Appendix F – Drainage and Stormwater Management Report

Schedule “C” Class Environmental Assessment for Airport Road from Braydon Boulevard / Stonecrest Drive to Countryside Drive

Airport Road Class Environmental Assessment

Braydon Boulevard / Stonecrest Drive to Countryside Drive

City of Brampton

Drainage and Stormwater Management Report

Regional Municipality of Peel

April 28, 2021

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1 Introduction

The Regional Municipality of Peel retained HDR to conduct a Schedule C Municipal Class Environmental Assessment (EA) Study to determine specific improvements to accommodate the current and future transportation needs of pedestrians, cyclists, transit users and motorists along the Airport Road corridor from Braydon Boulevard/Stonecrest Drive to Countryside Drive within the City of Brampton.

This Drainage and Stormwater Management Report has been prepared in support of the Class EA Study. The Airport Road Class EA Study limits are illustrated in **Figure 1**.

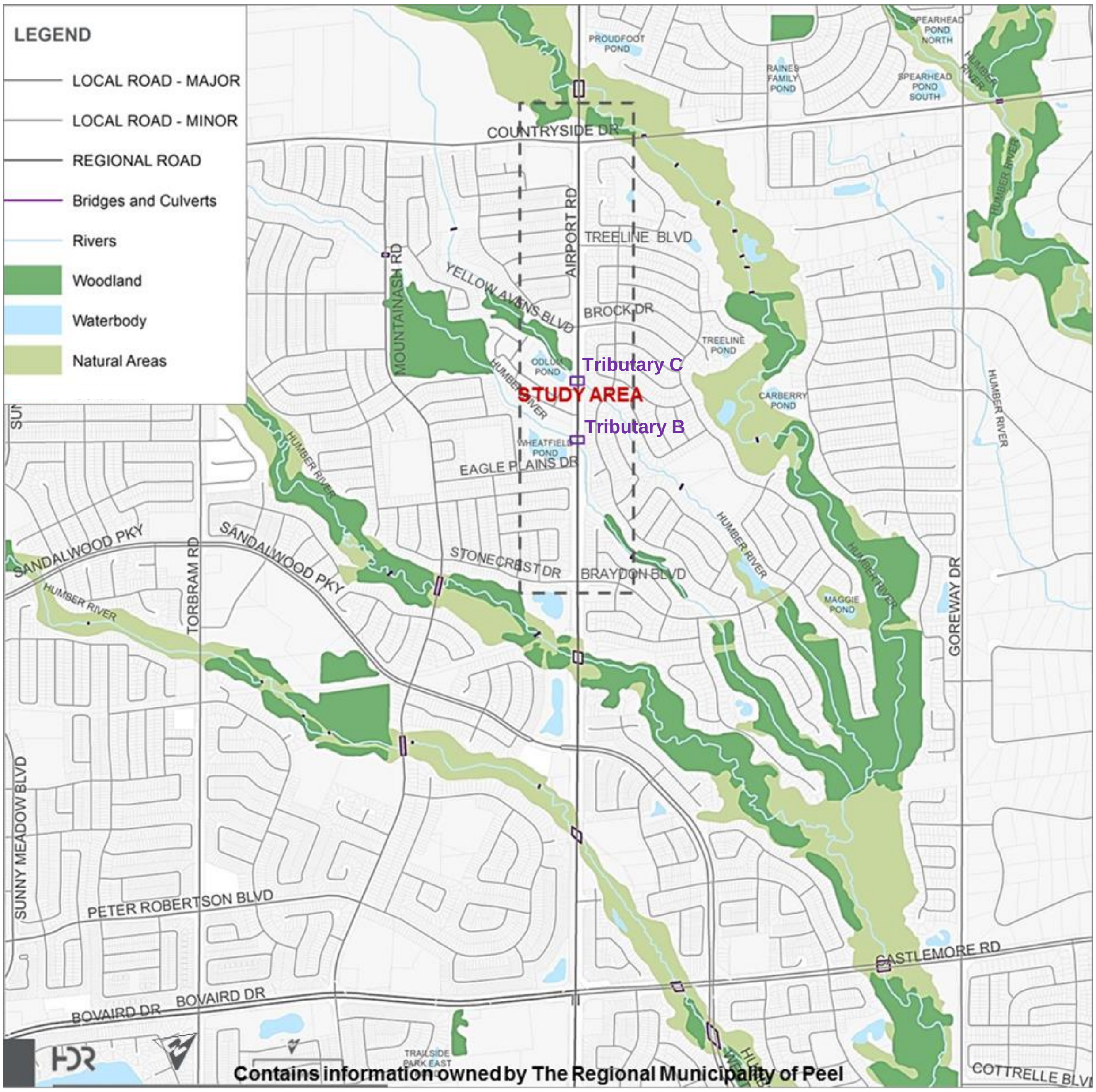


Figure 1: Study Area and Watercourse Locations

This report complies with the Ministry of the Environment, Conservation and Parks (MECP), Toronto Region Conservation Authority (TRCA), Regional Municipality of Peel, and City of Brampton's Policies and Standards.

The Study Corridor spans approximately 2.2 km of Airport Road. Within the project limits, Airport Road is a four lane, north-south regional arterial road located in the City of Brampton. It intersects with a number of local roads and entrances, and the land use is primarily residential throughout the study corridor.

There are two watercourses that cross Airport within the project limits, both of which are tributaries to West Humber River. At the point where these watercourses cross Airport Road, the general drainage direction is from west to east.

The objective of the Drainage and Stormwater Management Report is to develop a strategic approach to the level of development of the proposed project that will:

- Identify and evaluate existing drainage patterns and transverse culvert and bridge locations;
- Identify potential stormwater runoff quality and quantity impacts to the receiving watercourses from any proposed increase in pavement area; and
- Propose an appropriate drainage system, transverse culvert and bridge upgrades, and stormwater management systems in conjunction with the proposed road widening.

1.1 Background information

In preparation of the Airport Road Class Environmental Assessment Drainage and Stormwater Management Report, the following essential documents were obtained and reviewed:

1. Public Works Stormwater Design Criteria and Procedural Manual, Peel Region, 2019;
2. LID Implementation Process for Regional Road Right-of-Ways, Peel Region and Credit Valley Conservation, 2014;
3. Region of Peel, Public Works Design, Specifications & Procedures Manual, Linear Infrastructure, Storm Sewer Design Criteria, July 2009;
4. City of Brampton Engineering & Design Standard Drawings, Storm Sewers, Rainfall Intensities Curves, Apr. 1992;
5. Ministry of the Environment (MOE) Stormwater Management Practices Planning and Design Manual, March 2003;
6. Ministry of Transportation (MTO) Highway Drainage Design Standards, January 2008;
7. Toronto Region Conservation Authority (TRCA) Stormwater Management Criteria, August 2012;
8. Toronto Region Conservation Authority (TRCA) and Credit Valley Conservation (CVC) Low Impact Development Stormwater Management Planning and Design Guide, 2010;
9. City of Brampton Development Design Guidelines, 2003;
10. Ministry of Natural Resources and Forestry (MNRF) Guidance for Development Activities in Redside Dace Protected Habitat, March 2016;
11. Draft Natural Heritage Report, prepared by ASI Inc., Oct. 2017;

12. Draft Fluvial Geomorphology Assessment Report, prepared by Matrix Solutions Inc., Nov. 2017;
13. Geotechnical Investigation, Airport Road Widening and Reconstruction, Bovaird Drive to Mayfield Road, prepared by Terraprobe, May 2003;
14. Draft Pavement/Geotechnical and Environmental Investigation and Preliminary Design Report, Airport Road from Braydon Boulevard/Stonecrest Drive to Countryside Drive, prepared by Golder, February 14, 2020;
15. Hydrogeological Desktop Report, Airport Road from Braydon Boulevard/Stonecrest Drive to Countryside Drive, prepared by Golder, June 26, 2020; and
16. MECP Response to Notice of Commencement, May 31, 2018.

2 Existing Drainage Conditions

2.1 Watershed and Subwatershed

The study area falls under the jurisdiction of the Toronto Region Conservation Authority (TRCA) and the Ministry of Natural Resources and Forestry (MNRF) Aurora District. The study area is located within the West Humber River watershed, over which TRCA has jurisdiction with respect to drainage and stormwater management. In total, there are two (2) watercourse crossings located within the study area, both of which are located within TRCA regulated areas. Refer to **Figure 1** for watercourse crossing locations.

2.1.1 West Humber River Watershed

The Humber River Watershed encompasses approximately 911 km^2 of land area. The West Humber River begins in Caledon and flows 45 km over the Peel Plain in Brampton before joining the Main Humber River in Toronto. Tributaries B and C of Campbell's Creek, which is tributary to West Humber River are situated within the study area.

2.2 Land Use

Based on the site investigation and the available information, the existing land use for the adjacent properties along Airport Road is primarily residential properties between Braydon Boulevard/ Stone Crest Drive and Countryside Drive, with a commercial plaza located south of Countryside Drive.

2.3 Hydrogeological Conditions

A Geotechnical Investigation was completed for Airport Road between Bovaird Drive and Mayfield Road in 2003 (Terraprobe). As part of this investigation, 17 boreholes were drilled between Braydon Boulevard/Stonecrest Drive and Countryside Drive. The drilled boreholes encountered native glacial till, except for one location (Tributary C), where a deposit of clayey silt overlaid the glacial till. Both glacial till and clayey silt have been shown to have low infiltration rates.

As part of the Geotechnical Investigation, groundwater levels were measured at two borehole locations within the project limits, one at Brock Drive intersection and the other at Tributary C. The groundwater level at Brock Drive intersection was measured to be 3.0m below grade. The groundwater level at Tributary C was measured to be 1.2m below grade.

A Geotechnical Investigation was completed for Airport Road study corridor in 2019 (Golder). As part of this investigation, 42 boreholes were advanced to a depth of 1.5 m and 2 boreholes were advanced to a depth of 8 m between Braydon Boulevard/Stonecrest Drive and Countryside Drive. One of the boreholes was completed with a standpipe piezometer to complete groundwater level measurements.

Based on the geotechnical investigation, Golder prepared a Hydrogeological Desktop Report. The borehole drilling results indicated native surficial deposits generally consisted of silty clay and silty clay till. The expected hydraulic conductivity for such material could range from approximately 1×10^{-8} m/s to 1×10^{-10} m/s. For the purpose of preliminary design in this study, an average infiltration rate of 4 mm/hr was considered within the project limits, using Table C1 of Appendix C of the CVC/TRCA LID SWM Guide (2010) and a factor of safety of 3.

