Study – SWM Retrofit Scenarios* (June, 2016), provided in Appendix B. Feasibility-level designs or functional designs were also provided. This scenario included retrofits to be implemented by 2027.

3. **East Baseline Bus Rapid Transit (BRT) Development**: The eastern segment of the Baseline BRT is expected to be implemented before 2027. The project includes the widening of roadways that will result in increased imperviousness in the Pinecrest Creek subwatershed.

4. **Highway 417 Widening**: This MTO highway widening will extend from Maitland Avenue in the east to Highway 416 in the west and is expected to be implemented before 2027. The project includes the widening of roadways that will result in increased imperviousness in the Pinecrest Creek subwatershed.

5. **Stage 2 OLRT and Related Projects**: Construction of the Stage 2 OLRT is scheduled to be completed by 2023. The LRT includes a number of components that will impact the Pinecrest Creek subwatershed, including:

   a. The addition and removal of impervious surfaces in the Pinecrest Creek corridor between Richmond Road and Baseline Station;

   b. Realignment of a reach of Pinecrest Creek to allow for the construction of the Iris Street overpass at the LRT;

   c. New Baseline LRT/BRT Station, including a new storm sewer connection to, and the commissioning of, the new storm outfall (not yet commissioned) that will service Baseline Station, located downstream of Woodroffe Avenue;

---

1 During the course of the CIS, the Highway 417 widening project was added to the scope of work for Stage 2 OLRT to be implemented by 2023. However, at the time of reporting, it had been excluded from that scope. Consequently, any new implementation timelines were unknown to the study team.

2 The details for this project were provided by CTP2 through MHL based on the conceptual design prepared during the preliminary engineering phase of the Stage 2 OLRT project. The conceptual design is subject to refinements or changes altogether during the forthcoming detailed design phase, as long as the requirements outlined in the project specifications are satisfied.
- New Queensview and Pinecrest LRT Stations, including SWM controls designed to meet the Pinecrest Creek SWM criteria;
- Bioretention swales where feasible along the LRT runningway within the Pinecrest Creek corridor;
- New Lincoln Fields LRT/BRT Station, including LIDs and other SWM controls designed to meet the Pinecrest Creek criteria;
- Relocation of a segment of the Connaught Avenue trunk sewer where it crosses Highway 417 near Pinecrest Road due to a conflict with the proposed LRT track; and
- Relocation of a segment of the Carling Avenue East and Richmond Road trunk sewers near Lincoln Fields due to conflicts with the proposed LRT track.

**Future Ultimate (2037) Conditions**

The Future Ultimate (2037) Conditions scenario includes the following development and transit projects and SWM controls, additional to the projects/development noted above:

1. **West Baseline Bus Rapid Transit (BRT) Development:** The western segment of the Baseline BRT is expected to be implemented after 2031. The project includes the widening of roadways that will result in increased imperviousness in the Pinecrest Creek subwatershed.

2. **Centrepont Town Centre Redevelopment:** Redevelopment plans within the CTC include both an increase in impervious areas as well as SWM controls. The City provided the necessary information to model the projected changes.

3. **Intensification Projects within the Official Plan Horizon (2031):** A number of intensification projects are planned in the subwatershed. For the purposes of the CIS, it was assumed that these projects would include SWM controls that meet the Pinecrest Creek SWM criteria.

4. **SWM Retrofit Projects:** Additional retrofits projected to be implemented between 2027 and 2037.
Figure 2: Subcatchments with SWM Controls for Future (Interim and Ultimate) Conditions (after JFSA Figure 5-1)
Figure 3: Future (Interim and Ultimate) retrofit project locations (after JFSA Figure 8-1)
Figure 4: Future (Interim and Ultimate) development project locations (after JFSA Figure 8-2)
2.4 Hydrology (PCSWMM)

The hydrologic modelling, including channel routing, was completed using PCSWMM (version 5.1.012) software. PCSWMM was used to simulate 2- to 100-year storms in the Pinecrest Creek system. Runoff volumes, peak flows, and peak water levels were compared at key locations for the analysis.

In 2009, a SWMHYMO model was prepared as part of the Pinecrest / Centreponte SWM Criteria Study (JFSA, 2010). The SWMHYMO model was converted to a PCSWMM model for the CIS (refer to Appendix B, Section 3.1 for details.)

Comparison of the results from the SWMHYMO and PCSWMM models showed peak flows and runoff volumes results to be comparable (refer to Table 3-1 in Appendix B). A slight difference was noted in the shape of the hydrograph, with the PCSWMM model generating slightly higher peak flows for urban catchments, but lower peak flows for natural catchments.

Once converted to PCSWMM, the model was then updated from 2009 conditions to 2015 conditions, reflecting changes in the Pinecrest Creek subwatershed that occurred in the intervening years. Changes include new catchment areas, changes to the boundary of existing catchments, and subdivision of existing catchment areas into two or more new catchments. The imperviousness of the catchments was also updated using the City’s 2015 imperviousness data.

Existing SWM controls were modelled for the City Archives Library and Algonquin College ACCE sites, using the SWMM 5 LID Tool. Both sites have SWM control requirements in their design reports that meet the 10 mm retention and 100-year peak flow limit conditions of the Pinecrest Creek criteria. The City Archives Library site is also understood to meet the 25 mm detention requirement for erosion control.

Measured flow, rainfall and radar data from 2009 to 2015 were assessed to determine if a hydrologic calibration could be undertaken. The available rain and flow data were deemed inappropriate for such an effort and therefore the hydrologic models are uncalibrated (refer to Appendix B, Section 3.6 for further details.)

Design storm rainfalls used were the 12-hour SCS for 2-, 5-, 10-, 25-, 50-, and 100-year return periods provided by the City (City of Ottawa, 2012). The 100-year 24-hour SCS design storm used in previous studies was also run; however, the 12-hour SCS event from the City was found to produce the highest peak flows, and, was therefore selected as the most critical for this analysis.

Assumptions and Limitations

In order to better simulate runoff from urban greenspace, in particular lawns and agricultural areas, natural areas with less than 7% imperviousness were modelled in PCSWMM as having 7% imperviousness (not less). This is comparable to a runoff coefficient of 0.25 for design storm events.

Trunk sewers with a diameter or width greater than 600 mm were modelled as conduits in PCSWMM with flow limits corresponding to trunk capacity when this data was available, or to the 5-year peak flow when data was not available. With trunk sewers simulated directly, the flow restrictions on the minor system that had been applied in SWMHYMMO were removed.
Nine catchment areas are connected to the minor system of Pinecrest Creek but have major overland flow routes directed to other subwatersheds (outside of Pinecrest Creek). Additionally, a number of catchment areas are situated immediately adjacent to Pinecrest Creek and have overland flow routes directly to the Creek. In most cases, however, catchment areas do not have overland flow routes that efficiently direct flows in excess of the minor system capacity to Pinecrest Creek. In these cases, the PCSWMM model simulated ponding at trunk inlets when flow limits of the trunks are reached, until such a time when flows can enter the system (i.e., once there is capacity in the receiving sewer.)

The channel routing information for the Creek in the PCSWMM model was taken from the HEC-RAS model described in Section 2.5. Aside from the ORPP, the PCSWMM model did not account for the storage effects of structures (bridges and culverts).

