APPENDIX

I

STORMWATER MANAGEMENT AND DRAINAGE REPORT

City of Brampton

East-West Connection Mount Pleasant Go Station to West of Mississauga Road (Lagerfeld Drive), Municipal Class EA

Stormwater Management and Drainage Report

July 03, 2020

FINAL - Rev 1

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Stormwater Management and Drainage Report

City of Brampton

FINAL - Rev 1

Project No.: 141-15409-00
Date: July 03, 2020

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July 03, 2020

FINAL - Rev 1

City of Brampton
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Attention: Mario Goolsarran, Project Manager

Dear Mr. Goolsarran:

Subject: East-West Connection Mount Pleasant Go Station to West of Mississauga Road (Lagerfeld Drive), Municipal Class EA

We are pleased to submit the Final – Rev. 1 Stormwater Management and Drainage Report for the East-West Connection Mount Pleasant Go Station to West of Mississauga Road (Lagerfeld Drive), Municipal Class EA. This report documents the preliminary drainage and stormwater conceptual design associated with the proposed road extension.

We trust the submission of this document meets your requirements. Should you have any comments we look forward to your response.

Yours sincerely,

Sherif Iskandar, M.Sc., P.Eng., PMP
Project Manager, Water Resources

SI/RZ
Encl

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Revision History

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Date

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1 INTRODUCTION

1.1 Scope

WSP Canada Inc. (WSP) was retained by the City of Brampton (the City) to provide a drainage and stormwater management plan for the proposed East-West Connection Mount Pleasant Go Station to West of Mississauga Road (Lagerfeld Drive), Municipal Class EA Study in Brampton, Ontario. This report applies to the proposed drainage area for this road expansion. The drainage conditions for the subject site under existing conditions as well as under the proposed development conditions are summarized in this report. Additionally, this report summarizes the different measures that will be considered to address erosion control, water quantity control, quality treatment, and water balance associated with the proposed road extension.

1.2 Site Location

The proposed East-West Connection Lagerfeld Drive will be located from approximately 700 m west of Mississauga Road to the existing limit of Lagerfeld Drive, between the CN Rail to the north and Bovaird Drive West to the south. See **Figure 1-1** for illustration. The site will cross over the TransCanada Pipeline and Huttonville Creek. The site covers a total drainage area of 4.78 hectares, divided into four catchment areas (A, B, C, D) with associated outlets.

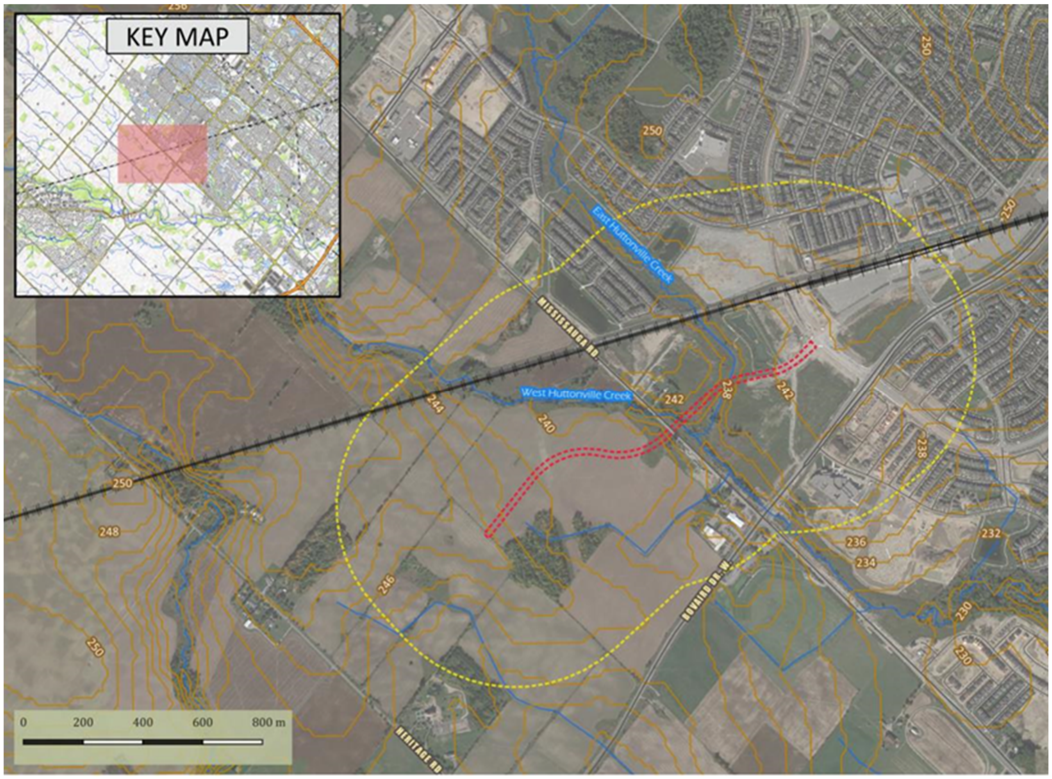


Figure 1-1: Approximate Study Limits

1.3 Stormwater Management Design Criteria

All new development within the City of Brampton must adhere to stormwater management criteria from the City as well as the local conservation authority - for this site Credit Valley Conservation (CVC). Criteria which must be met to obtain approval from these authorities is summarized in **Sections 1.3.1** and **1.3.2** below.

1.3.1 Credit Valley Conservation (CVC)

The CVC document “Stormwater Management Criteria” (August 2012) includes stormwater management criteria that new development must adhere to within CVC regulated areas. This site is within the Huttonville Creek Subwatershed area, and specific criteria applicable to this watershed is summarized below:

- **Erosion Control:** a minimum on-site retention of 5 mm is required for road drainage that does not discharge to a SWM pond. For sites with stormwater management (SWM) ponds, 25 mm – 48 hr detention is required.
- **Quantity (Flood) Control:** Control post-development peak flows to pre-development levels for all return period storms (i.e. 2, 5, 10, 25, 50 & 100-year).

— **Quality Control:** Enhanced Level of Protection (80% TSS removal) as per the latest MOE SWMPD Manual is required.
— **Water Balance:** Endeavor to match pre-development proportions of infiltration, runoff, and evapotranspiration on an average annual basis.

1.3.2 City of Brampton Criteria

Stormwater management criteria for the City of Brampton is included in the City of Brampton Subdivision Design Manual (December 2008). This document details standards for stormwater conveyance design, and stormwater management facilities design, however, stormwater management criteria is specified through area specific master plans or the conservation authority. The specific criteria applicable for the major and minor systems is summarized below:

— The major stormwater system must be designed to accommodate runoff exceeding the capacity of the minor system for the flows up to the 100-year return frequency. Major overland flow must be contained within the road allowance and walkways only.
— The maximum water depth for the overland flow shall be the lesser of 0.3 m from the gutter or the water level up to the right-of-way limit.
— The storm sewer system should use a 10-year return storm design plus adequate provision for continuous overland drainage of roads.
— Catch basin spacing is as follows:

≥ 10 m pavement	≤ 4.5% slope	75 m
	> 4.5% slope	60 m
< 10 m pavement	≤ 4.5% slope	90 m
	> 4.5% slope	75 m

This document has equal or less stringent requirements than the CVC document outlines in Section 1.3.1; therefore, the CVC document criteria govern.