The available groundwater data suggested that the depth of water table in the vicinity of the corridor is on the order of 3 m, and fluctuate by 1 m to 2 m on a seasonal basis. As the result, shallow groundwater levels may be expected to be 1 m to 2 m below ground.

Further investigation will be required at the detail design stage to confirm the native soil infiltration rate and groundwater levels at locations were LID measures are proposed.

2.4 Existing Drainage Patterns

The study area along Airport is primarily an urban cross-section and the roadway and boulevard surfaces are drained by a network of catchbasins and storm sewers, discharging to the watercourse crossings and the existing storm drainage systems. A summary of the existing drainage conditions including outlet locations is provided in **Table 2-1**.

Table 2-1: Summary of Existing Drainage Conditions

Airport Road Section	Description
From Braydon Boulevard to 190m north of Braydon Boulevard (190m)	EBL and WBL drain southerly via storm sewers to the existing storm sewer trunk running east along Braydon Boulevard.
From 190m north of Braydon Boulevard to Tributary B Crossing (300m)	EBL and WBL drain northerly and southerly via storm sewers to Tributary B.
From Tributary B Crossing to Tributary C Crossing (240m)	EBL and WBL drain southerly via storm sewers to Tributary B.
From Tributary C Crossing to 100m south of Countryside Drive (790m)	EBL and WBL drain southerly via storm sewers to Tributary C.

2.5 Aquatic Resources

The two West Humber River tributaries in the study corridor are warmwater tributaries and provide fish habitat, downstream of each crossing location. Both watercourses are under the jurisdiction of Toronto and Region Conservation Authority (TRCA), the Ministry of Natural Resources and Forestry (MNRF), and the Ministry of the Environment, Conservation and Parks (MECP). The MNRF background information provided in 2017 confirmed that these tributaries contribute flow to downstream Redside Dace occupied habitat. No occupied habitat for Redside Dace exists within the study area reach of these tributaries, however both crossing locations are subject to the regulations of the Endangered Species Act of 2007, currently administered by MECP.

2.6 Transverse Drainage Crossings

There are two watercourse crossings within the Airport Road project limits. TRCA has jurisdiction of the West Humber River watershed, where these watercourses are located. **Table 2-2** summarizes the size, type, and location of the culvert structures. Refer to **Figure 1** and the Drainage Plans provided in **Appendix A** for the location of the watercourse crossings within the study corridor.

The portion of Airport Road between Braydon Boulevard/Stone Crest Drive and Countryside Drive consists of an urban cross-section and the roadway and boulevard surfaces are drained by a network of catch-basins and storm sewers, discharging to the watercourse crossings and existing storm drainage systems.

Table 2-2: Summary of Watercourse Culvert and Bridge Crossings

Watercourse Crossing	Location of Crossing	Culvert Dimensions (Width x Height) mm	Culvert/Bridge Description	Length (m)
Tributary B	110 m north of Eagle Plains Drive	4500 x 1200*	Concrete Box Culvert	98.0
Tributary C	60m north of Camrose Street	3000 x 1250* 2400 x 1200**	Concrete Box Culvert	90.7 99.25

* Includes 0.3 m embedment

** This culvert combines SWM pond discharge and Tributary C flows

2.6.1 Assessment Criteria

In view of the proposed improvements, hydraulic assessments of the existing transverse crossings within the Airport Road Class EA study area were undertaken in accordance to the Ontario Ministry of Transportation's Highway Drainage Design Standards (2008).

Design Flows

Based on the MTO Drainage Standard WC-1, the design storm return period for structures crossings Freeway & Urban Arterial roadways with spans less than 6.0 m is the 50-year event.

Freeboard

The minimum required freeboard at culvert crossings of Freeway & Urban Arterial roadways is specified as 1.0 m between the high water level for the design storm to the edge of the travelled lane as per the MTO Drainage Standard WC-7.

2.6.2 Hydraulic Assessment of Existing Transverse Crossings

A hydraulic analysis was conducted for all crossings to assess their hydraulic capacity under the existing conditions. The HEC-RAS hydraulic model was obtained from TRCA for all crossings and updated using the culvert design drawings.

Design Flows

The peak flows at the crossings for various storm events were obtained from the HEC-RAS models. A summary table of the storm design peak flows of the transverse crossing is presented in **Table 2-4.**

It is recommended that during detail design, the assessment results be reviewed and verified to confirm any changes to the land-use and associated hydrologic information that may affect the peak flows presented in this Class EA study.

Table 2-3: Design Peak Flow for the Transverse Crossings

Watercourse Crossing	Culvert/ Crossing ID	Peak Flow (m^3/s)		
		50 Year Storm	100 Year Storm	Regional
Tributary B	Trib-B	10.78	12.37	24.34
Tributary C	Trib-C	7.35	8.31	10.59

Hydraulic Assessment

The HEC-RAS models obtained from TRCA were reviewed and used to conduct the hydraulic assessment for the two crossings. It is recommended that during detail design, the assessment results be reviewed and verified to confirm the existing conditions based on a topographic survey.

As per the MTO Highway Drainage Design Standards, culvert capacities were assessed based on the 50-year storm event peak flow for structure with spans less than 6.0 m to determine the available freeboard and clearance.

Table 2-5 summarizes the hydraulic analysis results for the transverse crossings along the study corridor. All hydraulic assessment output files are provided in **Appendix B**.

Table 2-4: Hydraulic Analysis Results for the Transverse Culverts (Existing Condition)

Crossing ID	Type	U/S Invert* (m)	D/S Invert* (m)	Length (m)	Road Elev. (m)	Water Surface Elevation (m)			Free-board (m)	Remarks
						50-yr	100-yr	Reg.		
Trib-B	Culvert	210.75	210.26	98.0	212.14	212.93	213.01	213.27	-0.79	Does not meet MTO criteria, Regional flood overtops road by 1.13m
Trib-C	Culvert	213.15 212.29	212.58 212.00	90.7 99.25	215.22	213.85	213.88	214.98	1.37	Meets MTO criteria

*River bed elevation

Based on the hydraulic analysis results, Trib-C Crossing is in compliance with the Ontario Ministry of Transportation Highway Drainage Design Standards (January 2008), as the freeboard provided is more than 1.0m from the design high water level (50-yr storm event). However, Trib-B Crossing does not meet the vertical freeboard criteria of minimum 1.0 m from the design high water level (50-yr storm event). Under the Regional storm condition, no overtopping of Airport Road will occur at Trib-C Crossing, but Airport Road is overtopped at the lowest point of the driving surface at Trib-B Crossing by 1.13m. It is recommended to review the hydraulic conditions of the Trib-B culvert crossing, and in particular the existing 3.0m x 1.5m parallel culvert that discharges from the adjacent SWM pond, to ascertain whether Trib-B flows are conveyed by this culvert. This will need to be confirmed with TRCA.

3 Proposed Drainage Condition

3.1 Roadway Drainage System

The preferred alternative design concept for Airport Road from Braydon Boulevard/Stone Crest Drive to Countryside Drive recommends widening the road from four to six lanes, as well as the replacement of sidewalks with multi-use pathways and providing landscaped zones as feasible. Overall, the existing drainage patterns and discharge locations will not be altered as per the proposed roadway improvements.

3.1.1 Minor Drainage System

The storm sewer system draining the pavement for the ultimate roadway configuration should have the capacity to convey the peak flow from the 10-year storm event as per Peel Region SWM Guidelines. There is no change in the overall drainage pattern from the existing conditions to the proposed conditions. To accommodate the proposed roadway widening, catchbasin relocations are anticipated. Proposed roadway drainage will be collected by a series of catchbasins and will be conveyed by storm sewers to the existing storm outlet locations. There are a number of existing outlets for Airport Road runoff within the study corridor. For the storm sewer discharge locations, refer to the Drainage Plans in **Appendix A**. A summary table listing the right-of-way drainage area characteristic is provided in **Table 3-1**.

Table 3-1: Drainage Area Summary

Drainage Area ID	From Station	To Station	Drainage Area (ha)	Discharge Location
A-1	11+507	11+707	1.11	Municipal storm sewer along Braydon Blvd.
A-2	11+707	12+006	1.48	Tributary B
A-3	12+006	12+255	1.23	Tributary B
A-4	12+255	13+055	4.20	Tributary C

A preliminary pipe capacity assessment was completed for the last section of the storm sewer (before outfall) at each catchment area based on a 10-year design peak flow. The assessment showed that except for Catchment A-4, the storm sewers have adequate capacity to convey the 10-yr design storm under the proposed 6-lane widening condition. The details of the analysis are provided in **Appendix E**.

3.1.2 Major Drainage System

The roadway design should ensure that the major system runoff up to the 100-year storm event can be safely conveyed to watercourse locations and should allow at least one lane in each direction to be clear of any flooding. Major system relief will occur at major watercourse crossings and intersections. At the locations, major system inlets will capture the 100-year flow and direct it to the outfall. A spread analysis should be completed at the detail design stage to ensure that the ponding at the low point maintains at a minimum one lane of traffic in each direction clear of flooding.

For major system flow route details, refer to the Drainage Plans provided in **Appendix A**.

3.2 Transverse Culverts

As per **Section 2.6**, there are a total of two (2) watercourse crossings located within the study corridor. The project team considered key factors affecting the design of each watercourse crossings. The proposed size, structure, and locations of each crossing was determined based on existing culvert condition assessments, fluvial geomorphologic assessments, proposed roadway geometry, grading impacts, and hydraulic performance, with the objective of improving the drainage condition at each crossing and addressing any existing deficiencies. Neither of the crossings are required to be extended to accommodate the proposed roadway improvements. There would be no change to the hydraulic capacity of the two crossings and there will be no impact to the watercourses, including the section of Tributary B, which runs parallel along the east side of Airport Road.

3.2.1 Hydraulic Assessment of Proposed Transverse Crossings

Under the proposed conditions, the drainage boundary and design peak flow values for the transverse crossings are considered to remain unchanged compared to the existing conditions. The increased pavement area within the corridor improvements is negligible in comparison to the large external drainage areas contributing to each watercourse crossing location. Therefore, the hydraulic assessment of the Crossings B and C (**Table 2-5**) is still valid under the proposed conditions.

It is recommended to review the hydraulic conditions of the Trib-B culvert crossing, and in particular the existing 3.0m x 1.5m parallel culvert that discharges from the adjacent SWM pond, to ascertain whether Trib-B flows are conveyed by this culvert. This will need to be confirmed with TRCA.