2.5 Hydraulics (HEC-RAS)

The hydraulic modelling was completed using HEC-RAS software (version 5.0.3). In 2010, a HEC-RAS model was developed by JFSA as part of the Pinecrest/Centrepointe SWM Criteria Study (JFSA and JTBES, 2010). Creek cross-sections were delineated using channel survey data collected by NCC in 2005 and LiDAR data from 2007. For the CIS, the 2010 HEC-RAS model was updated with 2008 survey data from NCC and 2014 LiDAR data from the City.

The HEC-RAS model was also updated with data (dimensions and elevations) from a survey of the Ottawa River Parkway Pipe (ORPP) completed as part of Stage 2 OLRT in 2017. The Richmond Road and Carling Avenue overpasses were added to the SJAM Parkway overland flow segment of the updated HEC-RAS model.

Fixed water levels were used as a downstream boundary condition at the outfall of Pinecrest Creek into the Ottawa River, based on the Ottawa River Flood Risk Mapping from Shirley’s Bay to Cumberland (RVCA, 2014).

The HEC-RAS flow split optimization routine calculated the flow split between the ORPP and the overland spill to the SJAM Parkway (refer to Sections 3.3 and 3.4 of Appendix B for details.)

City hydrometric and hydrologic data were reviewed for the purpose of calibrating the HEC-RAS model, however it was determined that the available data was not suitable for this purpose (refer to Section 3.6 of Appendix B for details.) Therefore, neither the 2015 HEC-RAS nor PCSWMM models were calibrated.

Peak flows from the 2015 PCSWMM model were input to the updated 2015 HEC-RAS model, which has structures in place, to simulate flood levels. All reported water level results in the CIS are based on the HEC-RAS model.

2.6 Erosion

In 2006, the NCC initiated a fluvial geomorphology study of Pinecrest Creek that assessed the health of the creek and provided a Restoration Plan to remediate its degraded condition (JTBES, 2007). Restoration designs were developed for a total of ten reaches, and in 2008 the seven highest priority designs were implemented, followed by 3 years of monitoring.
Three restoration reaches of lowest priority were not selected for immediate implementation (refer to Figure 9 in Section 4.2 for locations):

- Restoration Reach #8, located approximately 100 m downstream of the Queensway
- Restoration Reach #9, located approximately 500 m downstream of the Queensway
- Restoration Reach #10, located at the most upstream end of the daylighted Creek, at Baseline Road.

The Restoration Plan also noted fluvial issues around twin cell culverts on the Creek, where sedimentation was leading to risk of poor culvert function. The 2007 study identified three culverts in particular where these issues were occurring (refer to Figure 9 in Section 4.2 for locations), including one culvert (Transitway culvert #1) where sedimentation was accumulating in one of the cells, partially blocking flow. Transitway culvert #1, the furthest upstream culvert of the three identified, was cleaned out during culvert repairs completed in 2015. No measures have been undertaken at the other two culverts, Transitway culvert #2 and the Iris Street culvert. The Iris Street culvert will be removed as part of the Stage 2 OLRT channel realignment of this reach.

In conjunction with the Feasibility Study for the B/W Pond (JFSA et al., 2015), an updated fluvial geomorphic assessment was completed to identify the location of sensitive areas that could be impacted by the B/W Pond. As part of this assessment, erosion of high severity was identified in the most upstream daylighted section of Pinecrest Creek, corresponding with Restoration Site #10 in the Restoration Plan (JTBES, 2007). The 2015 fluvial geomorphic assessment also identified a new erosion site of high severity, located approximately 90 m upstream of Iris Street.

In 2018, a further fluvial geomorphic assessment update was completed in conjunction with the B/W Pond detailed design (MHL et al., 2018). This assessment identified three areas along the Creek where erosion is of concern:

- Erosion Site #1, located upstream of the Iris Street culvert;
- Erosion Site #2, located immediately downstream of the Queensway culvert; and
- Erosion Site #3, located downstream of Erosion Site #2.

Erosion Site #1 is the same site that was identified by the 2015 fluvial geomorphic assessment update. The reach that contains this area of erosion concern will be realigned with construction of Stage 2 OLRT. As a result, Erosion Site #1 will effectively be eliminated and was therefore not included in this analysis.

Erosion Site #2 had not been identified in any study prior to the 2018 fluvial geomorphic assessment completed in support of the B/W Pond detailed design.

Erosion Site #3 was originally identified in 2006 and generally corresponds with Restoration Site #8 from the Restoration Plan (JTBES, 2007).

For this study, cumulative impacts to the fluvial geomorphic functioning of Pinecrest Creek were assessed by JTBES using a threshold analysis. A threshold analysis measures the erosion potential of a watercourse by counting the number of hours for which a certain discharge threshold is exceeded. The erosion discharge threshold (or thresholds) can be established using a number of indicators, for instance the discharge that results in a certain shear stress or velocity that results in the transport of sediment. Other indicators used to
assess sensitivity to erosion in a stream include sediment regime and size, channel stability, and depth of flow.

The erosion threshold analysis was completed based on continuous flow data generated by the hydrologic (PCSWMM) model for the following existing and future scenarios:

i. Existing (2015) Conditions;
ii. Future Interim (2027) Conditions; and
iii. Future Ultimate (2037) Conditions.

The erosion threshold analysis focused on nine representative cross-sections: one in the reach upstream of Woodroffe Avenue, three between Woodroffe Avenue and Iris Street, one between Iris Street and the Queensway, and four downstream of the Queensway (Highway 417), including two that represent Erosion Sites #2 and #3, respectively. The locations of the three erosion sites and nine representative cross-sections are shown on Figure 5.

![Figure 5: Location of representative sections and erosion-sensitive sites](image)

Grain size analyses for twenty-four stream bed samples (collected as part of an earlier study by JTBES) led to the selection of the following representative grain sizes used in the erosion analysis: 2 mm, 5 mm, 10 mm, 25 mm, 50 mm, and 64 mm. The corresponding critical discharge for shear strength exceedance ranges from 1.46 m$^3$/s to 46.62 m$^3$/s, while the critical discharge for velocity exceedance ranges from 0.27 m$^3$/s to 1.34 m$^3$/s. Critical discharges were also identified for the two remaining erosion sites: 0.315 m$^3$/s for Erosion Site #3 and 0.450 m$^3$/s for Erosion Site #2. Refer to Appendix C for additional details regarding the grain size analyses.

JFSA performed continuous hydrologic simulations and provided the resulting continuous hydrographs to JTBES for the erosion threshold analysis. Continuous simulations were completed using hourly rainfall data from Environment Canada for the Ottawa MacDonald Cartier International Airport. Rainfall data from 1967 to 2007, less 2001 and 2005 due to
missing data, and from April 1st to October 31st inclusive, were used for the continuous simulations.

Finally, the continuous hydrographs were input to a geomorphology-based model that determines the total number of hours where critical discharges are exceeded under Existing (2015) and Future (2027, 2037) Conditions.

2.7 Water Quality

For the water quality impact assessment, JFSA simulated pollutant concentrations and loadings at various locations along Pinecrest Creek for Existing (2015) and Future (2027, 2037) Conditions using the PCSWMM model (version 5.1.012). The methodology was adapted from the *Eastern Subwatersheds SWM Retrofit Study* (MHL and Aquafor Beech, September 2018).

The methodology for the water quality simulations is summarized in five steps:

1. **Identify pollutants to be analyzed.** These were stipulated in the Terms of Reference and include total suspended solids (TSS), total phosphorus (TP), *E. coli*, copper (Cu), and zinc (Zn).