2 PRE-DEVELOPMENT CONDITIONS

2.1 General

Under existing conditions, the right-of-way (ROW) lands consist primarily of vacant land and farmland. The grades within the ROW generally slope gently towards Huttonville Creek, a tributary of Huttonville Creek east of Mississauga Road, and a Provincially Significant Wetland (PSW) which outlets to a separate tributary of Huttonville Creek west of Mississauga Road. Huttonville Creek and the tributary of Huttonville Creek east of Mississauga Road both cross the ROW boundaries, and the PSW outleting to the tributary of Huttonville Creek west of Mississauga Road located just south of the site ROW.

Surficial soils within the ROW consist of hydrologic soil group type C soils (clay loam). These soils consist of fine grain sizes which are not conducive to rainfall abstraction and will generally contribute to larger runoff volumes than type A or B soils.

The existing condition and drainage boundaries is included in **Appendix A-1 Exhibit 1**.

2.2 Geological and Hydrogeological Investigations: Potential for Infiltration

Geological and hydrogeological investigations were undertaken for the ROW by WSP and summarized in a report dated October 2018. From the hydraulic conductivity testing, native soils range from 2.9×10^{-7} cm/s to 1.5×10^{-4} cm/s. These hydraulic conductivities correlate to infiltration rates of 10 mm/hr to 50 mm/hr based on the TRCA SWM Guide Appendix C, Table C2 and Figure C11. For infiltration on the site in areas with native design infiltration rates less than 15 mm/hr, an overflow / underdrain will be required to remove excess volume that cannot drain within 48 hours. Note that design infiltration rates are determined by applying a safety factor to the measured infiltration rates, ranging from 2.5 to 8.5 depending on the difference in soil layers below an infiltration practice.

As part of the same report, the water table has been measured. Although it is recommended that further groundwater monitoring be undertaken to inform detailed design, the depth to groundwater measured in July 2018 ranges from 1.08 m to 2.58 m. As the month of July is considered to be a dry month, it is recommended to measure groundwater depths during March / April months as it is considered to be seasonably high. Based on the alternative profiles of the proposed roadway, the design grades will raise the ground surface which will increase the distance between grade and groundwater. As infiltration practices require a 1 m clearance from the seasonably high groundwater table, there may be sections of the site where infiltration may not be feasible.

3 DRAINAGE EVALUATION OF THE ROAD DIFFERENT ALIGNMENTS

3.1 Conceptual Road Alignments

A series of conceptual road alignments were developed for the preferred solution at a preliminary level of detail to properly assess the potential impacts and benefits associated with each alignment. Five alignments were generated as shown in the attached figures in **Appendix A-2**.

The conceptual road alignments that were developed and evaluated are described in **Table 3-1** below. It must be noted that under each of the conceptual road alignments 1, 3 and 4, two alternative creek crossings (A and B) were investigated with different bridge spans and overall bridge widths.

Table 3-1: Description of Conceptual Road Alignments

Alignment Design Concepts	Description
Alignment 1	Continuation of the existing Mount Pleasant GO Station access road to lands west of Mississauga Road. Alignment to past through Mississauga Road at 419 m offset from Bovaird Drive centreline.
Alignment 2	Continuation of the existing Mount Pleasant GO Station access road to lands west of Mississauga Road. Alignment to past through Mississauga Road at approximately 240 m offset from Bovaird Drive centreline.
Alignment 3	Continuation of the existing Mount Pleasant GO Station access road to lands west of Mississauga Road. Alignment to past through Mississauga Road at the proposed Huttonville Creek bridge location, at a 70° angle, approximately 473 m offset from Bovaird Drive centreline.
Alignment 4	Continuation of the existing Mount Pleasant GO Station access road to lands west of Mississauga Road. Alignment does not intersect with Mississauga Road but utilize proposed slip road north of Huttonville Creek crossing, just south of CN Rail.
Alignment 5	Not connecting Mississauga Road with Mount Pleasant GO Station. East-West connection will start at Mississauga Road, extending to the west, at 419 m offset from Bovaird Drive centreline.

As requested by CVC, WSP was instructed by the City of Brampton Project Manager to complete a HEC-RAS preliminary hydraulic analysis and floodplain assessment for the full range of road alignments. At early stages of the study, Alignments 4 and 5 were considered not feasible and were excluded from the evaluation process. WSP's drainage team completed hydraulic analysis and floodplain evaluation to assess the potential negative impacts that may result from the potential creek crossings (bridges) under Alignments 1 (a and b), 2 and 3 (a and b).

Configurations of the bridge crossings that were considered are as follows:

— **Crossing 1A East:** with 3 spans (22 m, 22 m and 33 m clear opening widths) and the minimum soffit elevation at 239.36 m.
— **Crossing 1B East:** with 1 span of 33 m clear opening width and the minimum soffit elevation at 239.36 m.
— **Crossing 1A West:** with 2 spans (29 m and 22 m clear opening widths) and the minimum soffit elevation at 240.52 m.
— **Crossing 2:** with 2 spans (36 m and 27 m clear opening widths) and the minimum soffit elevation at 237.32 m.
— **Crossing 3A East:** with 3 spans (24 m, 30 m and 24 m clear opening widths) and the minimum soffit elevation at 240.67 m.
— **Crossing 3B East:** with 1 span of 26 m clear opening width and the minimum soffit elevation at 239.95 m.
— **Crossing 3A West:** with 2 spans (35 m and 35 m clear opening widths) and the minimum soffit elevation at 240.20 m.

3.2 Drainage Evaluation of Different Alignments

As indicated above, drainage evaluation was undertaken for Alternatives 1, 2 and 3 at a high-level using the following criteria:

— Potential increase in flooding risk in the creeks
— Potential to increase stormwater run-off (water quantity)
— Increase in pollutants to receiving watercourses (water quality)
— Flooding and Erosion Hazards

HEC-RAS hydraulic models were obtained from CVC and updated to reflect existing conditions at each alignment. During the project meeting dated September 8, 2017, CVC requested that WSP staff combine the two existing hydraulic models (the Heritage Heights model and the East Huttonville Creek model) into one hydraulic model and update the Bovaird Drive Structure in this model. Also, it was requested that new cross-sections be cut and coded in the East Huttonville Creek using the available contour maps and survey information to update the existing model. The proposed creek crossings were coded in the model using the preliminary General Arrangement drawings of each water crossing. CVC also recommended that the existing Mississauga Road Crossing be maintained in the existing model. The model will then be considered as "Updated Existing Condition Model". The following summarizes the updates that WSP staff applied and agreed by CVC to create the Existing Updated Model:

- Added junction 8 to combine Huttonville Creek and East Huttonville Creek reaches
- Updated cross-sections 4, 5, 6, 7 and 8 on East Huttonville Creek (HV4-2) as they were not georeferenced
- Added cross-sections 480 and 490 in Reach HV3-1 to be bounding cross-sections for Alignment 1A-West
- Added levees for cross-sections adjacent to Mississauga Road to reflect the retaining wall on the east side of Mississauga Road and coded the Mississauga Road in cross-sections located east of Mississauga Road.