4 Stormwater Management Strategy

4.1 Stormwater Management Criteria

The stormwater management plan for the Airport Road Class EA Study shall be developed to comply with the MOE Stormwater Management Practices Planning and Design Manual, Peel Region Guidelines for the Preparation of Stormwater Management Reports and the Toronto Region Conservation Authority Stormwater Management Guidelines.

4.1.1 Water Quality Control

Watercourses within the TRCA's jurisdiction are classified as requiring an "Enhanced" level of protection, which equates to 80% Total Suspended Solids (TSS) removal.

As per the MECP Response to Notice of Commencement Letter dated May 31, 2018, water quality control measures within the study limits will be designed to provide "Enhanced" water quality treatment, as a minimum, for the increased pavement area as a result of roadway widening/improvements.

4.1.2 Water Quantity Control

Within the project limits, the storm runoff from Airport Road discharges either into existing storm sewers or outlets at watercourse crossings (**Table 3-1**).

Municipal Storm Sewer Systems

The last section of the storm sewer system at each catchment area is assessed to ensure there is enough capacity to convey the design storm (10-yr peak flow). The existing storm sewer trunk running east along Braydon Boulevard will ultimately discharge into the City's SWM Pond located in Chand Park at the end of Crocker Drive. This system is assessed to ensure there is sufficient capacity on the pond to receive the runoff from Airport Road (Catchment A-1). Refer to **Sections 4.4.2** and **4.4.3**.

A detail assessment of the existing storm sewer capacity should be completed at the detail design stage. A parallel storm sewer system can be considered to provide any capacity increase, if required, in combination with the existing system.

Watercourse Crossings

TRCA has established quantity control targets for the watersheds under its jurisdiction (TRCA Stormwater Management Criteria). Accordingly, flood control is not required for storm outfalls at the two tributary branches of West Humber River, where the study area is located.

4.1.3 Water Balance and Erosion Control

TRCA criteria for water balance and erosion control requires the retention of the first 5 mm of rainfall. These criteria are applicable to increased pavement area because of roadway widening/improvements.

Region of Peel has additional Water Balance Control Requirements within Endangered Species Habitat:

- Post development water balance to match predevelopment water balance in order to protect the natural hydrological functions of streams.
- Control of the runoff from to Regional Specific 90th percentile rainfall volume using the Control Hierarchy:
  - Priority 1 –Volume Retention (infiltration, re-use and/or ET) using LIDs to satisfy the pre-development water balance requirements. Minimum post development recharge of the first 5 mm for any precipitation event.
  - Priority 2 – LID Volume Capture and Release using LIDs filtration techniques. Treat remainder of 90th percentile rainfall volume (27-28mm) not retained using Priority 1 measures to enhance water quality and reduce runoff volumes.
  - Priority 3 – Volume Capture and Release using OGS, dry-ponds, wet-ponds and/or wetlands. Treat remainder of 90th percentile rainfall volume (27-28mm) not retained or filtered using Priority 1 and Priority 2 measures respectively to enhance water quality and reduce runoff volumes.
- Retention of the run-off from rainfall in the range of 5 – 15 mm (depending on the recommendations set forth in the sub-watershed plan and on soil permeability).

4.2 Hydrologic Modeling

A hydrologic analysis has been conducted using the Rational Method to calculate the surface runoff under various storm events for both the existing and proposed condition scenarios.

Peel Region IDF curves were applied to calculate the proposed peak flows and the City of Brampton IDF curves were used to calculate the existing peak flows using a minimum inlet time (T_c) of 15 minutes.

4.3 Pavement Area Analysis

A pavement area analysis was performed to determine the increase in impervious surface which will result from the roadway widening to 6 lanes and the replacement of sidewalks with new multi-use trails. In addition, it is proposed to resurface the median with permeable material, which will result in a reduction of the impervious surfaces. It was determined that the proposed roadway improvements will result in an additional 0.92 ha increase in pavement area within the study limits.

Table 4-1: Pavement Area Analysis

Study Area	Existing Pavement Area (ha)	Proposed Pavement Area (ha)	Increased Pavement Area (ha)	Percentage Increase (%)
Airport Road	4.58	5.50	0.92	20

4.4 Water Balance Analysis

A water balance analysis for pre-development and post-development conditions has been completed in accordance with the MECP SWM Guideline (Table 3.1) to determine the net reduction in infiltration as a result of the proposed roadway widening.

Pre-development Conditions

The total project corridor site area is approximately 8.02 ha, comprised of 4.58 ha (57%) of pavement with zero infiltration and 3.44 ha (43%) urban lawns (shallow rooted crops) with an average annual infiltration of 115.4 mm/yr based on an annual rainfall volume of 661.6 mm/yr (Canadian Climate Normals 1971-2000, Lester B. Pearson) and silty clay and silty clay till soils (Hydrologic Soil Group D), or approximately 3970 m^3/yr.

Post-development Conditions

The total increase in pavement area would be 0.92 ha (20%). Therefore, the urban lawn area will be reduced to 2.52 ha with an average annual infiltration of approximately 2908 m^3/yr. There would be a net reduction in infiltration of approximately 1062 m^3/yr, which would need to be infiltrated annually using the proposed SWM measures. This is discussed in more detail in the following sections.

4.5 Stormwater Best Management Practice Options

Various Best Management Practices (BMPs) for stormwater management were reviewed and assessed for their applicability to this project. An LID screening was completed consistent with Region and CVC's LID Implementation Process for Regional Road Right-of-Ways (2014). The results are presented in **Appendix C**. Due to the nature of this facility (i.e. linear transportation corridor) and the limited space within the roadway right-of-way, a series of infiltration trenches parallel to storm sewers are proposed to provide quality treatment, water balance, and erosion control.

4.5.1 Infiltration Trenches

Infiltration trenches are linear conveyance facilities lined with geotextile fabric and clean granular fill (50 mm clear stone) for quality treatment of roadway runoff. In addition to removing TSS particles, the granular filter within the trench reduces water temperature impact and enhances stream base flows through groundwater recharge. It also contributes to water balance and controlling downstream erosion by reducing flow velocities.

The design criteria specified in the SWM Planning and Design Guide (MOE, 2003) and LID SWM Planning and Design Guide (TRCA and CVC, 2010) were applied to determine the depth and footprint area for the infiltration trenches. The maximum allowable depth of the stone reservoir for design without an underdrain can be calculated using the following formula (Equation 4.3 of the MOE SWM Planning and Design Manual, 2003):

$$d = PT / (1000n)$$

where, P is the percolation rate of the native soils, which was estimated to be 4 mm/hr within the project limits based on the Hydrogeological Investigation (**Section 2.3**); T is time to drain, which is recommended to be 48 hr; and n is void space ratio of the aggregate used, which is typically 0.4 for clear stone. Accordingly, the maximum allowable depth of the reservoir can be calculated to be d_{max} = 481 mm.

For this project, 2.7 m wide by 0.48 m deep infiltration trenches are proposed. A typical detail of the proposed infiltration trench is provided in **Appendix D**. The footprint area of the infiltration trench can be calculated using the following formula (Equation 4.3 of the MOE SWM Planning and Design Manual, 2003):

$$A = 1000V / (PnT)$$

where, V is the required water quality volume to meet the 'Enhanced' level protection (80% TSS removal), which is determined based on the contributing drainage area and the imperviousness using Table 3.2 of the SWM Planning and Design Manual (MOE, 2003). The ratio of the impervious drainage area to footprint area of the infiltration trench should be between 5:1 and 20:1 to limit the rate of accumulation of fine sediments and thereby prevent clogging.

The bottom of the infiltration trench should be one (1) metre above the seasonally high water table. According to the Hydrogeological Investigation (**Section 2.3**), the groundwater table measured within the project limits is 3.0m deep and fluctuate on a seasonal basis to a minimum of 1-2 m deep. Therefore, it should be feasible to construct the infiltration trenches provided that they are at sufficient distance from the watercourses. Further investigation should be completed during the detail design stage to confirm the adequate separation at each location.

The infiltration trenches are proposed for drainage Areas A-2, A-3, and A-4, where runoff discharges directly into natural watercourses. Since the receiving watercourses (Tributaries B and C of West Humber River) are classified as sensitive, the infiltration trenches are designed to treat the runoff from the entire pavement area within the catchment. In addition to providing 'Enhanced' level protection (80% TSS removal), the infiltration trenches provide water balance, erosion control and thermal mitigation benefits to the receiving watercourses. The conceptual locations of the proposed infiltration trenches are shown in the Drainage Plans in **Appendix A**.

Runoff Volume Control

The provided storage volume within the infiltration trenches includes the volume required to retain the 90th percentile volume (28 mm) from the increased pavement areas to meet the Priority 1 of the Region of Peel's Control Hierarchy for retrofit projects. TRCA water balance and erosion control target (5 mm) and the Peel Region additional water balance control requirements within Endangered Species habitat (15 mm) will be met as well.

Since the entire 90th percentile volume will be retained within the proposed infiltration trenches, Priorities 2 and 3 will not apply; however, the existing OGS units will provide additional treatment by volume capture and release as part of a treatment train approach.

Pre-treatment of the runoff directed to the infiltration trenches will be facilitated by the use of catchbasin inserts (e.g. Goss Trap, CB Shield).

Table 4-2 lists the details of the infiltration trenches proposed along the study corridor. Accordingly, water quality, water balance and erosion control treatment will be provided for 4.83 ha of pavement area, which exceeds the MECP requirement of providing treatment to the increased pavement area of 0.91 ha. The total provided storage volume of 464 m^3 is equivalent to the retention of 8.4 mm of runoff over the entire pavement area of 5.50 ha. This corresponds to retaining the 63rd percentile rainfall volume, which is equivalent to 22,793 m^3/yr, well exceeding the required 1062 m^3/yr infiltration needed to meet the pre-development water balance.

For conceptual locations of the proposed infiltration trenches, refer to the Drainage Plans provided in **Appendix A**. Detail calculations are provided in **Appendix E**.

Table 4-2: Summary of Proposed Water Quality Treatment Strategy (Infiltration Trench)

Drainage Area ID	Treated Pavement Area (ha)	Required WQV[1] (m^3)	Required Water Balance Storage[2] (m^3)	Total Required Storage (m^3)	Proposed Length[3] (m)	Provided Storage Volume (m^3)
A-1	-	4	22	22	-	-
A-2	1.02	36	48	48	510	98
A-3	0.86	30	45	45	430	83
A-4	2.95	104	143	143	1475	283
Total	**4.83**	**170**	**258**	**258**	**2415**	**464**

[1] Water Quality Volume
[2] Based on the retention of 28 mm of precipitation from increased pavement areas
[3] Based on a 20:1 pavement to infiltration trench area ratio

4.5.2 Storm Sewer Assessment

The last section of the storm sewer system (before outfall) at each catchment area is assessed to ensure there is enough capacity to convey the design storm (10-yr peak flow).