2. **Define land uses and assign land uses to subcatchments.** Land uses are identified based on GIS data from the City, and include categories for agriculture, commercial, forest, industrial, institutional, open space, residential, and streets.

3. **Define in-stream Event Mean Concentration (EMC) values for the subwatershed using available stream flow and water quality monitoring data.** The EMC is the average concentration of a pollutant over a period of flow and is defined as the total pollutant mass divided by the total runoff volume. Flow data was obtained from a flow gauge at the Woodroffe Avenue culvert over Pinecrest Creek. Water quality data was obtained from a wet-weather auto-sampler located upstream of the Woodroffe Avenue culvert. The method for calculating in-stream EMC values was adapted from Baird (April, 2011) and is described in detail in Section 4.1 of Appendix B.

4. **Determine the pollutant loading concentrations (washoff EMCs) to be applied to each land use type based on observed stormwater event mean concentration data.** This is an iterative process that begins with a PCSWMM simulation using typical washoff EMC values from literature. These values are subsequently adjusted (calibrated) until the simulation results are comparable to the measured in-stream concentrations. This method is further described in Appendix B, Sections 4.2 and 4.3.

5. **Define pollutant removal functions of existing and proposed SWM controls, including lot level and conveyance controls, and end-of-pipe facilities.** Water quality percent removal values for SWM measures are based on values obtained from the National Pollutant Removal Database (Centre for Watershed Protection, 2007) and the International Stormwater Best Management Practices Database (2014), except for TSS removal.

JFSA conducted a continuous model simulation using 40 years of hourly rainfall data from the Ottawa International Airport (1967 – 2007). The 40-year average annual concentration of each
pollutant was estimated at four key locations along Pinecrest Creek. This became the benchmark for measuring impacts of future developments on water quality.

**Assumptions and Limitations**

It has been assumed that all existing developments with SWM controls (ACCE and Archives Library) and future developments (Centrepoinete Town Centre redevelopment and intensification projects within the official plan horizon) will meet the Pinecrest Creek SWM criteria for runoff volume/erosion control, flood control, and water quality (80% TSS removal), with the exception that the erosion control criteria is not met by the ACCE. The Baseline BRT corridor and the Highway 417 expansion were assumed to have no SWM controls.

For Stage 2 OLRT, it was assumed that Queensview, Pinecrest, and Lincoln Fields stations would all meet the Pinecrest Creek SWM criteria in full. Baseline Station is assumed to meet the Pinecrest Creek SWM criteria with on-site quality control and off-site quantity control to be provided by the B/W Pond.

For this study, conceptual sizing for the LRT track and ballast SWM controls (bioretention swales) was optimized based on site constraints (e.g. soils, topography, property limits, depth to bedrock and groundwater), not on volume requirements to meet the Pinecrest Creek SWM criteria. For this exercise, a value of 100% imperviousness was assigned to the ballast. This approach is considered conservative with respect to assessing the potential for negative cumulative impacts on the creek. Impacts of the LRT track and ballast are discussed in Section 4.3.1.
3. IMPACT ASSESSMENT

3.1 Impacts to Hydrology and Hydraulics

Impacts to the flow regime of Pinecrest Creek were assessed by JFSA through the simulation of future conditions models with varying degrees of future project development and SWM retrofit and comparing results to existing conditions. This section summarizes the findings of JFSA.

3.1.1 Future Uncontrolled Scenarios

Future scenarios fall under two categories: uncontrolled and controlled. The uncontrolled scenarios do not include SWM controls and, when compared with existing conditions, serve to evaluate the impacts of proposed development if it were to proceed without SWM controls. Uncontrolled scenarios include:

- Uncontrolled Future Interim (2027) Conditions
- Uncontrolled Future Ultimate (2037) Conditions
- Uncontrolled Future Interim (2027) Conditions + B/W Pond
- Uncontrolled Future Ultimate (2037) Conditions + B/W Pond

The results for the first two scenarios, uncontrolled without the B/W Pond, show increased flood levels on Pinecrest Creek due to the additional development. These results demonstrate the impacts to the Creek that can be expected if no SWM controls are implemented.

The last two uncontrolled scenarios were modelled to assess the effects of the B/W Pond (prior to detailed design) in isolation of other SWM retrofit measures. Results from these scenarios, both interim and ultimate, show a reduction in peak flow during the 100-year event when compared to the Existing (2015) Conditions model.

The results from the uncontrolled scenarios confirm that the B/W Pond will provide adequate quantity control to compensate for the Baseline OLRT Station proceeding without on-site quantity controls. It will also compensate for the Baseline BRT corridor and the Highway 417 expansion, which were assumed to have no SWM controls.

3.1.2 Future Controlled Scenarios

While the uncontrolled scenarios serve primarily as a sensitivity test to gauge both the impacts of developing without SWM control and the benefits of the B/W Pond on its own, the controlled scenarios serve to assess the cumulative impacts of both development and SWM controls. The controlled scenario results provide an indication of the impacts of future development when it is implemented with SWM controls, and of the need for mitigation, such as additional SWM controls, retrofits, or in-stream works.

The Existing and Future Conditions PCSWMM and HEC-RAS models were used to estimate peak flows and water levels along Pinecrest Creek, the ORPP, and spilling to the SJAM Parkway for the 2-year through to the 100-year design storms. Continuous hydrologic simulations were also completed for use in the erosion and water quality analyses.
Key results from these simulations are presented in Table 4. Under existing conditions, in the PCSWMM model, the peak flow in the Creek upstream of the ORPP is estimated as 29.8 m³/s in a 2-year rainfall event and 51.7 m³/s in a 100-year event. When modelled in HEC-RAS, these peak flows result in flooding of the Parkway during the 2-year event, with flooding depths on the Parkway reaching 0.36 m in the 2-year event and 0.9 m in a 100-year event.

Under Future Interim (2027) Conditions, the peak flow upstream of the ORPP is reduced to 22.3 m³/s in a 2-year event and 37.4 m³/s in a 100-year event, a 25% and 28% reduction (respectively) compared to existing conditions. Flooding on the Parkway is eliminated in the 2-year event and reduced to 0.63 m in the 100-year event. Under Future Ultimate Conditions, peak flows are reduced slightly further.

Table 4: Summary of hydrologic and hydraulic modelling results Existing (2015) Conditions, Future Interim (2027) Conditions, and Future Ultimate (2037) Conditions (after JFSA Table 5-9)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Event</th>
<th>Existing (2015)</th>
<th>Interim (2027)</th>
<th>Ultimate (2037)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creek Hydrology</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak Flow Upstream of ORPP Inlet (m³/s) (PCSWMM)</td>
<td>2-year</td>
<td>29.82</td>
<td>22.27</td>
<td>22.02</td>
</tr>
<tr>
<td></td>
<td>5-year</td>
<td>35.19</td>
<td>29.18</td>
<td>29.07</td>
</tr>
<tr>
<td></td>
<td>100-year</td>
<td>51.69</td>
<td>37.39</td>
<td>37.25</td>
</tr>
<tr>
<td>Peak Parkway Flow (m³/s) (HEC-RAS)</td>
<td>2-year</td>
<td>1.43</td>
<td>-*</td>
<td>-*</td>
</tr>
<tr>
<td></td>
<td>5-year</td>
<td>4.39</td>
<td>0.57</td>
<td>0.51</td>
</tr>
<tr>
<td></td>
<td>100-year</td>
<td>23.11</td>
<td>7.77</td>
<td>7.62</td>
</tr>
<tr>
<td>Peak Water Level at ORPP Inlet (m) (HEC-RAS)</td>
<td>2-year</td>
<td>67.16</td>
<td>65.61</td>
<td>65.59</td>
</tr>
<tr>
<td></td>
<td>5-year</td>
<td>67.31</td>
<td>67.09</td>
<td>67.07</td>
</tr>
<tr>
<td></td>
<td>100-year</td>
<td>67.69</td>
<td>67.52</td>
<td>67.51</td>
</tr>
<tr>
<td>Depth along Parkway at Carling Ave (m) (HEC-RAS)</td>
<td>2-year</td>
<td>0.36</td>
<td>-*</td>
<td>-*</td>
</tr>
<tr>
<td></td>
<td>5-year</td>
<td>0.52</td>
<td>0.27</td>
<td>0.26</td>
</tr>
<tr>
<td></td>
<td>100-year</td>
<td>0.90</td>
<td>0.63</td>
<td>0.63</td>
</tr>
</tbody>
</table>