CVC reviewed the original model updates as recommended by WSP to reflect existing conditions. CVC also, recommended that WSP use the existing 5 m span bridge at Mississauga Road crossing and not the 60% designed bridge. The model was then saved as "*Updated Existing Condition Model*" and used for comparison purposes and to assess impacts of different road alternatives. More details of the updates that were applied to the original HEC-RAS model is included in **Appendix B**.

Different creek crossing bridges were coded in the HEC-RAS model and compared to the "*Updated Existing Condition Model*". The creek crossings that were coded can be summarized as follows:

<u>Alignment 1A:</u> Under Alignment 1A, two water crossings are proposed:

- Crossing 1A-East is located on East Huttonville Creek (HV4-2) between cross-sections 5 and 6
- Crossing 1-West is located on Huttonville Creek (HV3-1) between cross-sections 490 and 480

<u>Alignment 1B:</u> Under Alignment 1B, two water crossings are proposed:

- Crossing 1B-East is located on East Huttonville Creek (HV4-2) between cross-sections 5 and 6

- Crossing 1-West is located on Huttonville Creek (HV3-1) between cross-sections 490 and 480

Alignment 2: Under Alignment 2, there is only one proposed water crossing located on Huttonville Creek (HV5-1) between cross-sections 245.7111 and 193.3116

Alignment 3A: Under Alignment 3A, two water crossings are proposed:

- Crossing 3A-East is located on East Huttonville Creek (HV4-2) between cross-sections 5 and 6
- Crossing 3-West is on Huttonville Creek (HV3-1) between cross-sections 519.2031 and 496.1559. This crossing is located at the existing Mississauga Road crossing but with different skew angle

Alignment 3B: Under Alignment 3B, two water crossings are proposed:

- Crossing 3B-East is located on East Huttonville Creek (HV4-2) between cross-sections 5 and 6
- Crossing 3-West is on Huttonville Creek (HV3-1) between cross-sections 519.2031 and 496.1559. This crossing is located at the existing Mississauga Road crossing but with different skew angle

3.3 Floodline Delineation and Impact Assessment

WSP completed and submitted a “Floodplain Assessment under Different Alignments” Memo (included in **Appendix B**) that summarized drainage impacts (changes in water surface elevations and flow velocities) resulting from different creek crossings when compared with existing conditions.

Tables 3-2 to 3-8 present the change in water surface elevations resulting from the proposed water crossings under Alignments 1, 2 and 3 under both the 100-Year and the Regional storm events.

Table 3-2: Flood Elevation Comparison under Crossing 1A East

River	Reach	River Station	100 Year Water Surface Elevation		Regional Water Surface Elevation	
			Existing	Crossing 1A East	Existing	Crossing 1A East
HV4	2	8	240.07	240.04	240.35	240.31
HV4	2	7	239.38	239.43	239.61	239.71
HV4	2	6	239.08	239.35	239.35	239.62
HV4	2	5	238.25	238.25	238.41	238.47
HV4	2	4	237.09	237.09	237.33	237.33

Table 3-3: Flood Elevation Comparison under Crossing 1B East

River	Reach	River Station	100 Year Water Surface Elevation		Regional Water Surface Elevation	
			Existing	Crossing 1B East	Existing	Crossing 1B East
HV4	2	8	240.07	240.06	240.35	240.31
HV4	2	7	239.38	239.39	239.61	239.70
HV4	2	6	239.08	239.28	239.35	239.58
HV4	2	5	238.25	238.25	238.41	238.53
HV4	2	4	237.09	237.09	237.33	237.33

Table 3-4: Flood Elevation Comparison under Crossing 1A West

River	Reach	River Station	100 Year Water Surface Elevation		Regional Water Surface Elevation	
			Existing	Crossing 1A West	Existing	Crossing 1A West
HV3	1	519.2031	240.61	240.65	242.70	242.68
HV3	1	496.1559	238.69	238.73	238.96	238.99
HV3	1	490	238.35	238.13	238.70	238.39
HV3	1	480	237.67	237.66	237.81	237.81
HV3	1	331.0246	237.19	237.19	237.38	237.38

Table 3-5: Flood Elevation Comparison under Crossing 2

River	Reach	River Station	100 Year Water Surface Elevation		Regional Water Surface Elevation	
			Existing	Crossing 2	Existing	Crossing 2
HV3	1	490	238.35	238.35	238.70	238.70
HV3	1	480	237.67	237.67	237.81	237.81
HV3	1	331.0246	237.19	237.19	237.38	237.45
HV5	1	245.7111	236.61	236.67	237.03	237.08
HV5	1	193.3116	236.68	236.41	236.94	236.93

Table 3-6: Flood Elevation Comparison under Crossing 3A East

River	Reach	River Station	100 Year Water Surface Elevation		Regional Water Surface Elevation	
			Existing	Crossing 3A East	Existing	Crossing 3A East
HV4	2	8	240.07	240.07	240.35	240.34
HV4	2	7	239.38	239.38	239.61	239.62
HV4	2	6	239.08	239.09	239.35	239.29
HV4	2	5	238.25	238.25	238.41	238.48
HV4	2	4	237.09	237.09	237.33	237.33

Table 3-7: Flood Elevation Comparison under Crossing 3B East

River	Reach	River Station	100 Year Water Surface Elevation		Regional Water Surface Elevation	
			Existing	Crossing 3B East	Existing	Crossing 3B East
HV4	2	8	240.07	240.05	240.35	240.29
HV4	2	7	239.38	239.41	239.61	239.75
HV4	2	6	239.08	239.21	239.35	239.51
HV4	2	5	238.25	238.30	238.41	238.59
HV4	2	4	237.09	237.09	237.33	237.33

Table 3-8: Flood Elevation Comparison under Crossing 3A West

River	Reach	River Station	100 Year Water Surface Elevation		Regional Water Surface Elevation	
			Existing	Crossing 3A West	Existing	Crossing 3A West
HV3	1	856.9374	240.66	240.05	242.76	240.26
HV3	1	749.2748	240.66	239.35	242.76	239.49
HV3	1	710	240.66	238.88	242.76	239.11
HV3	1	519.2031	240.61	238.60	242.70	238.96
HV3	1	496.1559	238.69	238.53	238.96	238.90
HV3	1	490	238.35	238.35	238.70	239.70

It should be noted that under the Regional storm event, none of the road alignments are flooded and the proposed creek crossings have adequate capacity to fully convey the Regional flow without being overtopped. It should be noted as well that flood elevations at the Mississauga Road would not increase under any of the proposed creek crossings.