The results of the assessment at each catchment are summarized in **Table 4-3**. Except for Catchment A-4, all storm sewers have sufficient capacity to convey the design storm. Detail calculations are provided in **Appendix E**.

A detail assessment of the existing storm sewers capacity should be completed at the detail design stage. A parallel storm sewer system can be considered to provide any capacity increase, if required, in combination with the existing system.

Table 4-3: Summary of Storm Sewer Capacity Assessment

Drainage Area ID	Drainage Area (ha)	Design Peak Flow (m^3/s)	Pipe Diameter (mm)	Slope (%)	Full Flow Capacity (m^3/s)
A-1	1.11	0.175	600	0.30	0.336
A-2	1.48	0.233	525	0.30	0.236
A-3	1.23	0.199	450	0.71	0.240
A-4	4.20	0.633	525	1.50	0.527

[1] Calculated using the Manning's equation

4.5.3 Braydon Boulevard Storm Sewer System

The existing storm sewer trunk running east along Braydon Boulevard will ultimately discharge into the City's SWM Pond located in Chand Park at the end of Crocker Drive. According to the Vales of Castlemore South Subdivision Storm Tributary Area Plan (City of Brampton, May 2010), this system has been designed to receive runoff from a 10.59 ha external drainage area as well as a 0.35 ha drainage area from the northbound lanes of Airport Road, at its inlet at Airport Road. In the proposed conditions, only Catchment A-1 with a drainage area of 1.11 ha will discharge to this system at this location. The minor flows (10-yr) at this location under pre-development and proposed conditions are summarized in **Table 4-4**. The flow under proposed conditions is significantly smaller than the flows for which the Braydon Boulevard system has been designed. Therefore, there will be sufficient capacity in the City's SWM Pond for the runoff from this portion of Airport Road.

Table 4-4. Inflows to Braydon Boulevard Storm Sewer System at Airport Road

Condition	Drainage Area (ha)	Runoff Coefficient C	Minor Peak Flow (m^3/s)
Pre-development	10.59	0.20	0.54
	0.35	0.40	0.04
Proposed	1.11	0.64	0.18

4.5.4 Supplemental BMP Measures

The proposed infiltration trenches in combination with the existing OGS units will meet the minimum SWM criteria. However, through discussions with MNRF and TRCA, opportunities to implement supplemental stormwater best management practice measures to provide additional treatment can be considered in order to further enhance the quality control, peak flow reductions, and water balance and erosion control. The supplemental BMP measures can also provide additional mitigation for the thermal impacts to the receiving watercourses.

The supplemental BMP measures shall be designed based on the site conditions and further geotechnical and hydrogeological investigations undertaken during the next phase of design. Any low impact development measures shall meet the design criteria as per the CVC/TRCA Low Impact Development Stormwater Management Planning and Design Guide.

A list of potential LID measures that should be considered for implementation within the study corridor is provided below:

Bioretention Systems

Bioretention systems allow for stormwater filtration, infiltration, and evapotranspiration from tree and vegetative plantings.

For roadway applications, these can take the form of sub-surface modular units that are filled with lightly compacted soil within a trench situated beneath the roadway boulevards. The trench unit consists of a filter bed which is a mixture of sand, fines, and organic material to support vegetation and promote evapotranspiration by allowing surface runoff to route through a distribution pipe via gravity within the trench. Soil filtration, bioremediation, and evapotranspiration will occur as water filtrates through the soil from the perforated distribution pipe.

Since trees require water to sustain their health and allow for growth, the concept of integrating stormwater runoff from the right-of-way and discharging the runoff directly into the soil trench systems has the following advantages:

- Boulevard landscaping (trees) will receive a supply of rainwater during every rainfall event, thus sustaining their health;
- Stormwater runoff from the roadways could potentially see significant detention within the soil trench systems, which will result in a reduction of peak flows;
- Significant water quality treatment will also be realized since stormwater can be routed through the soil trench's soil and tree root matrix, thus creating a subsurface bioretention system;
- For smaller rainfall events (i.e. less than 13 mm rainfall), the soil trenches can provide (in the long-term) for complete capture of the runoff through root uptake and evapotranspiration.

Applicability of soil trench bioretention systems along roadway segments should be investigated further during detail design stage to determine the applicability of providing soil trench bioretention systems.

Outfall Mitigation

Vegetated filter strips operate through a combination of sedimentation and infiltration. Shallow flows are routed over grassed areas, which allow the filter strips to function by slowing down the runoff velocity and filter out suspended sediment and associated pollutants and allowing infiltration into underlying soils. Filter strips are applicable where there are low, flat vegetated areas that will allow runoff to disperse over a wide area.

Plunge pools are a designated depression area at the base of storm outfalls to prevent scouring and erosion due to the high velocity of the flow at the outfall pipe locations. The plunge pool also functions as a level spreader that reduces the concentrated flow from the outfall, and spreads the flow onto a natural vegetated floodplain area.

There is a storm sewer outfall at the Tributary B valley, on the west side of the watercourse (drainage area A-2). Vegetative filter strips and plunge pools should be considered at this location to disperse the energy of the flow and to provide additional water quality control in series with infiltration trenches as a treatment train system.

4.6 Erosion and Sediment Control during Construction

Erosion and sediment control measures should be implemented and monitored through the construction period. Construction activity should be conducted during periods that are least likely to result in in-stream impacts to fish habitat.

Detailed erosion and sediment control plans will be required as part of the detailed design component for all phases of the construction. The erosion and sediment control plans will be subject to review and approval by the various external agencies involved in the project. These would include the Toronto and Region Conservation Authority.

During construction, disturbances to watercourse riparian vegetation should be minimized. If riparian vegetation is removed or disturbed, erosion and sediment control measures such as silt fences, rock flow check dams and sedimentation ponds should be utilized to provide a maximum protection of local and downstream aquatic resources. These measures should be maintained during construction and until disturbed areas have been stabilized with seed and mulch. Additionally, topsoil should not be stockpiled close to the watercourses and water should not be withdrawn from these sensitive streams for construction purposes.

The site engineer and contractor will be responsible for delineating work areas, and ensuring that erosion and sediment control measures are functional. In addition, the engineer will ensure that provisions related to fisheries and watercourse protection is met and that fish habitat compensation measures are implemented in accordance with the terms and conditions of the Fisheries Act Authorization, if required during detailed design, as a result of a DFO self-screening.

4.7 Stormwater Management Plan Summary

The proposed stormwater management plan for the project has been developed by examining the opportunities and constraints within the entire project area. Runoff from the paved roadway area will be conveyed to the proposed infiltration trenches and roadway storm sewer systems and discharge into either existing storm sewer systems or natural watercourses. As per **Section 4.3**, the total roadway pavement area will increase by 0.92 ha, including the multi-use trail and sidewalk within the boulevard areas. The stormwater management plan for this project is presented on the Drainage Plans in **Appendix A**. **Table 4-5** provides a summary of the water quality treatment strategy proposed to mitigate the increase in impervious surface within the project limits.

Table 4-5: Summary of Stormwater Management Plan

Drainage Area ID	Drainage Area (ha)	Existing Pavement Area (ha)	Additional Pavement Area (ha)	% Impervious	Preliminary Quality and Water Balance Storage Provided (m^3)	Pavement Area Receiving Quality Treatment[1] (ha)
A-1	1.11	0.59	0.08	60.4	0	0
A-2	1.48	0.85	0.17	68.9	98	1.02
A-3	1.23	0.70	0.16	69.9	83	0.86
A-4	4.20	2.44	0.51	70.2	283	2.95
Total	**8.02**	**4.58**	**0.92**	**68.6**	**464**	**4.83**

[1] Total pavement area is treated due to the sensitivity of the receiving watercourse.

5 Conclusions

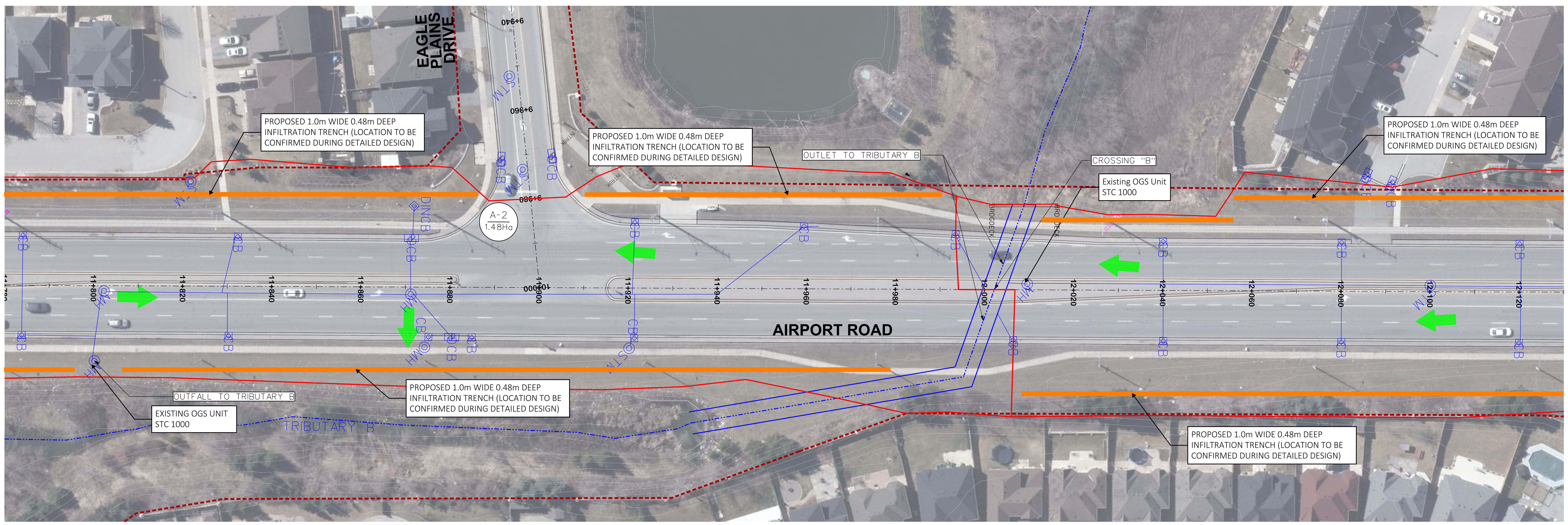
Airport Road corridor between Braydon Boulevard/Stone Crest Drive and Countryside Drive is proposed to be widened from 4 to 6 lanes, and will include upgrades to the existing subsurface road drainage system, consisting of storm sewer systems with catchbasins along the curb lines to convey stormwater runoff to the various outfall locations along the corridor.