*The 2027 and 2037 simulation results showed no spill to the Parkway for the 2-year event. Model results for the 12-hour SCS storm (City of Ottawa, 2012).

Future Controlled Scenarios key findings include:

- The Future Uncontrolled Scenarios showed that proposed development projects in the subwatershed would increase runoff volumes and peak flows if SWM controls were not implemented. When implemented with SWM controls, Future (2027, 2037) Conditions peak flows are lower than Existing (2015) Conditions for the 2- to 100-year event. This reduction, primarily attributable to the B/W Pond, is seen for the full length of the Creek from the SWM pond outlet to the ORPP inlet. The B/W Pond and other SWM controls eliminate the spill to the Parkway during the higher frequency events (2-year return period events and smaller).

- This flow reduction translates to a reduction in flooding depths on the SJAM Parkway by approximately 0.3 m in a 100-year storm. Peak flows and depths on the SJAM...
Parkway are reduced for all modelled storm events when comparing Future Conditions to Existing, pointing to a net reduction in flood risk to the Parkway.

- The level of service of the ORPP under Existing (2015) Conditions is less than 2-years, and increases to between 2- and 5-years for Future Conditions.

- Future Interim and Ultimate Conditions scenarios account for additional redevelopment projects that include both increased imperviousness and on-site SWM controls. Additional retrofit SWM measures are planned by the City for implementation between 2017 and 2037. A comparison of results between the Future Interim (2027) and Future Ultimate (2037) Conditions shows that peak flows are reduced slightly over this period, indicating that the proposed SWM retrofit controls provide additional benefit to the Creek.

- Average runoff volumes to the Creek are decreased at most locations with the exception of the most upstream reach of the Creek, between Baseline Road and Woodroffe Avenue, where an increase in runoff volume is projected as a result of the uncontrolled flows from the future Baseline BRT development.

- It is noted that 100-year HEC RAS results are not regulatory flood lines or levels.

3.2 Erosion Impacts

Cumulative impacts to the fluvial geomorphic functioning of Pinecrest Creek were assessed by JTBES using an erosion threshold analysis. A threshold analysis measures the erosion potential of a watercourse by counting the number of hours for which a certain discharge threshold is exceeded. The results of the fluvial geomorphological analysis are presented below.

3.2.1 Results of the Erosion Threshold Analysis

The cumulative duration of exceedance of the critical discharge (or critical erosion threshold) under existing conditions was compared to that of exceedance under future conditions. Key results are presented in Table 5 and show the percent increase or decrease in threshold exceedance hours from existing to future conditions for each critical discharge. Results are presented for the most upstream (5060) and the most downstream (1177) cross-sections analyzed.
Table 5: Results of Erosion Threshold Exceedance Analysis

<table>
<thead>
<tr>
<th>Critical Discharge (m³/s)</th>
<th>Future Interim (2027)</th>
<th>Future Ultimate (2037)</th>
<th>Future Interim (2027)</th>
<th>Future Ultimate (2037)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cross-section 5060</td>
<td>Cross-section 1177</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.1</td>
<td>209.6</td>
<td>209.5</td>
<td>188.2</td>
<td>188.3</td>
</tr>
<tr>
<td>0.2</td>
<td>126.2</td>
<td>126.1</td>
<td>147.8</td>
<td>148.2</td>
</tr>
<tr>
<td>0.315</td>
<td>38.9</td>
<td>38.8</td>
<td>112.6</td>
<td>113.3</td>
</tr>
<tr>
<td>0.45</td>
<td>22.6</td>
<td>22.6</td>
<td>98.8</td>
<td>98.9</td>
</tr>
<tr>
<td>0.6</td>
<td>24.1</td>
<td>24.1</td>
<td>92.7</td>
<td>92.6</td>
</tr>
<tr>
<td>0.7</td>
<td>25.2</td>
<td>25.2</td>
<td>89.7</td>
<td>89.6</td>
</tr>
<tr>
<td>0.9</td>
<td>28.0</td>
<td>28.0</td>
<td>85.2</td>
<td>85.0</td>
</tr>
<tr>
<td>1.0</td>
<td>29.4</td>
<td>29.4</td>
<td>83.1</td>
<td>82.9</td>
</tr>
<tr>
<td>1.5</td>
<td>33.8</td>
<td>33.8</td>
<td>73.2</td>
<td>72.9</td>
</tr>
<tr>
<td>5</td>
<td>31.5</td>
<td>31.5</td>
<td>63.1</td>
<td>62.8</td>
</tr>
<tr>
<td>10</td>
<td>50.0</td>
<td>50.0</td>
<td>56.2</td>
<td>55.8</td>
</tr>
<tr>
<td>15</td>
<td>0.0</td>
<td>0.0</td>
<td>51.5</td>
<td>51.5</td>
</tr>
</tbody>
</table>

2. The Exceedance Hours (%) represent the change in exceedance hours from existing to future conditions for a particular critical discharge. Values over 100 indicate an increase in hours; values less than 100 indicate a decrease.

Overall, results show that for a discharge threshold of 0.315 m³/s or less, exceedance hours increase from existing to future conditions, while the opposite is true for discharge thresholds of 0.450 m³/s or more. The differences between the results of the interim and ultimate scenarios are minimal, less than 0.6 of a percentage point for all critical discharges analyzed.

Results also show that the greatest decreases in exceedance hours are seen in the reach of Pinecrest Creek located immediately downstream of the proposed B/W Pond, which has been designed to attenuate peak flows to 0.38 m³/s or less for all storms up to the 25 mm event. As a result, following a storm, the Creek does not immediately return to baseflow conditions, but instead continues to receive the 0.38 m³/s from the pond, in addition to baseflow, for up to 48 hours until the water level in the pond is drawn down to the permanent pool level. The increase in exceedance hours for lower discharge thresholds (0.315 m³/s or less) is directly attributable to this phenomenon.

At section 5060, closest to the outlet of the B/W Pond, exceedance hours for the critical discharge threshold of Erosion Site #3 (0.315 m³/s) are reduced to well below existing condition hours. Moving downstream, the flow attenuation benefit of the pond is overshadowed by inputs from storm sewer outfalls, and exceedance hours for the same critical discharge at section 1177 increases by 13%. Exceedance hours for the critical discharge threshold of Erosion Site #4 (0.450 m³/s) are reduced at section 5060 and remain approximately the same at section 1177 from existing to future conditions.