4 DRAINAGE AND STORMWATER MANAGEMENT OF THE PREFERRED ALIGNMENT

4.1 General

The ROW land under post-development conditions is divided into four drainage areas: A, B, C, and D with a total site area of 4.78 ha. It is primarily an impervious road surface with a sidewalk on either side and a grassed boulevard outside the sidewalk. This is an increase in imperviousness from existing conditions where the land cover was primarily vacant land and farmland. For the high-level analysis provided in this report, a typical cross-section has been applied to the entire length of each catchment for a conservative analyzed area of 4.78 ha.

Stormwater quality treatment, erosion control and water balance criteria set out in **Section 1.3** of this report can be met through the use of Low Impact Development (LID) measures, specifically bioretention or urban tree root support systems within the grassed boulevard. Typically, stormwater quantity control is required by CVC for development within this subwatershed as set out in **Section 1.3**. However, quantity controls are not required for this site as the proposed road extension will result in negligible impacts on flood elevations upstream and downstream of the site. In addition, it is not practical to implement stormwater management ponds for subcatchments A. B and C. This is due to the relatively small drainage catchment size (i.e., less than 5 ha) and limited space available for quantity control facilities. Detailed explanations are provided in **Section 4.6**.

Bioretention uses layers of different media to filter the runoff before being infiltrated into the subsoil or collected by the storm sewer. It shall be designed as per the *Low Impact Development Stormwater Management Planning and Design Guide* (2010) published by the Toronto and Region Conservation Authority and Credit Valley Conservation Authority. Bioretention can take many forms but is often vegetated at the surface level and can positively contribute to the overall site aesthetic. The total footprint of bioretention required for this site is approximately 255 m^2 as established in **Section 4.4.1** below.

Urban tree root support systems for stormwater management consist of proprietary products (such as Silva Cells, Cupolex Railto, ArborFlow, Filterra, etc.) that are specifically designed for stormwater management and tree growth. They utilize evapotranspiration, absorption and interception while filtering water before infiltration or collection for the storm sewer. The cells are modular and can be covered by different land uses including hardscaping. Each tree requires approximately 20 m^3 of soil to support it when sharing soil structures with additional trees. Assuming a comparable water quality volume to the bioretention estimate and a void ratio of 0.3, approximately 133 trees are required for this site.

4.2 Proposed Major and Minor System Road Runoff Scheme

Runoff not retained by the bioretention or urban tree root system will drain via an overflow system to the storm sewer system within the ROW. Section III Storm Drainage and Sewer Design of the City's Subdivision Design Manual outlines the general requirements for storm sewer design flows and pipe design. The guideline specifies that the design flow is to be calculated using the Rational Method equation. Runoff coefficients are to be selected from the table in Section III Subsection 4.

Runoff from Catchment A will be conveyed westerly through the future extension of Lagerfeld Drive not covered by this EA. Conveyance of external drainage may be required during the detailed design stage.

In the interim, 3 options have been proposed:

- Option A: Extending gravity pipe outlet from the west end of catchment A to 466.5 m south west to the nearest water course. OGS and/or CB Shield should be applied for quality control. Option A would require temporary easement (9.0 m wide strip for entire length) for the extended pipe outlet.
- Option B: Do not build road west of Trans Canada Pipeline until completion of the future planning process which includes the future development planning as well as future stormwater management requirements are known.
- Option C: Pump flow from the west end of catchment A to the sensitive wetland area. OGS and/or CB Shield should be applied for quality control. Salt management plan should be implemented for winter application (using less salt) or dilute the salt more – detailed salt management plan has to be based on sensitive wetland assessments conducted in detailed design. Options C (involving pumping) would require scheduled maintenance by the City.
- Option D: Pump flow from the west end of catchment A to the MH close the high point of Catchment B at Station 81+375 and then through sewer system of

catchment B to outlet. This would result in increase in sewer diameters of catchment B network. Options D (involving pumping) would require scheduled maintenance by the City.

Option C and D are not preferred due to the significant costs associated with pumping as well as additional maintenance efforts. Option A is considered as a preferred interim solution given all the information to date, should the road construction be required ahead of Heritage Heights block planning and development. Additional easement through properties as well as the preferred interim solution pipe alignments are identified in **Appendix A-1 Exhibit 8**. The interim design alternatives should be further evaluated and confirmed during detail design.

Runoff from Catchment B will outlet overland to Huttonville Creek upstream of the Mississauga Road crossing. Runoff from Catchment C will outlet to a tributary of Huttonville Creek, east of Mississauga Road, just upstream of where it joins to Huttonville Creek. Catchment D will outlet to an existing stormwater management pond located north of Lagerfeld Drive near the existing cul-de-sac to be extended, the existing pond drainage boundary drawing is included in **Appendix A-3** for reference. Major system flow will be conveyed overland to the proposed respective outlets where it has been designed for 100-year storm events. For runoff treatment, bioretention methods will be used prior to the storm sewer collection system. As bioretention does not fit within the ROW for the east portion of catchment B as well as the majority of catchment C due to conflict with the bridge approach slabs, OGS and CB Shield units can be added at the outlet of the storm sewers to provide a level of treatment for all runoff. **Appendix A-1 Exhibit 2** presents the proposed road runoff scheme, proposed drainage catchments and grading plan for storm sewers.

For the storm sewer design, the following parameters were used:

- The rainfall intensity is based on the Initial Time of Concentration (Tc) of 10 minutes.
- Manning's formula is used to determine the capacity of the storm sewers. The guideline recommends a Manning's n of 0.013 with 300 mm as the minimum pipe diameter for storm sewers. Using Manning's formula, preliminary storm sewers design was completed to meet the following criteria:
  - Maximum flow velocity of 4.5 m/s and minimum flow velocity of 0.75 m/s.
  - This storm sewer system will be sized to convey the 10-year storm event, with excess flows from larger events collecting at sags in the roadway.
  - As these sags will be located at natural outlet points, catch basins and storm sewers will be sized to capture the 100-year event for outlet at these sags.

The storm sewer design sheet is located in **Appendix C** and summarized in **Table 4-1**.

Table 4-1: Summary of Storm Sewer Design

Catchment Area ID	U/S MH	D/S MH	Length (m)	Size (mm)	Capacity (%)
A	1	2	60.4	300	60.1
A	2	3	100.0	450	51.1
A	3	4	68.4	525	65.2
B	5	6	74.7	375	41.0
B	6	7	75.0	450	47.5
B	7	8	53.1	450	61.3
B	8	9	75.7	525	56.0
B	9	10	62.9	525	67.2
C	11	12	57.6	300	62.7
C	12	13	50.3	450	52.3
D	14	15	61.3	300	70.0
D	15	Ex MH	62.9	450	65.0

4.3 Erosion Control

As stated in **Section 1.3**, a minimum on-site retention of 5 mm is required to meet the erosion control criteria for drainage that cannot be treated by a SWM pond. It is assumed that all landscaped areas will retain at least 5 mm of rainwater prior to runoff generation due to shallow depression storage and wetting, with consequent evaporation. Based on these assumptions, the total 5 mm volume to be retained on site has been determined as 119.78 m^3 in **Table 4-2** below and **Appendix C**. This can be achieved by infiltration beneath the bioretention or tree root support system, as well as through retention in the void space of the soil media in these systems (i.e. total storage void is 0.3, retention storage void is 0.2). **Section 4.4.1** has details on bioretention sizing for this site. Bioretention and tree root support systems sized for this site will require storage adequate to infiltrate the erosion volume calculated or have capacity within the 0.2 soil media void space to retain the full erosion volume.