The study area is within the area regulated by the TRCA and a portion of the corridor is within the regulatory floodplain. A total of two (2) watercourse crossings are located within the project limits. No impact to the watercourse crossing is anticipated as a result of the proposed improvements, as the road widening does not require a culvert extension or replacement at these two crossings.

Based on the hydraulic analysis results, Trib-C Crossing is in compliance with the Ontario Ministry of Transportation Highway Drainage Design Standards (January 2008) and no road overtopping occurs under the Regional storm event. However, Trib-B Crossing does not meet the vertical freeboard criteria and under the Regional storm condition, Airport Road is overtopped at the lowest point of the driving surface at Trib-B Crossing by 1.13m. It is recommended to review the hydraulic conditions of the Trib-B culvert crossing, and in particular the existing 3.0m x 1.5m parallel culvert that discharges from the adjacent SWM pond, to ascertain whether Trib-B flows are conveyed by this culvert. This will need to be confirmed with TRCA.

The proposed road widening will result in an additional pavement area of 0.92 ha. Stormwater best management practices, including infiltration trenches, are proposed for quality treatment of the runoff from the roadway right-of-way and to meet water balance and erosion control requirements. The proposed infiltration trenches in combination with the existing OGS units will provide a treatment train approach. No quantity control will be required as the result of the proposed improvements and the receiving systems will have adequate capacity for the runoff from proposed pavement areas. As part of the SWM strategy, a total of 4.83 ha of pavement area will receive quality treatment through the proposed infiltration trenches, which exceeds the MECP requirement of providing treatment to the increased pavement area. The Region of Peel’s Control Hierarchy will be met by retention and infiltration of a runoff volume equivalent to 28 mm from the increased pavement areas using the proposed infiltration trenches. This corresponds to retaining a rainfall volume equivalent to 22,793 m^3/yr, well exceeding the net reduction of 1062 m^3/yr infiltration as a result of the proposed improvements.

Appendix A: Drainage Plans



LEGEND:

- EXISTING R.O.W.
- WATERCOURSE
- CL EXISTING ALG
- CATCHMENT BOUNDARY
- DRAINAGE CATCHMENT I.D. AND AREA (A-X, xx Ha)
- EXISTING STM SEWER
- OVERLAND FLOW DIRECTION
- PROPOSED IMPROVEMENTS
- EXISTING CATCHBASIN
- EXISTING MANHOLE
- STORM SEWER SYSTEM CONNECTION
- PROPOSED INFILTRATION TRENCH

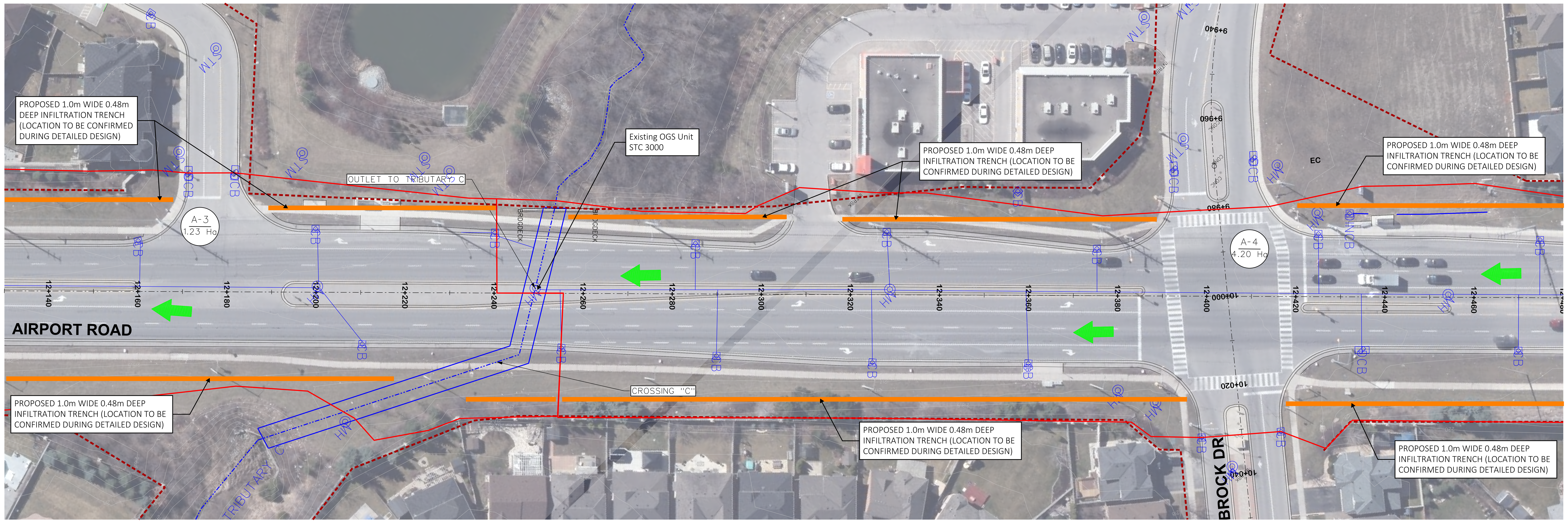
HDR

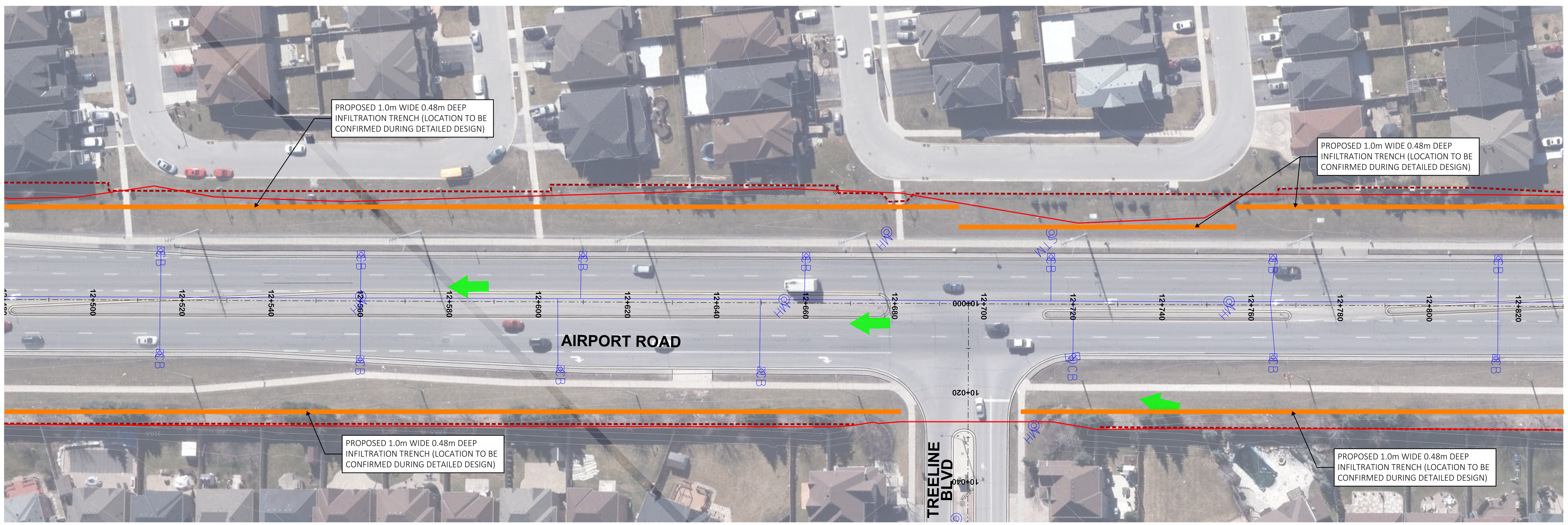
Region of Peel
Working for you

AIRPORT ROAD
(BRAYDON BLVD./STONECREST DR. TO COUNTRYSIDE DR.)
ENVIROMENTAL ASSESMENT
DRAINAGE PLAN
STA. 11+400 TO 12+130

SHEET NO.
DRG001

APRIL 2019





LEGEND:

EXISTING R.O.W.	DRAINAGE CATCHMENT I.D. AND AREA (A-X xx Ha)
WATERCOURSE	EXISTING STM SEWER
CL EXISTING ALG	OVERLAND FLOW DIRECTION
CATCHMENT BOUNDARY	PROPOSED IMPROVEMENTS
EXISTING CATCHBASIN	EXISTING MANHOLE
STORM SEWER SYSTEM CONNECTION	PROPOSED INFILTRATION TRENCH

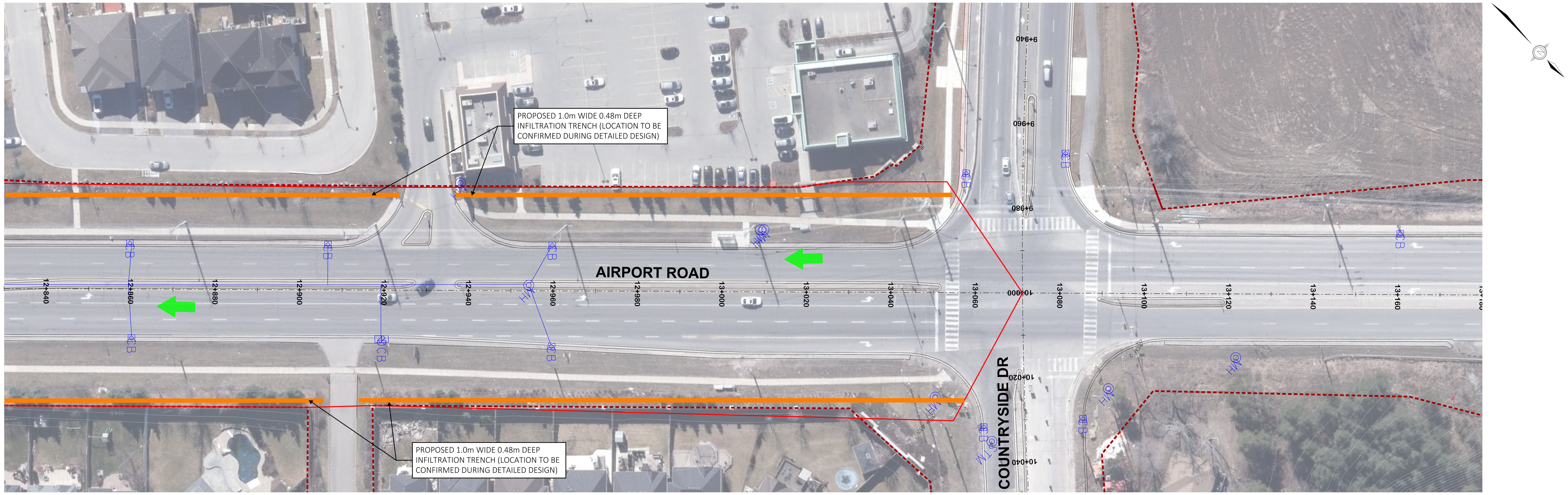
HDR

Region of Peel
Working for you

AIRPORT ROAD
(BRAYDON BLVD./STONECREST DR. TO COUNTRYSIDE DR.)
ENVIROMENTAL ASSESMENT
DRAINAGE PLAN
STA. 12+130 TO 12+830