The same analysis was done once more, this time using critical discharges that represent the shear stress and velocity required to transport particles of a certain size, ranging from 2 mm to 65 mm diameter. The results show that, only for particles of 2 mm diameter or less, the velocity threshold is exceeded more frequently under future conditions compared to existing. For particles with a 5 mm or greater diameter, the velocity and shear stress exceedance hours will remain approximately the same or decrease under future conditions as compared to existing.
### 3.2.2 Cumulative Erosion Impacts

The results of the erosion impacts analysis indicate that, under future conditions, the B/W Pond, in combination with other proposed SWM retrofits, greatly reduces the exceedance of most erosion thresholds, and therefore erosion itself in the reach immediately downstream of the pond; however, this benefit is tempered by additional flow inputs from other outfalls downstream of Woodroffe Avenue.

The results also indicate that erosion thresholds for the smallest particles (2 mm or less) will see an increase in exceedances. This is a direct result of the B/W Pond, which releases flows over an extended period during drawdown of the pond following a storm event. Although the pond is attenuating the highest and most erosive flows, the discharge during the drawdown period is enough to produce the velocities required to transport particles of 5 mm or finer. These results could mean a loss of fine grains in the Creek if a natural supply of fines is not available.

Erosion Site #2 will continue to be affected by toe erosion under future conditions, however it is expected to be at a decreased frequency and magnitude, allowing for more opportunity to intervene if risk to the adjacent pathway develops. The adjacent pathway, shown in Figure 6, is an informal desire line used by pedestrians and cyclists.

Erosion Site #3 will experience a decrease in the number of exceedances of its critical erosion threshold under future conditions. Erosion risk at this site is expected to decrease accordingly. The erosion site is shown in Figure 7.

![Figure 6: Erosion Site #2 in spring of 2010 (left) and fall of 2018 (right), both looking upstream. The photos show a high eroding bank on the west side of the creek, and an informal pathway atop the eroding bank.](image-url)
Figure 7: Erosion Site #3 in spring of 2010 (left) and fall of 2018 (right), both looking upstream. The photos show the high eroding bank on the east side of the creek. In summer 2018, erosion undercutting of the bank resulted in the toppling of a large tree, creating a barrier to flow and causing a debris jam.

### 3.3 Impacts to Water Quality

For the water quality impact assessment, JFSA simulated pollutant concentrations and loadings along Pinecrest Creek for Existing (2015) and Future (2027, 2037) Conditions. Pollutants analyzed include total suspended solids (TSS), total phosphorus (TP), *E. coli*, copper (Cu) and zinc (Zn). The model simulation was conducted using 40 years of rainfall data. An average annual concentration for each pollutant was estimated and results were processed and presented at four locations along Pinecrest Creek. Key results are presented in the tables below, including Existing (2015) Conditions pollutant concentrations and the percent reduction in pollutant loadings from Existing to Future Interim (2027) Conditions and to Future Ultimate (2037) Conditions. Refer to Section 7.1 of Appendix B for additional details.

*Table 6: Existing (2015) Conditions annual average pollutant concentrations at key locations (after JFSA Table 6-5)*

<table>
<thead>
<tr>
<th>Location</th>
<th>Cu mg/L</th>
<th><em>E. Coli</em> counts/100mL</th>
<th>TP mg/L</th>
<th>TSS mg/L</th>
<th>Zn mg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Woodroffe Avenue</td>
<td>0.021</td>
<td>33,334</td>
<td>0.189</td>
<td>133.3</td>
<td>0.061</td>
</tr>
<tr>
<td>Iris Road</td>
<td>0.020</td>
<td>31,650</td>
<td>0.188</td>
<td>132.1</td>
<td>0.057</td>
</tr>
<tr>
<td>ORPP Outlet</td>
<td>0.020</td>
<td>31,322</td>
<td>0.186</td>
<td>131.1</td>
<td>0.056</td>
</tr>
<tr>
<td>Ottawa River</td>
<td>0.020</td>
<td>31,278</td>
<td>0.186</td>
<td>131.3</td>
<td>0.055</td>
</tr>
</tbody>
</table>
Table 7: Reduction in annual average pollutant concentrations at key locations from Existing (2015) Conditions to Future Interim (2027) Conditions (after JFSA Table 6-8)

<table>
<thead>
<tr>
<th>Location</th>
<th>Cu</th>
<th>E. Coli</th>
<th>TP</th>
<th>TSS</th>
<th>Zn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Woodroffe Avenue</td>
<td>52%</td>
<td>63%</td>
<td>48%</td>
<td>72%</td>
<td>59%</td>
</tr>
<tr>
<td>Iris Road</td>
<td>25%</td>
<td>30%</td>
<td>21%</td>
<td>33%</td>
<td>26%</td>
</tr>
<tr>
<td>ORPP Outlet</td>
<td>15%</td>
<td>19%</td>
<td>13%</td>
<td>21%</td>
<td>16%</td>
</tr>
<tr>
<td>Ottawa River</td>
<td>14%</td>
<td>18%</td>
<td>12%</td>
<td>20%</td>
<td>15%</td>
</tr>
</tbody>
</table>

Table 8: Reduction in annual average pollutant concentrations at key locations from Existing (2015) Conditions to Future Ultimate (2037) Conditions (after JFSA Table 6-9)

<table>
<thead>
<tr>
<th>Location</th>
<th>Cu</th>
<th>E. Coli</th>
<th>TP</th>
<th>TSS</th>
<th>Zn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Woodroffe Avenue</td>
<td>52%</td>
<td>63%</td>
<td>48%</td>
<td>72%</td>
<td>59%</td>
</tr>
<tr>
<td>Iris Road</td>
<td>25%</td>
<td>30%</td>
<td>21%</td>
<td>34%</td>
<td>26%</td>
</tr>
<tr>
<td>ORPP Outlet</td>
<td>17%</td>
<td>19%</td>
<td>15%</td>
<td>23%</td>
<td>17%</td>
</tr>
<tr>
<td>Ottawa River</td>
<td>16%</td>
<td>18%</td>
<td>14%</td>
<td>22%</td>
<td>16%</td>
</tr>
</tbody>
</table>

Based on the modelling results, the in-stream average concentrations and average loadings of all five pollutants are reduced at all locations for Future Conditions (both Interim and Ultimate) compared to Existing Conditions. This is driven by an increase in SWM controls in the watershed. The proposed B/W Pond is expected to provide most of the water quality improvement.

The Future Ultimate conditions include additional retrofit LIDs compared to the Future Interim Conditions that provide a further reduction in pollutant concentrations.
4. MITIGATION

The two primary objectives of the CIS are to assess the cumulative impacts on Pinecrest Creek of future projects and to identify appropriate measures to mitigate these impacts.

Many mitigation measures have already been identified as part of the future projects (i.e., SWM controls), and results of the cumulative impacts assessment show a reduction in peak flows, flooding depths, pollutant loadings, and exceedances of most erosion thresholds when future projects are implemented with the proposed SWM controls.

The following section presents how the proposed mitigation measures (SWM controls) are working to mitigate impacts to Pinecrest Creek, and whether any additional SWM controls or in-stream works are required to fully mitigate these impacts. Table 9 summarizes the cumulative impacts of all future projects, including SWM controls, on the hydrology, hydraulics, and water quality of the Creek. No additional mitigation is recommended at this time.

4.1 Hydrology, Hydraulics, and Water Quality

This section is excerpted from Appendix B, Section 8.1.