Subcatchment D will discharge to an existing SWM pond, so erosion control requirement will be achieved through the pond.

Table 4-2: 5 mm Event Volume

Surface Type	Area (m^2)	Initial Abstraction (m)	Volume Abstracted (m^3)	5 mm Volume (m^3)	Erosion Control Volume Required (m^3)
Catchment A					
Impervious	5,982	0.000	0.00	29.91	29.91
Pervious	3,718	0.005	18.59	18.59	0.00
Catchment B					
Impervious	10,607	0.000	0.00	53.03	53.03
Pervious	6,593	0.005	32.97	32.97	0.00
Catchment C					
Impervious	5,797	0.000	0.00	28.98	28.98
Pervious	3,603	0.005	18.02	18.02	0.00
Catchment D					
Impervious	8,689	0.000	0.00	43.44	43.44
Pervious	2,811	0.005	14.06	14.06	0.00
Total	**47,800**	**-**	**83.63**	**239.00**	**155.37**

Note: Typical cross-sections has been applied to the entire length of each catchment for this analysis.

With a total erosion volume of 155.37 m^3 a minimum of 776.85 m^3 of soil media is required to store the volume within the 0.2 retention void space of the media.

4.4 Water Quality Control

Enhanced level water quality control (80% TSS removal) can be achieved by capturing and treating the 5 mm storm event. Water quality control is required for Catchments A, B, and C only. Catchment D will achieve the water quality criterion using the existing stormwater management (SWM) pond to the north. Details of this pond area are available in the Mattamy (Credit River) Limited Phase 1 SWM Report and FSR and accompanying drawings in **Appendix A-3**. From the February 26, 2013 memo subject “Hydrologic Verification of SWM Facility HE-6B, City of Brampton” prepared by AMEC, it states that subcatchments 723 and 756 (and others) will be treated for extended detention. As per the drainage plan from this memo, subcatchments 723 and 756 include the proposed Lagerfeld Drive extension area.

Over Catchments A, B, and C, a 5 mm rainfall, less initial abstraction outlined in **Table 4-2**, is equivalent to a volume of 239.0 m^3.

This can be achieved by filtration and infiltration through the bioretention or urban tree root support systems. These measures may be combined with one or more pre-treatment measures to achieve the desired water quality.

4.4.1 Bioretention Preliminary Sizing

To achieve the water quality criterion, a bioretention system has been preliminarily sized. It consists of the layers and sizing described in the tables below. Detailed calculations are available in **Appendix D-2**, and a preliminary sketch of the road cross-section with bioretention is included in **Appendix A-1 Exhibit 3**.

Table 4-3: Bioretention Layers

Layer	Depth (mm)	Void Ratio	Unit Storage (mm)
Freeboard	150	0	0
Ponding	200	1	200
Mulch	100	0.7	70
Filter Media	600	0.3	180
Choking Layer	100	0.4	40
Clear Stone + Pipe	300	0.4	120
Total (mm)	**1450**	**-**	**610**
Total (m)	**1.45**	**-**	**0.61**

In order to achieve 0.2 m of ponding depth and 0.15 m of freeboard (for a total depth of 0.35 m above the soil media), bioswales should be sized to be approximately 3 m wide to allow for a 1 m wide bottom and 3:1 side slopes. With 3 m wide bioretention on either side of the roadway, the width is much greater than the minimum width as determined in **Table C6** in **Appendix D-2**. With a much wider bioretention unit sized, the design length of the bioretention units across the site can be reduced. Bioretention for the site can be broken into several separate units, and bioretention spacing shall be such that the system captures all site runoff, inlets meet the City of Brampton catch basin spacing requirements, and the capacity of the bioretention can capture the 5 mm event for quality control. Larger events that overtop the bioretention will be captured by catch basins located within the bioretention with grate elevation at the top of ponding elevation. These catch basins will outlet to the proposed storm sewer system within the roadway.

Table C6 in **Appendix D-2** outlines the bioretention sizing for volume storage calculations in detail. The percentage length of LID coverage column in the table corresponds to the estimate of percentage available areas in each catchment to place bioretention units. For example, in catchment A, bioretention units can be placed anywhere while comparing to catchment C, there is only very limited spots where bioretention units can be placed. The required footprint (m^2) equals the runoff to be treated (m^3) divide by the storage depth (m) assuming unit storage from **Appendix D-2 Table C6**. Runoff volume is the 5 mm generated volume over the entire catchment (m^3) subtracting the initial abstraction (m^3). The maximum bioretention length is the road length of LID coverage (m). As the bioretention units are offset from back of the curb by 0.5 m for snow storage, it is not anticipated that there will be any issues with pavement performance. However, geotechnical review should be performed as part of the detailed design. If the bioretention units are to be located adjacent to the pavement structure, special consideration should be taken by the geotechnical engineer.

From **Appendix D-2 Table C7**, the proposed roadway can be broken into subcatchments consistent with the City's catch basin spacing requirements (however, in this proposed alternative these will be bioretention inlets and not catch basins). From the City of Brampton storm sewer design standards, catch basin spacing shall be 75 m for road width greater than 10 m of pavement, and slope less than 4.5 %. With a width of 3 m and treating a length of roadway of 75 m, bioretention units can be separated into 9.5 m long sections along the roadway. Note that it is assumed each bioretention unit will treat runoff from half the roadway width and will be located on both sides of the road to capture runoff from the full roadway width. **Appendix A-1 Exhibit 3** shows a schematic of how the bioretention units are connecting to the storm sewer systems. **Appendix A-1 Exhibit 6** shows approximate bioretention spacing.

4.4.2 Urban Tree Root System Preliminary Sizing

An alternative to achieve the water quality criterion is using an urban tree root system. One proprietary system is Silva cells from Deeproot. Each tree requires approximately 20 m^3 of soil to support it when sharing soil structures with additional trees. Assuming a comparable water quality volume to the bioretention estimate and a void ratio of 0.3, 133 trees are required for this site. Detailed calculations are available in **Appendix D-2**, and a preliminary sketch of the road cross-section with an urban tree root support system is included in **Exhibit 7 Appendix A-2**. The urban tree root system is not the City of Brampton's preferred alternative based on the City's internal cost benefit analysis. As tree root support systems are proprietary bioretention units, the water quality volume to be treated will be the same amount used for regular bioretention units. The water quality volume (assuming a 0.3 void ratio in soil), number of trees required and associated calculations can be found in **Appendix D-2**.

4.4.3 Pre-Treatment Options

Many pre-treatment devices and concepts are currently available. Pre-treatment is considered as a best management practice at this moment while there is currently no criteria surrounding this. Some examples of available pre-treatment options include CB Shields (catch basin baffle), Oil and grit separator (OGS units) and level spreaders / inlet sumps.