SHEET NO.
DRG002

APRIL 2019



LEGEND:

- EXISTING R.O.W.
- WATERCOURSE
- CL EXISTING ALG
- CATCHMENT BOUNDARY
- A-X / xx Ha — DRAINAGE CATCHMENT I.D. AND AREA
- EXISTING STM SEWER
- OVERLAND FLOW DIRECTION
- PROPOSED IMPROVEMENTS
- EXISTING CATCHBASIN
- EXISTING MANHOLE
- STORM SEWER SYSTEM CONNECTION
- PROPOSED INFILTRATION TRENCH

HDR

Region of Peel
Working for you

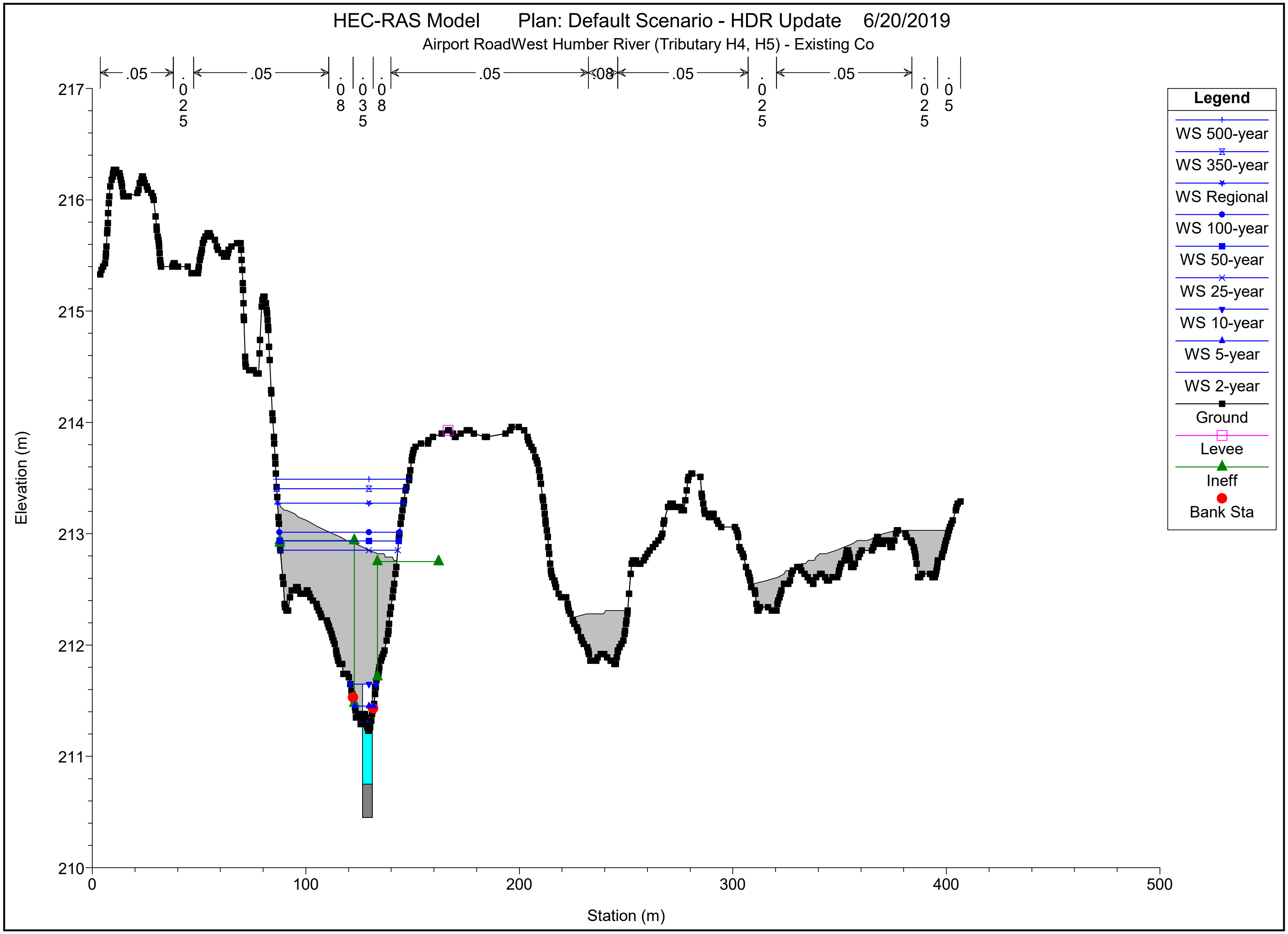
AIRPORT ROAD
(BRAYDON BLVD./STONECREST DR. TO COUNTRYSIDE DR.)
ENVIROMENTAL ASSESMENT
DRAINAGE PLAN
STA. 12+830 TO 13+055

SHEET NO.
DRG003

APRIL 2019

Appendix B: Hydraulic Model Output File

Site 1: Tributary B (also known as TribC in the TRCA HEC-RAS model)

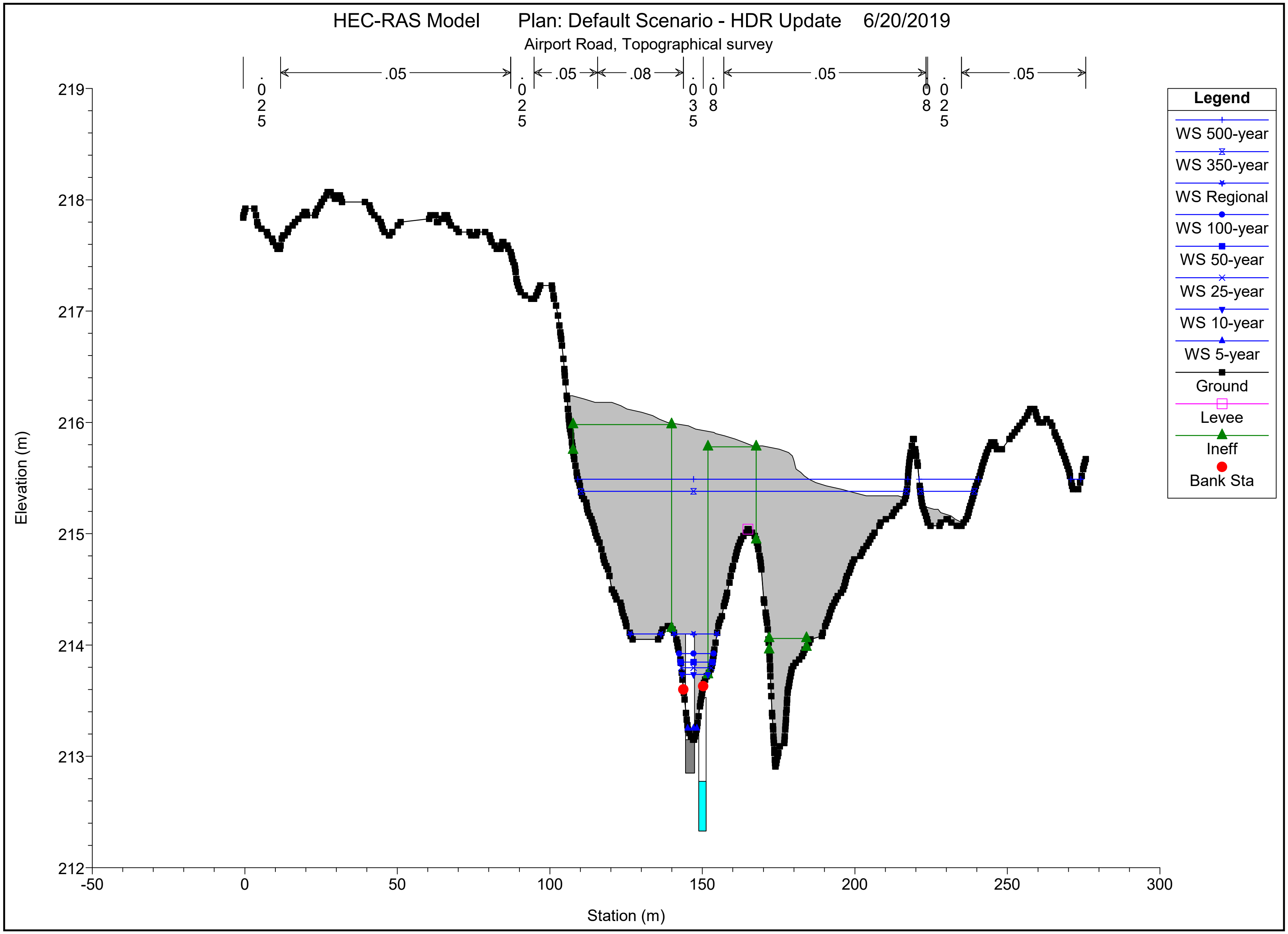


HEC-RAS Model Plan: Default Scenario - HDR Update 6/20/2019
Airport RoadWest Humber River (Tributary H4, H5) - Existing Co
.05
.025
.05
.08
.035
.08
.05
.08
.05
.025
.05
.025
.05
Elevation (m)
Station (m)
Legend
WS 500-year
WS 350-year
WS Regional
WS 100-year
WS 50-year
WS 25-year
WS 10-year
WS 5-year
WS 2-year
Ground
Levee
Ineff
Bank Sta