The cumulative impacts from the proposed development projects within the Pinecrest Creek subwatershed up to the years 2027 and 2037 have been assessed. The assessments are based on hydrologic, hydraulic and water quality numerical simulations using PCSWMM and HEC-RAS.

The existing conditions within the Pinecrest Creek subwatershed are characterised by urban development that proceeded without SWM controls. As such, the current state of the Creek is degraded compared to a natural state and experiences high peak flows (flood risk), high runoff volumes and flashy responses to rainfall (erosion risk) and relatively high pollutant loadings (water quality risk). Various studies conducted over the past decade have resulted in the implementation of retrofit and rehabilitation works to gradually improve the Creek’s health.

The objective of the hydrologic and hydraulic component of the CIS is to ensure that adequate mitigation measures are proposed to offset the potential negative flood and water quality impacts from all planned future projects within the subwatershed up to the year 2037.

Several future projects include on-site mitigation controls, while others rely (at least in part) on control in-lieu provided by the proposed B/W Pond. As such, some future developments result in no negative impacts at the project scale. Others (e.g., Baseline LRT Station) are expected to result in negative impacts on flood risk and water quality at the project scale. The net benefit to Pinecrest Creek for both flood risk and water quality is therefore driven by the inclusion of the proposed retrofit SWM pond as in-place for both Future Controlled scenarios (2027 and 2037).

Accounting for the overall effects of: future proposed development projects, SWM retrofit projects and on-site SWM controls, the two Future Controlled conditions (2027 and 2037) show incremental reductions in flood risk (peak flows) and water quality (pollutant loading) from the upstream end of the daylit portion of Pinecrest Creek (north of Baseline Road) through to its outlet at the Ottawa River.
Table 9: Hydrologic, Hydraulic and Water Quality Impacts and Mitigation (after JFSA Table 8-1)

<table>
<thead>
<tr>
<th>Projects</th>
<th>Water Quantity</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Baseline Road / Woodroffe Avenue Retrofit SWM Pond</td>
<td>No negative water quantity impacts due to Baseline Road / Woodroffe Avenue Retrofit SWM Pond.</td>
<td>No negative impacts on pollutant loadings. Reduction in open channel creek length by approximately 60 m. Caused by diverting the 'first flush' of water (up to the peak of the 25-mm storm) into the pond, outflows from the pond discharge to Pinecrest Creek approximately 60 m downstream from the existing (as of 2015) daylit portion of the creek.</td>
<td>The retrofit pond is a SWM control project. It is to provide adequate quantity control (up to the 100-year storm) for a net peak flow reduction (control in-lieu) to Pinecrest Creek for the proposed future LRT/BRT development plus allowance for future City transit projects. The retrofit pond provides erosion control to 4.4 L/s/ha (for the 25-mm event) and flood control to 25.1 L/s/ha (for the 100-year storm) for the 445 ha drainage area to the pond. The average pollutant loadings decreased for the five modelled pollutants: Cu by 51%, E. coli by 61%, TP by 46%, TSS by 70% and Zn by 57% (at the Woodroffe Avenue culvert).</td>
<td></td>
</tr>
<tr>
<td>Retrofit SWM Control Projects</td>
<td>No negative water quantity impacts due to Retrofit SWM Control Projects.</td>
<td>No negative water quality impacts due to Retrofit SWM Control Projects.</td>
<td>With Retrofit SWM Controls Projects, the average runoff volume was reduced from 178.5 mm (for existing 2015 conditions) to 177.8 mm and the average pollutant loadings decreased for the five modelled pollutants.</td>
<td></td>
</tr>
<tr>
<td>East Baseline Rapid Transit (BRT) Development</td>
<td>Average imperviousness of project catchments increased from 71.5 % to 96.8 % Project total area = 8.65 ha. Project cumulative area = 25.29 ha</td>
<td>The change in existing land use to street increased the average pollutant loading for the five modelled pollutants.</td>
<td>No on-site controls are accounted for in the CIS. The Retrofit SWM Pond results in a net reduction in peak flow and pollutant loading to Pinecrest Creek.</td>
<td></td>
</tr>
<tr>
<td>Highway 417 Widening</td>
<td>Average imperviousness of project catchments increased from 76.1 % to 80.7 % Project cumulative area = 25.29 ha</td>
<td>The change in imperviousness increased the average pollutant loadings for the five modelled pollutants.</td>
<td>No on-site controls are accounted for in the CIS. The Retrofit SWM Pond results in a net reduction in peak flow and pollutant loading to Pinecrest Creek.</td>
<td></td>
</tr>
<tr>
<td>Stage 2 LRT Ballast and Track Development</td>
<td>Average imperviousness of project catchments increased from 31.6 % to 83.9 % Project cumulative area = 7.2 ha</td>
<td>The change in existing land use to industrial increased the average pollutant loadings for Cu, TP, TSS and Zn.</td>
<td>Bio-retention swales are proposed along several sections of the LRT ballast and track development; treating 5.47 ha of the project catchments and providing a reduction in average runoff volume from 403.0 mm to 115.9 mm. LIDs are over-controlling runoff volume as this volume is less than the existing volume of 148.3 mm. The proposed controls provide erosion control to 36.2 L/s/ha (for the 25-mm storm) and flood control to 36.2 L/s/ha (for the 100-year storm). As modelled in the CIS, peak flow attenuation for the 25-mm and 100-year storms is provided compared to uncontrolled conditions, however, the resulting unit flows are higher than the Pinecrest / Westboro SWM Guideline values. The average pollutant loadings decreased for E. coli and TSS, at the project scale.</td>
<td></td>
</tr>
</tbody>
</table>

2027

*Average runoff volume is from the continuous simulations conducted from April 1 to Oct 31 with the historic (1967 to 2007) rainfall data from Environment Canada.