CB Shield is a proprietary product that is inserted into catch basins to prevent the sediment in the sump of the catch basin from being scoured. CB Shield adds two small additional steps to regular catch basin maintenance as they need to be manually removed and replaced before and after maintenance respectively.

Level spreaders and inlet sumps are located where surface water enters the bioretention or urban tree root system. Level spreaders allow concentrated flows to collect in a trough, encouraging flows to spill over as sheet flow. This sheet flow reduces erosive velocities entering the system and allows for some sediment to settle out within the level spreader. Inlet sumps are similar as they also allow sediment to settle out before entering the treatment train facilities, but they are used at a point where the water enters the treatment train facilities directly rather than over a larger area.

OGS units allow the stormwater to enter through the inlet pipe(s) or inlet grate with a specially designed insert which slows the water down and directs it to a lower chamber. The non-turbulent chamber allows free oils and debris to rise, and sediment to settle. Free oils and other floatables remain trapped while other sediment settles and lies dormant while retained for later removal. Treated stormwater exists the unit via the outlet pipe and continue down the treatment train facilities.

Inlet sumps are recommended in the case of this EA; however, these pre-treatment options can be explored further during detailed design to determine a final selection.

4.5 Water Balance

An average annual water balance calculation has been undertaken to compare the post-development proportions of infiltration, runoff, and evapotranspiration of pre-development to post-development conditions. From **Table 4-4**, it can be seen that with no mitigation measures, the increase in imperviousness has resulted in less infiltration and evapotranspiration, and in greater runoff volumes. As the proposed stormwater management measures rely on either bioretention or urban tree root support systems, the effects of these measures on water balance can be assessed.

As approximately 90% of annual rainfall consists of events totalling 25 mm or less (water quality volume), the bioretention and tree root support measures capture approximately 90% of runoff on an average annual basis. Volume captured by the bioretention or urban tree root systems is infiltrated, retained in soil media, or overflows to the storm sewer in larger events. From **Table 4-4**, it can be seen that directing the impervious areas of the site to the bioretention or urban tree root systems results in a substantial reduction in runoff, and an increase in infiltration and evapotranspiration on an average annual basis. A more detailed analysis is included in **Appendix D-2**.

Table 4-4: Water Balance Analysis Summary

Site Conditions	Infiltration (m^3)	Evapotranspiration (m^3)	Runoff (m^3)
Pre-Development	8,060	21,786	12,089
Post-Development	2,816	10,340	28,779
Post-Development with Mitigation	34,399	(137)	7,673

4.6 Water Quantity Control

From **Section 1.3.1**, post development peak runoff flows are required to be controlled to pre-development conditions for all return period storms (i.e. 2-year to 100-year event). For this proposed site, Catchment D will drain to an existing stormwater management pond for quantity control, and Catchments A, B, and C will not be controlled. As discussed with CVC, the project area is relatively small compared to the overall watershed, and due to the challenges associated with quantity control storage within linear development, it has been agreed that no quantity control will be required for Catchments A, B, and C. In order to assess the impact of Catchments A, B, and C on the Huttonville Creek watershed, a VO5 model was created to estimate the peak runoff rate under the Regional storm event. The peak runoff rate for the Huttonville Creek watershed (taken from the HEC-RAS model provided by CVC) is 86.2 m^3/s, and the peak runoff rate for Catchments A, B and C is 0.47 m^3/s. As the site uncontrolled release rate accounts for 0.55% of the overall watershed, it was determined that the increase in impervious area of the Lagerfeld Drive extension will have no noticeable impact on downstream flood risks. The VO5 model output is included in **Appendix E**.

4.7 Outlet Erosion Control

High velocity flows discharged from storm sewer outfalls may cause erosion and scouring to the natural environment and degradation to watercourse banks. To mitigate the potential stream degradation, erosion protection measures will be provided at storm sewer outfalls for the Lagerfeld Drive extension to dissipate energy and encourage sheet flow. A typical measure is to install a plunge pool lined with rip-rap or riverstone at the outlet of storm sewer outfalls. These plunge pool outlets will be installed as dispersion berms or level spreaders to encourage sheet flow. Flows would then flow evenly across a span of naturalized / vegetated area before draining to a local watercourse. As erosive velocities are dissipated by the plunge pool, then released as sheet flow across naturalized / vegetated areas, the potential for watercourse bank erosion is mitigated.

However, plunge pools are not the preferred option for the City from a maintenance perspective. As such, regular riprap protection is recommended at the outlets for erosion control.

5 CONCLUSIONS AND RECOMMENDATIONS

This drainage and stormwater management report has been prepared to support the proposed drainage area for the East-West Connection (i.e. Lagerfeld Drive) road expansion in the City of Brampton, Ontario. The relevant guidelines have been reviewed and measures to adhere to those guidelines have been proposed and checked for proof of concept. The key points of this report are summarized below.

Five conceptual road alignments were developed and evaluated to select the preferred road alignment. WSP completed a preliminary HEC-RAS hydraulic analysis and floodplain assessment for different alignments to ensure that no negative impact would result from the proposed road extension. It should be noted that flood elevations at the Mississauga Road would not increase under any of the proposed creek crossings.

Erosion Control

Retention of 119.78 m^3 of water through bioretention or urban tree root systems will achieve the erosion control criterion for Catchments A, B, and C. Catchment D will discharge into an existing SWM pond such that erosion control will be achieved through the pond.

Water Balance

Using a treatment train approach (i.e., bioretention or urban tree root systems), pre-development proportions of infiltration and evapotranspiration on an average annual basis have been matched or exceeded.

Water Quantity Control

In consultation with CVC staff, quantity controls are not proposed for Catchments A, B, and C for the following reasons:

- Drainage area for Catchments A, B and C (3.38 ha) accounts for 0.36% of the total upstream contributing area (938 ha).
- A comparison of peak flows shows that the 100-year and Regional flows from Catchments A, B and C are 0.55% of the total peak flows at the site location.
- It was determined that the increase in impervious area of the Lagerfeld Drive extension will have negligible impacts on upstream and downstream properties.
- In addition, drainage areas from these subcatchments are too small (i.e., less than 5 ha) to implement a SWM pond. The limited space available for this project also

constrains the use of SWM ponds. Therefore, quantity controls are not provided for these subcatchments.

Quantity controls for Catchment D will be provided through an existing SWM pond located south of the CN Rail, north of Lagerfeld Drive, and west of Creditview Road.

Proposed Major and Minor System Road Runoff Control

The road runoff is proposed to be controlled through the implementation of a storm sewer system calculated using the Rational Method equation as per guidelines based on 10 year design storm event. The storm system will convey runoff from Catchment A westerly, Catchment B will outlet to Huttonville Creek, Catchment C will outlet to a tributary of Huttonville Creek and Catchment D will outlet to an existing SWM pond.