HEC-RAS Plan: HDR Update Locations: User Defined

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Campbells TribC	Reach1	601.786 32.15-01	2-year	3.04	211.23	211.56	211.56	211.67	0.018976	1.48	2.11	10.74	0.98
Campbells TribC	Reach1	601.786 32.15-01	5-year	4.34	211.23	211.63	211.63	211.76	0.017082	1.65	2.75	11.74	0.97
Campbells TribC	Reach1	601.786 32.15-01	10-year	7.64	211.23	212.37	211.75	212.40	0.000716	0.78	10.81	37.36	0.24
Campbells TribC	Reach1	601.786 32.15-01	25-year	9.41	211.23	212.85	211.82	212.87	0.000236	0.58	22.47	55.00	0.15
Campbells TribC	Reach1	601.786 32.15-01	50-year	10.78	211.23	212.93	211.86	212.95	0.000254	0.62	24.16	55.68	0.16
Campbells TribC	Reach1	601.786 32.15-01	100-year	12.37	211.23	213.01	211.90	213.02	0.000116	0.43	53.55	56.32	0.11
Campbells TribC	Reach1	601.786 32.15-01	350-year	33.74	211.23	213.40	212.42	213.42	0.000320	0.83	76.38	60.56	0.18
Campbells TribC	Reach1	601.786 32.15-01	500-year	41.70	211.23	213.49	212.58	213.51	0.000407	0.96	81.59	62.23	0.21
Campbells TribC	Reach1	601.786 32.15-01	Regional	24.34	211.23	213.27	212.22	213.29	0.000226	0.66	68.62	58.93	0.15

Site 2: Tributary C (also known as TribB in the TRCA HEC-RAS model)



HEC-RAS Model
Plan: Default Scenario - HDR Update
6/20/2019
Airport Road, Topographical survey
.025
.05
.025
.05
.08
.035
.08
.05
.08
.025
.05
Legend
WS 500-year
WS 350-year
WS Regional
WS 100-year
WS 50-year
WS 25-year
WS 10-year
WS 5-year
Ground
Levee
Ineff
Bank Sta
Elevation (m)
219
218
217
216
215
214
213
212
Station (m)
-50
0
50
100
150
200
250
300

HEC-RAS Plan: HDR Update Locations: User Defined

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
Campbells TribB	Reach1	701.911 32.13-01	2-year	2.24	213.15	213.54	213.54	213.67	0.019232	1.56	1.43	5.71	1.00
Campbells TribB	Reach1	701.911 32.13-01	5-year	3.16	213.15	213.61	213.61	213.76	0.017965	1.68	1.88	6.43	0.99
Campbells TribB	Reach1	701.911 32.13-01	10-year	5.23	213.15	213.74	213.74	213.93	0.015574	1.96	2.76	8.53	0.97
Campbells TribB	Reach1	701.911 32.13-01	25-year	6.45	213.15	213.80	213.80	214.02	0.014880	2.09	3.27	9.81	0.97
Campbells TribB	Reach1	701.911 32.13-01	50-year	7.35	213.15	213.85	213.85	214.07	0.013581	2.14	3.72	10.42	0.95
Campbells TribB	Reach1	701.911 32.13-01	100-year	8.31	213.15	213.88	213.88	214.13	0.013808	2.25	4.04	10.81	0.96
Campbells TribB	Reach1	701.911 32.13-01	350-year	15.07	213.15	215.38	214.14	215.39	0.000073	0.39	74.52	124.59	0.09
Campbells TribB	Reach1	701.911 32.13-01	500-year	18.93	213.15	215.49	214.28	215.49	0.000085	0.44	83.28	130.93	0.09
Campbells TribB	Reach1	701.911 32.13-01	Regional	10.59	213.15	214.98	213.97	215.01	0.000443	0.83	16.62	48.16	0.21

Appendix C: LID Screening

LID Options Feasibility Screening (Stage 1)

Options (Urban Reconstruction of Major Arterial Rd)	Suitable Outlet/ Overflow	Elevation Constraints	Available Area	Source of Stormwater	Grondwater/ Bedrock	Conflict with Utilities[1]	Road Structure	Sight-lines and Safety	Drainage Function	Aquatic Environment	Cost	OVERALL
Median Bioretention	Feasible	Not feasible	Feasible	Not feasible	Feasible	Feasible	Feasible	Feasible	Not feasible	Feasible	Feasible (moderate)	**Not feasible**
Boulevard Bioretention	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Not feasible	Not feasible	Feasible	Feasible (moderate)	**Not feasible**
Bioswale	Not feasible	Not feasible	Not feasible	Not feasible	Feasible	Feasible	Not feasible	Feasible	Not feasible	Feasible	Feasible (moderate)	**Not feasible**
Perforated Pipe / Soakaway (median)	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Not Feasible	Feasible	Not Feasible (very high)	**Not feasible**
Perforated Pipe / Soakaway (boulevard)	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible (moderate)	**Feasible**
Permeable Pavement (median)	Feasible	Not feasible	Feasible	Not feasible	Feasible	Feasible	Feasible	Feasible	Not feasible	Feasible	Feasible (moderate)	**Feasible[3]**
Permeable Pavement (sidewalk)	Feasible	Not feasible	Feasible	Not feasible	Feasible	Feasible	Feasible	Feasible	Not feasible	Feasible	Not feasible (very high)	**Not feasible**
Prefabricated Modules[2]	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Feasible	Not feasible (high)	**Not feasible**

Note 1: Utility conflicts are present (relocations required)

Note 2: Can be integrated with other options

Note 3: Proposed a measure to reduce impervious area

Table 9 – Recommended Feasibility Screening Criteria

Criteria	Description
Suitable Outlet/ Overflow	Ability of the proposed LID option to discharge to a suitable outlet or overflow (stormsewer or watercourse) based on capacity, elevations and additional structure requirements.
Elevation/ Grading Constraints	Ability of the proposed LID option to be integrated with the constructed/ proposed grades without the need for significant roadway alteration. Includes all surface and sub-surface infrastructure.
Available Area	Ability of the proposed LID option to be constructed with the available area.
Source of Stormwater	Ability of the proposed LID option to accept stormwater at surface or below grade given the constructed/ proposed roadway designs (top of pavement).
Groundwater	Ability for the invert of the proposed infiltration based LID option to be located a minimum of 0.5-1m above the seasonally high groundwater elevation based on the borehole logs and groundwater monitoring well (piezometer).
Bedrock	Ability for the invert of the proposed infiltration based LID option to be located a minimum of 0.5-1m above the local bedrock elevations.
Conflicts with Utilities	Ability of the proposed LID option to integrate within the constructed/ proposed roadway designs without conflicts to existing or proposed utilities. **Note:** at the feasibility screening stage, the criteria are limited to conflicts which cannot be mitigated in design and would require relocations or present an unacceptable risk. Includes impacts to existing or proposed sanitary sewers, water mains, electrical lines including signalization and surface walkways/pathways.
Road Structure	Ability of the proposed LID option to be integrated into the constructed/ proposed roadway designs without compromising the road structure including sub-base soils, aggregate base and roadway surface. Long-term design-life must also not be compromised. **Note:** Criteria includes reduction in load bearing capacity, reduced cross-sectional stiffness due to saturation effects or reductions in layer thicknesses.
Sight-lines and Safety	Ability of the proposed LID option to be integrated into the constructed/ proposed roadway designs without compromising vehicle sight-lines or user safety. Safety criteria include the ability of the LID system to meet H20 loading for areas within 1.0m of the roadway edge, LID location within the roadway and height/location of proposed vegetation.
Drainage Function	Ability of the proposed LID option to be integrated into the constructed/ proposed roadway designs without compromising the drainage system design or capacity. Criteria includes impacts related to transferring drainage from adjacent but previously separate drainage areas, reduced pipe/outlet capacity, risk of ponding on the roadway surface and storm sewer surcharging.
Aquatic Environment	Ability of the proposed LID option to comply with Federal, Provincial and Agency policy relating to sensitive, endangered or threatened aquatic species within local waterways or downstream of proposed or existing outlets locations as well as in-stream water quality and or discharge requirements.
Cost Effectiveness*	Relative cost of the proposed LID options. Criteria includes the screening of the options which present an unacceptably high construction costs based on the requirement for structural reinforcements, excessive infrastructure and or excavation or a high degree of disturbance to the built environment including the constructed roadway surface.

* Estimated costs are a high level, 'Class C' cost estimate

Table 4.3.9: LID options for the major arterial road

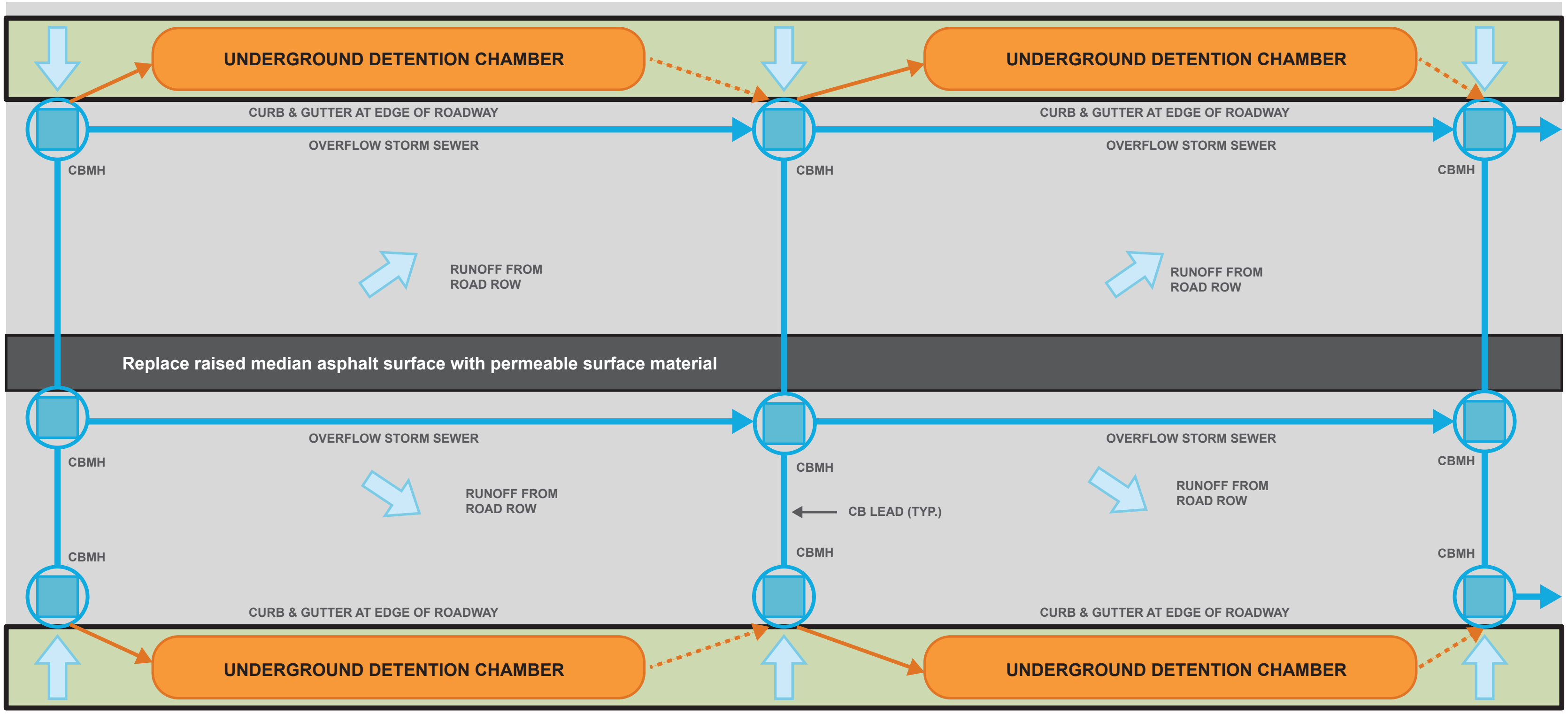
ROW Construction Type	Bioretention Planter	Curb Extension	Boulevard Bioretention	Bioswale	Enhanced Grass Swales	Perforated Pipe	Permeable Pavement (sidewalk)	Prefabricated Modules
Rural Resurfacing	○	○	◎	◎	●	◎	◎	◎
Rural Reconstruction	○	○	◎	◎	●	◎	◎	◎
Rural to Urban Reconstruction	○	○	◎	◎	○	●	●	●
Urban Resurfacing	○	○	◎	◎	○	◎	◎	●
Urban Reconstruction	●	○	◎	◎	○	●	●	●
Urban Reduction	●	○	◎	◎	○	●	◎	●