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<td><strong>Baseline LRT Station</strong></td>
<td>Average imperviousness of project catchments increased from 51.3 % to 98.2 % Project cumulative area = 3.68 ha Without SWM controls, potential increase in: - average runoff volume* from 218.7 mm to 457.7 mm; - 25-mm peak unit flow from 59.8 L/s/ha to 106.0 L/s/ha; - 100-yr peak unit flow from 173.9 L/s/ha to 288.0 L/s/ha.</td>
<td>The change in existing land use to industrial increased the average pollutant loadings for Cu, TP, TSS and Zn.</td>
<td>The modelling results show that the proposed Baseline / Woodroffe Retrofit SWM pond will provide adequate flow attenuation to provide a net flow reduction to the Creek; therefore on-site quantity control is not proposed. On-site quality control (oil- and grit separator) is proposed and the average pollutant loading decreased for TSS, at the project scale.</td>
<td></td>
</tr>
<tr>
<td><strong>Lincoln Fields, Queensview and Pinecrest LRT Stations</strong></td>
<td>Average imperviousness of project catchments increased from 25.4 % to 89.8 % Project cumulative area = 2.70 ha Without SWM controls, potential increase in: - average runoff volume* from 123.9 mm to 424.6 mm; - 25 mm peak unit flow from 29.6 L/s/ha to 129.6 L/s/ha; - 100-yr peak unit flow from 137.0 L/s/ha to 307.4 L/s/ha.</td>
<td>The change in existing land use to industrial increased the average pollutant loadings for Cu, TP, TSS and Zn.</td>
<td>Oversized storm sewer storages are proposed at Queensview and Pinecrest station to provide erosion control to 5.8 L/s/ha (for the 25-mm storm) and flood control to 33.5 L/s/ha (for the 100-year storm). The average pollutant loading decreased for Cu, E. coli and TSS, at the project scale. The average runoff volume reduced from 424.6 mm to 345.8 mm (less than uncontrolled conditions, but an increase on the project scale compared to existing 2015 conditions).</td>
<td></td>
</tr>
<tr>
<td><strong>Pinecrest Creek Realignment</strong></td>
<td>The creek realignment and proposed crossings have the potential to have negative water quantity impacts. Proper design principals must be followed to prevent potential impacts; see the mitigation column.</td>
<td>No negative impacts on pollutant loadings. Includes abandoning a portion of the existing channel and constructing a new channel alignment, proper design principals must be followed to prevent potential impacts; see the mitigation column.</td>
<td>The bridge crossings and proposed realigned cross-section shapes were designed to include a meandering channel (for geomorphic stability) and to maintain existing peak 100-year water levels at the upstream and downstream extents of the realignment.</td>
<td></td>
</tr>
<tr>
<td><strong>Sewer Relocation due to LRT Conflict (Carling Avenue and Richmond Road)</strong></td>
<td>Dynamic impact on how the ORPP interacts with inflows from Pinecrest Creek, particularly for peak flows. Proper design principals must be followed to prevent potential impacts; see the mitigation column. The CIS analysis did not include an assessment of the potential impact on local sewers.</td>
<td>No negative water quality impacts due to sewer relocation.</td>
<td>Richmond Avenue and Carling Avenue sewer realignments contribute to increased capacity from Pinecrest Creek into the ORPP inlet during the peak of design storm events. This contributes to a reduction in peak water levels and therefore spill, from Pinecrest Creek onto the Ottawa River Parkway.</td>
<td></td>
</tr>
<tr>
<td><strong>IKEA Storm Sewer Relocation</strong></td>
<td>Dynamic impact on how the local sewers interact before discharging into the ORPP. The CIS analysis did not include an assessment of the potential impact on local sewers.</td>
<td>No negative water quality impacts due to sewer relocation.</td>
<td>No specific mitigation measures are proposed regarding the sewer relocation.</td>
<td></td>
</tr>
</tbody>
</table>

*Average runoff volume is from the continuous simulations conducted from April 1 to Oct 31 with the historic (1967 to 2007) rainfall data from Environment Canada.
### Table 9: Hydrologic, Hydraulic and Water Quality Impacts and Mitigation (after JFSA Table 8-1)

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<tbody>
<tr>
<td><strong>2037</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Retrofit SWM Control Projects</strong></td>
<td>No negative water quantity impacts due to Retrofit SWM Control projects, does provide a benefit as described in the mitigation column.</td>
<td>No negative water quality impacts due to Retrofit SWM Control projects, does provide a benefit as described in the mitigation column.</td>
<td>With SWM controls, the average runoff volume reduced from 178.5 mm (for existing 2015 conditions) to 177.6 mm and the average pollutant loadings decreased for the five modelled pollutants. Note the SWM retrofit LiDs are implemented within larger sewershed areas. The 10.22 ha of treated area implemented within a total subcatchment area of 831.5 ha. The remaining subcatchments (total area 1050.4 ha) in the Pinecrest Creek Subwatershed (total area 1881.9 ha) do not have retrofit SWM controls proposed up to 2037. The average runoff volumes are calculated using the 831.5 ha area.</td>
</tr>
<tr>
<td><strong>West Baseline Rapid Transit (BRT) Development</strong></td>
<td>Average imperviousness of project catchments increased from 78.0 % to 92.8 %</td>
<td></td>
<td>No on-site controls are accounted for in the CIS. The Retrofit SWM Pond results in a net reduction in peak flow and pollutant loading to Pinecrest Creek.</td>
</tr>
<tr>
<td><strong>Intensification Projects within the Official Plan 2031 Horizon</strong></td>
<td>Average imperviousness of project catchments increased from 92.3 % to 100 %</td>
<td></td>
<td>On-site SWM controls are proposed to provide 10 mm retention depth, erosion control to 5.8 L/s/ha (for the 25-mm storm) and flood control to 33.5 L/s/ha (for the 100-year storm). The average runoff volume reduced was from 465.9 mm to 274.2 mm and the average pollutant loadings decreased for the five modelled pollutants, at the project scale.</td>
</tr>
<tr>
<td><strong>Centrepointe Town Centre Redevelopment Projects</strong></td>
<td>Average imperviousness of project catchments increased from 88.4 % to 100 %</td>
<td></td>
<td>On-site SWM controls are proposed to provide 10 mm retention depth, erosion control to 5.8 L/s/ha (for the 25-mm storm) and flood control to 33.5 L/s/ha (for the 100-year storm). The average runoff volume reduced was from 475.2 mm to 278.1 mm and the average pollutant loadings decreased for the five modelled pollutants, at the project scale.</td>
</tr>
</tbody>
</table>

*Average runoff volume is from the continuous simulations conducted from April 1 to Oct 31 with the historic (1967 to 2007) rainfall data from Environment Canada.*

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*Note: The SWM retrofit LiDs are implemented within larger sewershed areas. The 10.22 ha of treated area implemented within a total subcatchment area of 831.5 ha. The remaining subcatchments (total area 1050.4 ha) in the Pinecrest Creek Subwatershed (total area 1881.9 ha) do not have retrofit SWM controls proposed up to 2037. The average runoff volumes are calculated using the 831.5 ha area.*
4.2 Erosion

Changes in the Pinecrest Creek subwatershed over the coming decades will both benefit and impact the geomorphic stability of the Creek.

The proposed B/W Pond will result in the most pronounced changes to the Creek’s hydrograph, reducing its peak flow by 20% to 30% during larger events and thereby eliminating the most erosive flows, but also extending the drawdown limb of the hydrograph, resulting in longer periods of flows above baseflow. A slower return to baseflow is a positive impact to the distribution of sediment on bars, however it will increase the transport of grains with a 5 mm diameter or smaller.

When considered cumulatively, these changes to the Creek’s hydrograph are positive overall, however they are expected to impact the Creek’s geomorphic function and induce a new period of adjustment. Pinecrest Creek is currently in Stage III of a typical channel evolution model (see Figure 8), a stage characterized by widening of the flood plain and the beginning of bank failure. It is projected that the reduction in peak flow in the Creek will prompt the transition of the Creek to Stage IV: stabilizing and deposition.

Stage IV is also characterized by slope failures and can pose a risk to nearby property or infrastructure. However, intervention during this stage can be complicated, costly, and often unsuccessful, and the best practice is to allow the stabilization process to run its course where possible, i.e. where public safety, infrastructure, and property are not at risk.

The Pinecrest Creek corridor is sufficiently wide to allow for the adjustment of the channel as it transitions into Stages IV and V with minimal risk to safety, property, or infrastructure. Potential risk to infrastructure is present at storm outfalls and roadway crossings, and potential risk to public safety could materialize in areas where pathways (both formal and informal) are

Figure 8: Channel evolution schematic based on Schumm, 1977
adjacent to channel slopes. However, these risks can be minimized with regular monitoring throughout the Creek to identify new erosion sites as they develop gradually.

Though it is difficult to predict, the transition from Stage III into Stage IV and ultimately into stability (Stage V) is expected to take between 20 and 40 years. During this time, direct intervention is not recommended unless there is a risk to safety, property, or infrastructure. It is recommended that a detailed monitoring plan be developed and implemented in parallel with, and subsequent to, the projected development, in particular the Baseline/ Woodroffe SWM Pond. The monitoring plan should aim to identify risk of slope failure and determine when interventions are required in order to protect public safety, property, and infrastructure.