Runoff from Catchment A will be conveyed westerly through the future extension of Lagerfeld Drive not covered by this EA. Conveyance of external drainage may be required during the detailed design stage. As an interim solution, four alternatives have been developed: extending gravity pipe to nearest watercourse, do not build road west of Trans Canada Pipeline until future planning, pump flow to sensitive wetland area and pump flow to catchment B. Alternative A has been determined as the preferred interim solution given all the information to date. The interim design alternatives should be further evaluated and confirmed during detail design.

Runoff from Catchment B will outlet overland to Huttonville Creek upstream of the Mississauga Road crossing. Runoff from Catchment C will outlet to a tributary of Huttonville Creek, east of Mississauga Road, just upstream of where it joins to Huttonville Creek. Catchment D will outlet to an existing stormwater management pond located north of Lagerfeld Drive near the existing cul-de-sac to be extended. Major system flow will be conveyed overland to the proposed respective outlets where it has been designed for 100 year storm events.

Water Quality Control

An enhanced level of water quality treatment (i.e., 80% TSS removal) will be achieved through a treatment train approach using a combination of pre-treatment measures, on-site retention and detention measures. Assessed for feasible Quality treatment for Catchment D will be provided by an existing SWM pond located south of the CN Rail, north of Lagerfeld Drive, and west of Creditview Road. Bioretention and urban tree root system have been assessed. The urban tree root system is not the City of Brampton’s preferred alternative based the City’s internal cost benefit analysis.

Outlet Erosion Control

Plunge pools with dispersion berms and level spreaders will dissipate erosive velocity flows and encourage sheet flow to receiving watercourses. However, it is not a preferred option for the City from a maintenance perspective. Riprap stones will be placed beyond the outlets where feasible as erosion control measures.

Detailed Design Recommendations

Considerations for detailed design will include the following

1. A hydrogeological investigation must be completed that establishes the seasonally high groundwater level in accordance to CVC and TRCA's LID SWM Planning and Design Guide which states that "Designers should ensure that the bottom of the swale is separated from the seasonally high-water table or top of bedrock elevation by at least one (1) metre to prevent groundwater contamination."
2. The MOECC SWM Planning and Design Manual (2003) shall be referred to for detailed guidance on the design of a bioswale (dry swale) and bioretention facility.
3. The location(s) of pre-treatment measures utilized (CB Shields, inlet sumps, level spreaders) shall be identified in the ROW Typical Cross-Sections to ensure they are utilized in the appropriate location.
4. The Region of Peel is currently in the process of completing the detailed design for the Mississauga Rd. widening (from Bovaird Dr. to Mayfield Rd.). This widening proposes three outlets on the east side of Mississauga Rd., in the vicinity of the intersection with Lagerfeld Rd. It is CVC's preference to decrease the number of storm outlets to the regulated watercourses. Appropriate outlet locations shall be coordinated in conjunction with the related works.
5. All infrastructure (specifically storm outlets) must be located outside of the local erosion hazard associated with the regulated watercourses. This will be determined in conjunction with the geomorphic assessment at the detailed design stage. The detailed design of these outlets must incorporate appropriate erosion control measures and treatment as outlined in the EA.
6. The proponent is responsible for the submission and ultimate implementation of a comprehensive ESC plan for each stage of construction. If the construction duration is relatively long and/or the watercourse is sensitive, multistage construction ESC plans will be required to ensure adequate control for the entire period of work.
   a. If necessary, a flow diversion or by-pass plan must also be submitted.
   b. In the instances where groundwater is high and dewatering is required, during construction activities, a dewatering plan will be required by a qualified person.

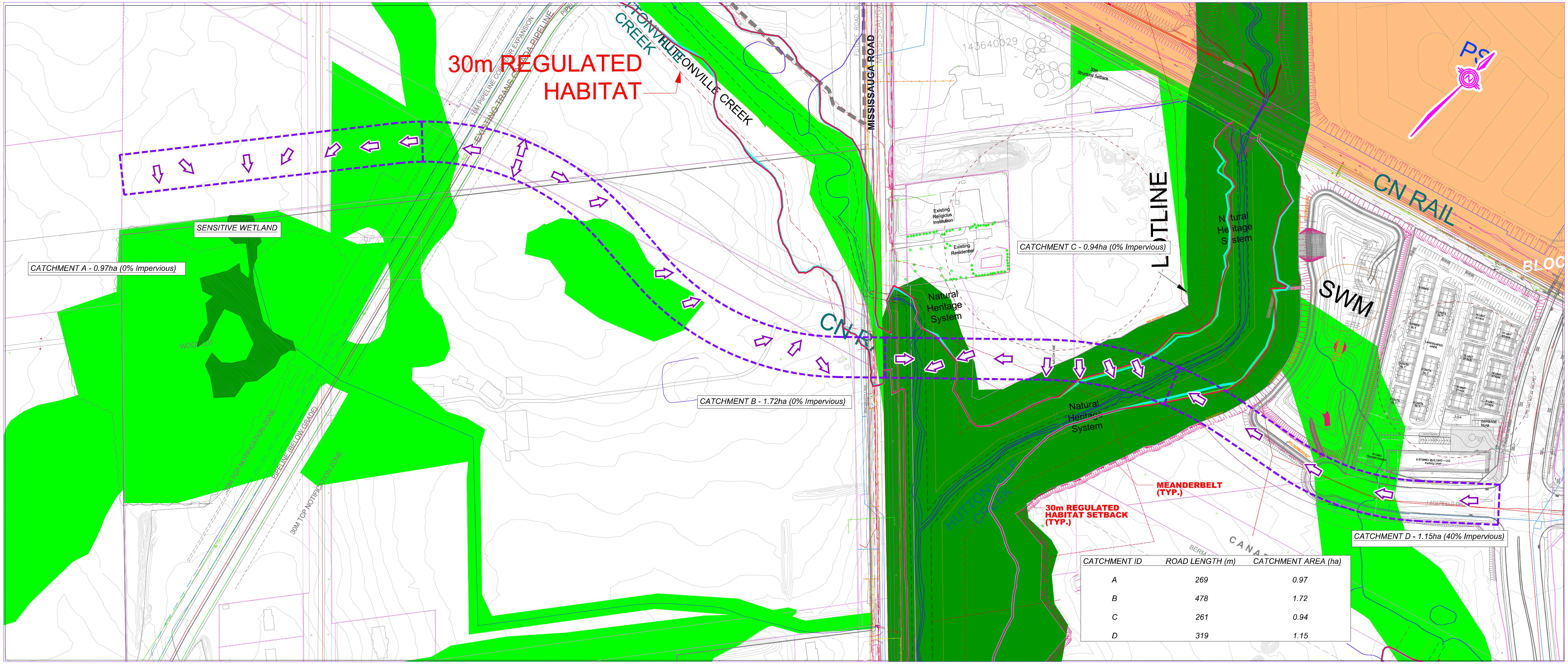
- Please refer to the Standard Notes for Drawings Submitted for CVC Review and apply the notes to the Erosion and Sediment Control drawings as necessary.