○ Unlikely Option ◎ Possible Option ● Common Option

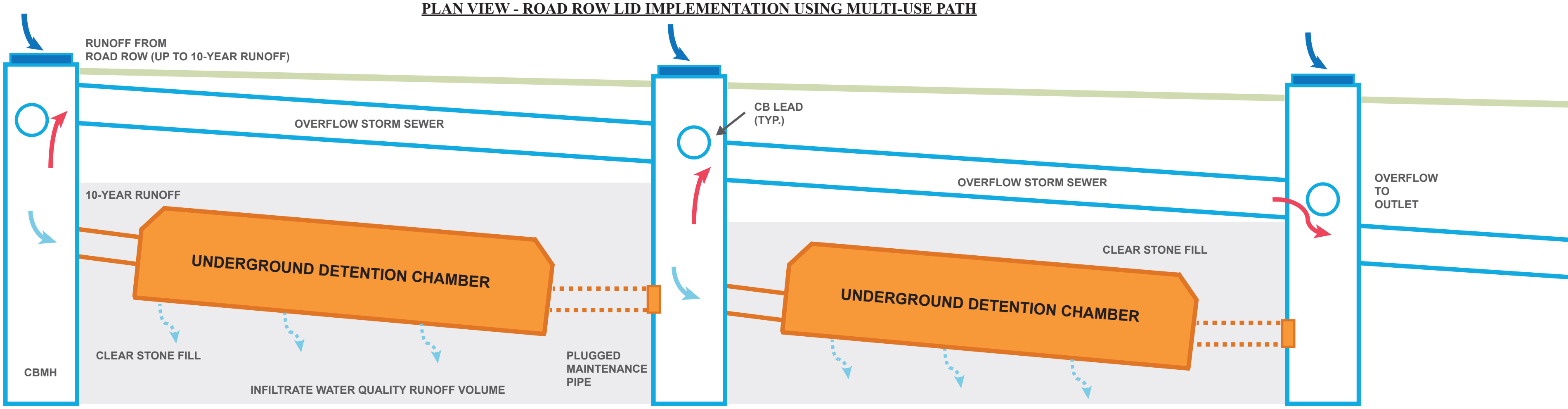
Figure 4.3.29

Appendix D: Infiltration Trench Schematic

SCHEMATIC OF LINEAR LID FEATURE (UNDERGROUND DETENTION) - FIGURE NOT TO SCALE



PLAN VIEW - ROAD ROW LID IMPLEMENTATION USING MULTI-USE PATH



PROFILE VIEW - SUB-SURFACE INFRASTRUCTURE

Appendix E: SWM Calculations

Stormwater Management Calculations

Project	AIRPORT RD CLASS EA	No.	--	
By	S. Kashi	Date	28-Apr-21	Page
Checked	A. Reitmeier	Checked	--	

PAVEMENT AREA ANALYSIS

Drainage Area ID	From Station	To Station	Segment Length (m)	Exaiting Drainage Area (ha)	Proposed Drainage Area (ha)	Existing Pavement Width (m)	Existing Pavement Area (ha)	Proposed Pavement Width (m)	Proposed Pavement Area (ha)	Increased Pavement Area (ha)	Percent Increase	Discharge Location (Station Number)
A1	11+507	11+707	200	1.11	1.11	26.7	0.59	31.00	0.67	0.08	14%	11+480
A2	11+707	12+006	299	1.48	1.48	26.7	0.85	31.00	1.02	0.17	20%	11+800
A3	12+006	12+255	249	1.23	1.23	26.7	0.70	31.00	0.86	0.16	23%	12+000
A4	12+255	13+055	800	4.20	4.20	26.7	2.44	31.00	2.95	0.51	21%	12+240
Total				**8.02**	**8.02**		**4.58**		**5.50**	**0.92**	**20%**	

Stormwater Management Calculations

Project	AIRPORT RD CLASS EA	AIRPORT RD CLASS EA	--		
By	S. Kashi	Date	28-Apr-21	Page	
Checked	A. Reitmeier	Checked	--		

QUALITY CONTROL REQUIREMENT CALCULATION

Drainage Area ID	Drainage Area (ha)	Existing			Proposed			Treated Pavement Area (ha)	Req. W.Q. Volume[1] (m^3)	Req. Water Balance Storage[3] (m^3)	Total Required Storage (m^3)	Req. Infiltration Trench Area[2] (m^2)	Req. Infiltration Trench Length (m)	Proposed Infiltration Trench Length (m)	Proposed Storage Volume (m^3)	Discharge Location
		Paved Area (ha)	% Impervious	Req. Volume (m^3)	Paved Area (ha)	% Impervious	Req. Volume (m^3)									
A1	1.11	0.59	53.2%	17.74	0.67	60.4%	21.60	-	4	22	22	-	-	-	-	Storm sewer along Braydon Blvd.
A2	1.48	0.85	57.4%	26.65	1.02	68.9%	35.51	1.02	36	48	48	510	510	510	98	Tibutary B
A3	1.23	0.70	56.9%	21.83	0.86	69.9%	30.20	0.86	30	45	45	430	430	430	83	Tibutary B
A4	4.20	2.44	58.1%	76.98	2.95	70.2%	103.87	2.95	104	143	143	1475	1475	1475	283	Tibutary C
Total	**8.02**	**4.58**	**57%**		**5.50**	**69%**		**4.83**	**170**	**258**	**258**	**2415**	**2415**	**2415**	**464**	

[1] From Table 3.2 of MOE SWM Planning and Design Manual (2003)

[2] 5% of the contributing pavemen area

[3] Based on 28 mm retention of runoff from increased pavement area

MOE Table 3.2

Impervious Level (%)	W.Q. Storage Volume* (m^3/ha)
35%	25
55%	30
70%	35
85%	40

* Based on infiltration

Infiltration Trench Dimensions

Hydraulic Conductivity =	1.01E-06 cm/s
Infiltration Rate, i =	12 mm/hr
Safety Factor =	3
Infilt. with Safety Factor =	4.0 mm/hr
d_p =	0 mm
t_s =	48 hr
V_r =	0.4
$d_{r\ max}$ =	481 mm
d_r =	0.48 m
Width =	1 m

LID SWM GUIDE Table C1

Kfs cm/s	T min/cm	1/T mm/hr
0.1	2	300
0.01	4	150
0.001	8	75
0.0001	12	50
0.00001	20	30
0.000001	50	12

Project	Airport Rd. EA	No.	
By	S. Kashi	Date	28-Apr-2021
Checked	A. Reitmeier		

Stormwater Management Calculations

WATER BALANCE CALCULATIONS

Site Chracteristics		
Site Area	5.5	ha

Retention Requirements		
rainfall/year (source:Canadian Climate Normals 1971-2000 Lester B. Pearson	661.6	mm/yr
Retain depth of	8.4	mm
% annual rain	63%	
Site requirement	22793.4	m^3/yr

Tabular Format of WWFMG - Figure 1A

% of Total Average Annual Rainfall Depth

Rainfall (mm)	% Annual
0	0
2.5	30
5	47
10	70
15	82
20	90
25	94
30	97
35	99
40	100

Airport Rd Class EA

STORM SEWER DESIGN

Q=0.0028*C*I*A (cms)
C : RUNOFF COEFFICIENT
I : RAINFALL INTENSITY [City of Brampton]
I = A / Tc ^ B For 10 Yr: A = 35.1
A : AREA (ha) B = -0.695

STREETS / AREA No.	MAINTENANCE HOLE FROM	MAINTENANCE HOLE TO	LENGTH (m)	INCREMENT C	INCREMENT A	INCREMENT C A	TOTAL C A	FLOW TIME (min) TO	FLOW TIME (min) IN	I (mm/h)	TOTAL Q (cms)	S (%)	D (mm)	Q FULL (cms)	V FULL (m/s)	Sec. Time (sec)	Accum. Time (sec)
Area 1	Ex Stm	Ex Stm	118.00	0.64	1.1100	0.7104	0.7104	15.99	1.65	87.97	0.1750	0.30	600	0.336	1.19	1.65	17.65
Area 2	71B	Trib B	3.00	0.70	1.4800	1.0360	1.0360	18.23	0.05	80.32	0.2330	0.30	525	0.236	1.09	0.05	18.28
Area 3	89	Trib B	7.00	0.70	1.2300	0.8610	0.8610	17.54	0.08	82.52	0.1989	0.71	450	0.240	1.51	0.08	17.62
Area 4	103	Trib C	4.00	0.71	4.2000	2.9820	2.9820	19.83	0.03	75.77	0.6326	1.50	525	0.527	2.43	0.03	19.86