One immediate intervention is recommended at Erosion Site #3, where a maple tree has fallen in the Creek, blocking flow and accumulating debris. Without intervention, flows will be forced around the blockage and exacerbate erosion issues at this site. The NCC has been alerted to this issue, and to the recommendation that the fallen tree be removed as soon as possible.

Figure 9 presents a summary of erosion areas of concern identified between 2006 and 2018, including Restoration Sites #8, #9, and #10, Transitway culvert #1 and #2, the Iris Street culvert, and Erosion Sites #1, #2, and #3. Refer to Section 2.6 of the report herein for a background summary of these erosion areas, and Appendix C for additional information.

While the creek undergoes this period of adjustment, it is recommended that all erosion sites and remaining restoration sites be monitored to ensure there is no accumulating risk to infrastructure. Erosion Site #1 will be removed with the channel realignment required for Stage 2 OLRT. At Erosion Site #2, the informal pathway adjacent to the top of the eroding bank will need monitoring. Erosion Site #3 is located in the same reach as Restoration Site #8. With the implementation of the proposed City projects, the work at Restoration Site #8 proposed in 2007 is currently not required now that the undercut tree and bank have collapsed. Further downstream, Restoration Site #9 is located adjacent to an eroding bank with toppling trees near the multi-use pathway. This site no longer present a concern now that the bank has stabilized, Restoration Site #10 will essentially be addressed with the armour stone wall removal and bank regrading associated with the B/W Pond implementation.

The City is committed to undertaking a detailed monitoring program for Pinecrest Creek and will prepare a detailed monitoring framework in 2019 in further consultation with the NCC. The monitoring plan will capture the full length of the remaining open channel, including the remaining erosion areas of concern, remaining restoration sites, and infrastructure near/within the Creek including culverts, pathways and outfalls.
Figure 9: Summary of Erosion Sites along Pinecrest Creek
4.3 Stage 2 OLRT

4.3.1 Impacts and Mitigation

A number of conservative assumptions were made with respect to the impacts and benefits provided by proposed SWM controls for Stage 2 OLRT to help ensure that impacts were not underestimated. Assumptions were based on the conceptual design for Stage 2 OLRT that was (and remains at the time of writing) the best available information for modelling the changes in imperviousness and SWM controls for the project. The conceptual design developed by CTP2 during Preliminary Engineering is considered preliminary and is subject to refinements or changes altogether during the forthcoming detailed design phase, as long as the requirements outlined in the project specifications are satisfied.

SWM controls for the LRT track and ballast were modelled based on the conceptual design noted above. For the current study, conceptual sizing for the LRT track and ballast SWM controls (bioretention swales) was optimized based on site constraints (e.g. soils, topography, property limits, depth to bedrock and groundwater) using a “best efforts” approach, not on volume requirements to meet the Pinecrest Creek SWM criteria. For this exercise, a value of 100% imperviousness was assigned to the ballast (literature values for track ballast are highly variable), resulting in the average imperviousness of the LRT track and ballast catchments increasing from 31.6% (existing) to 83.9% (future).

The above approach was taken to provide a conservative estimate of the potential for negative cumulative impacts on the creek resulting from Stage 2 OLRT track and ballast (in combination with the other identified projects and developments).

The CIS impact assessment results presented in Table 9 show that the bioretention swales proposed for the LRT track and ballast (and conceptually designed as described above) control the annual average runoff volume and 25 mm peak flow from the LRT track and ballast to less than existing conditions but do not fully meet Pinecrest Creek SWM criteria and do not control 100-yr peak flows to existing conditions. However, in combination with the B/W Pond, overall impacts from the LRT track and ballast are mitigated.

Notwithstanding the approach described above, the project specific output specifications (PSOS) require that the track and ballast for Stage 2 OLRT meet the criteria, where applicable. The detailed design will attempt to meet the criteria in full, while working with existing site constraints, additional site information and a more refined alignment.

During detailed design, attempts to comply with the Pinecrest Creek SWM criteria must be clearly demonstrated. Should consultation with the City and regulatory partners during detailed design conclude that the final design of the LRT track and ballast performs as well or better than the conceptual design but that the Pinecrest Creek SWM criteria cannot be met in full, then any additional SWM requirements (quantity control) could be offset by the B/W Pond as shown by the results herein.

The CIS has assumed that the oversized storm sewers and OGS’s proposed at Queensview and Pinecrest Stations and the LID measures at Lincoln Fields Station will meet Pinecrest Creek SWM criteria for flood control (100-year detention), and that the LID measures at Lincoln Fields Station will also meet Pinecrest Creek SWM criteria for 10 mm retention. All three stations drain directly to the ORPP, therefore the Pinecrest Creek criteria for erosion...
control (25 mm detention) does not apply here. These site-specific SWM controls are requirements of the Stage 2 OLRT PSOS and will be implemented as part of that project.

An OGS will meet quality control requirements on-site at Baseline Station while quantity control requirements will be met with the B/W Pond in lieu of on-site underground storage. SWM control at Iris Station will be provided by trackside swales designed to LID standards and will meet the Pinecrest Creek SWM criteria.

### 4.3.2 Flood Risk to Stage 2 OLRT

CIS modelling results were shared with CTP2 for their consideration of overland flow and flood risk as part of the preliminary design and procurement phases of Stage 2 OLRT.

The Stage 2 OLRT track alignment drops to below existing grade in the vicinity of Lincoln Fields Station, from just south of Carling Avenue to Richmond Road. This drop in elevation is such that the track is lower than the elevation of the Parkway in some sections and, therefore, below flooding depths on the Parkway, although higher ground separates the track from overland flow. Post-processing of the Future Ultimate (2037) Conditions HEC-RAS output shows the maximum simulated 100-year depth of overland flow to be contained on the west side of the corridor and hydraulically disconnected from below-grade track segments in this area (Figure 10).

The following general and site-specific requirements have been included in the PSOS for Stage 2 OLRT to mitigate flood risk:

- That the guideway (above and below grade) be protected from flooding due to all storm events up to and including the 100-year plus 20% event;
- That tunnel portals, tunnels, and stations be free from flooding due to all storm events up to and including the 100-year plus 20% event;
- That the guideway be designed and constructed such that ponding levels do not exceed the top of rail elevation during the 100-year event;
- That ponding does not contribute to subgrade instability for all storms up to the 100-year event; and
- That an overland drainage swale be constructed between Carling Avenue and Richmond Road, designed to convey the flood spill in a defined channel from the ORPP during the 100-year storm, without flooding adjacent properties, or endangering or inconveniencing users of the SJAM Parkway.
Figure 10: Future Ultimate (2037) Condition post-processed 100-year HEC-RAS water depths (after JFSA Figure P-1)
5. CLOSURE

Pinecrest Creek is expected to adjust over the next 20 to 40 years with the implementation of City and development projects, in particular the B/W Pond. During this adjustment period, detailed monitoring of erosion and adjacent infrastructure will be undertaken. Apart from the removal of a fallen tree at Erosion Site #3, no additional mitigation beyond the recommended SWM controls for City and development projects are required at this time.

We trust that this report is sufficient for your current requirements. Please contact the undersigned with any questions or clarifications.

Prepared by,

Karine Bertrand, P.Eng.
Morrison Hershfield Ltd.

Reviewed by,

Morrison Hershfield Ltd.
6. REFERENCES