APPENDIX

A Supporting Figures

APPENDIX

A-1 Catchment Plans, Preliminary Cross Sections and Bioretention Units Details



CATCHMENT ID	ROAD LENGTH (m)	CATCHMENT AREA (ha)
A	269	0.97
B	478	1.72
C	261	0.94
D	319	1.15

LEGEND

- EXISTING FLOODLINE
- DRAINAGE AREA
- CONTOUR
- OVERLAND FLOW ROUTE

LEGEND:

NATURAL HERITAGE SYSTEM
- Natural Heritage System Area
- Provincial Significant Wetland (PSW)

RESIDENTIAL
- Low / Medium Density
- Medium Density

INFRASTRUCTURE
- TransCanada Gas Pipeline
- Stormwater Management Facility

RETAIL
- District Retail

OTHER
- Mixed Use Area
- Special Policy Area 1-2
- Osmington Special Policy Area (Mixed Use Centre)

INSTITUTIONAL
- Public Secondary School Site

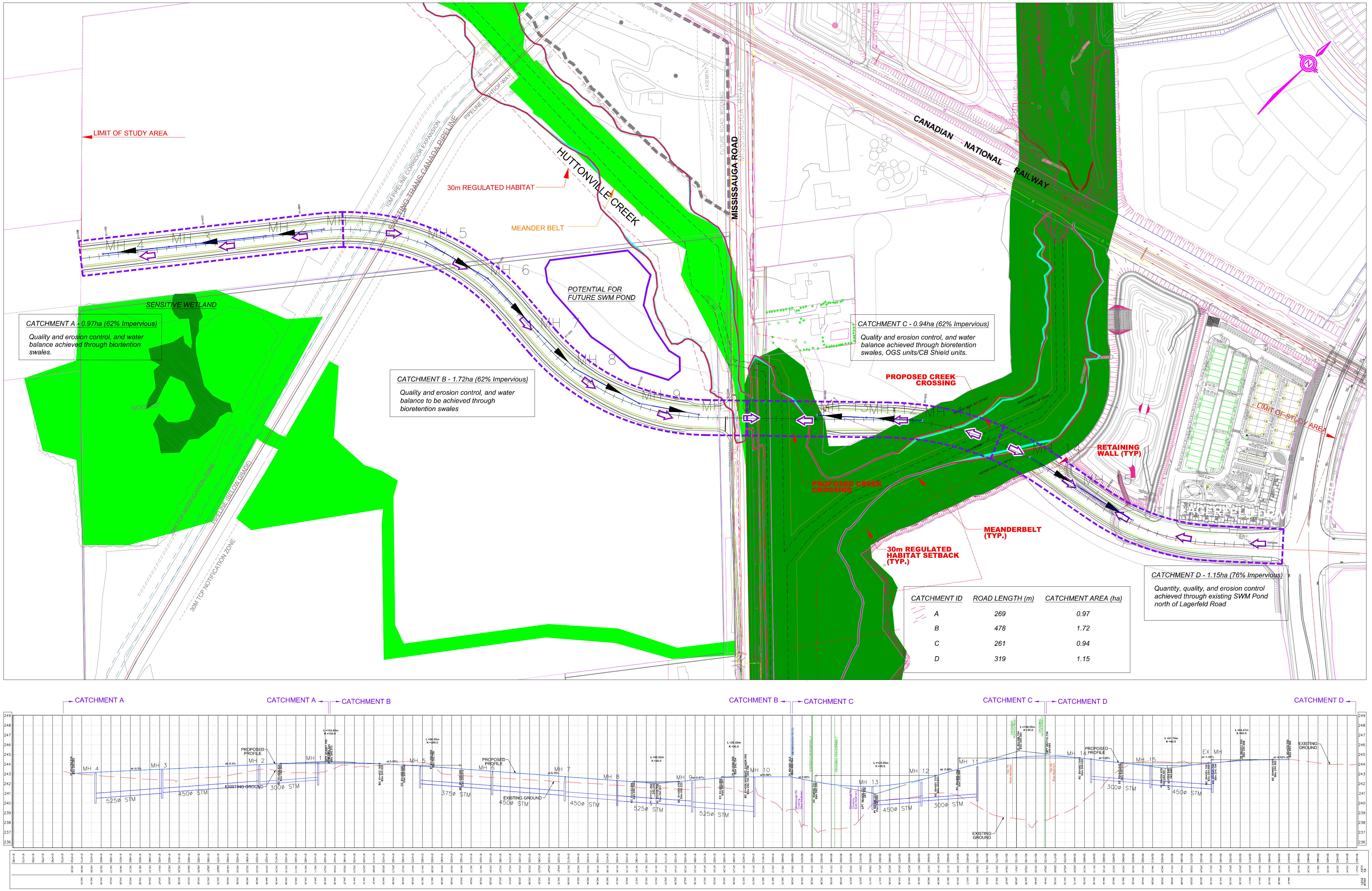
BRAMPTON Flower City
brampton.ca
Planning and Infrastructure Services
Public Works

wsp

EAST-WEST CONNECTION RD (LAGERFELD RD)
MOUNT PLEASANT GO STATION TO \
WEST OF MISSISSAUGA ROAD CLASS EA

EXISTING DRAINAGE CATCHMENTS PLAN

SURVEYED BY:	xxxxxx	DATE:	AUGUST 31, 2016	FILE NO.	xxxxx
DRAWN BY:	VM	CHECKED BY:	MD	DRAWING NO.	SHEET NO.
DESIGNED BY:	xxxxxx	CHECKED BY:	xxxxxx	xx-xx-xx	1
SCALE:	1:90	DATE:	MARCH 27, 2020		



CATCHMENT ID	ROAD LENGTH (m)	CATCHMENT AREA (ha)
A	269	0.97
B	478	1.72
C	261	0.94
D	319	1.15

BRAMPTON Flower City

Planning and Infrastructure Services

Public Works

wsp

EAST-WEST CONNECTION RD (LAGERFELD RD) MOUNT PLEASANT GO STATION TO \ WEST OF MISSISSAUGA ROAD CLASS EA

PRELIMINARY RECOMMENDED DRAINAGE PLAN

SURVEYED BY: xxxxxx	DATE: AUGUST 31, 2016	FILE NO. xxxxx	
DRAWN BY: xxxxxx	CHECKED BY: xxxxxx	DRAWING NO. Appendix A-1	SHEET NO. 2
DESIGNED BY: xxxxxx	CHECKED BY: xxxxxx		
SCALE: 1:90	DATE: JANUARY 10, 2020		

LEGEND:

- Existing Ground
- Proposed Profile
- Existing Floodline
- Proposed Floodline
- Proposed Drainage Area
- Overland Flow Direction

NATURAL HERITAGE SYSTEM
- Natural Heritage System Area
- Provincial Significant Wetland (PSW)

RESIDENTIAL
- Low / Medium Density
- Medium Density

INFRASTRUCTURE
- TransCanada Gas Pipeline
- SWM Stormwater Management Facility

RETAIL
- District Retail

OTHER
- Mixed Use Area
- 1-2 Special Policy Area 1-2
- Osmington Special Policy Area (Mixed Use Centre)

INSTITUTIONAL
- PS Public Secondary School Site

Note: Riprap should be considered as erosion control measures beyond the outlet where feasible

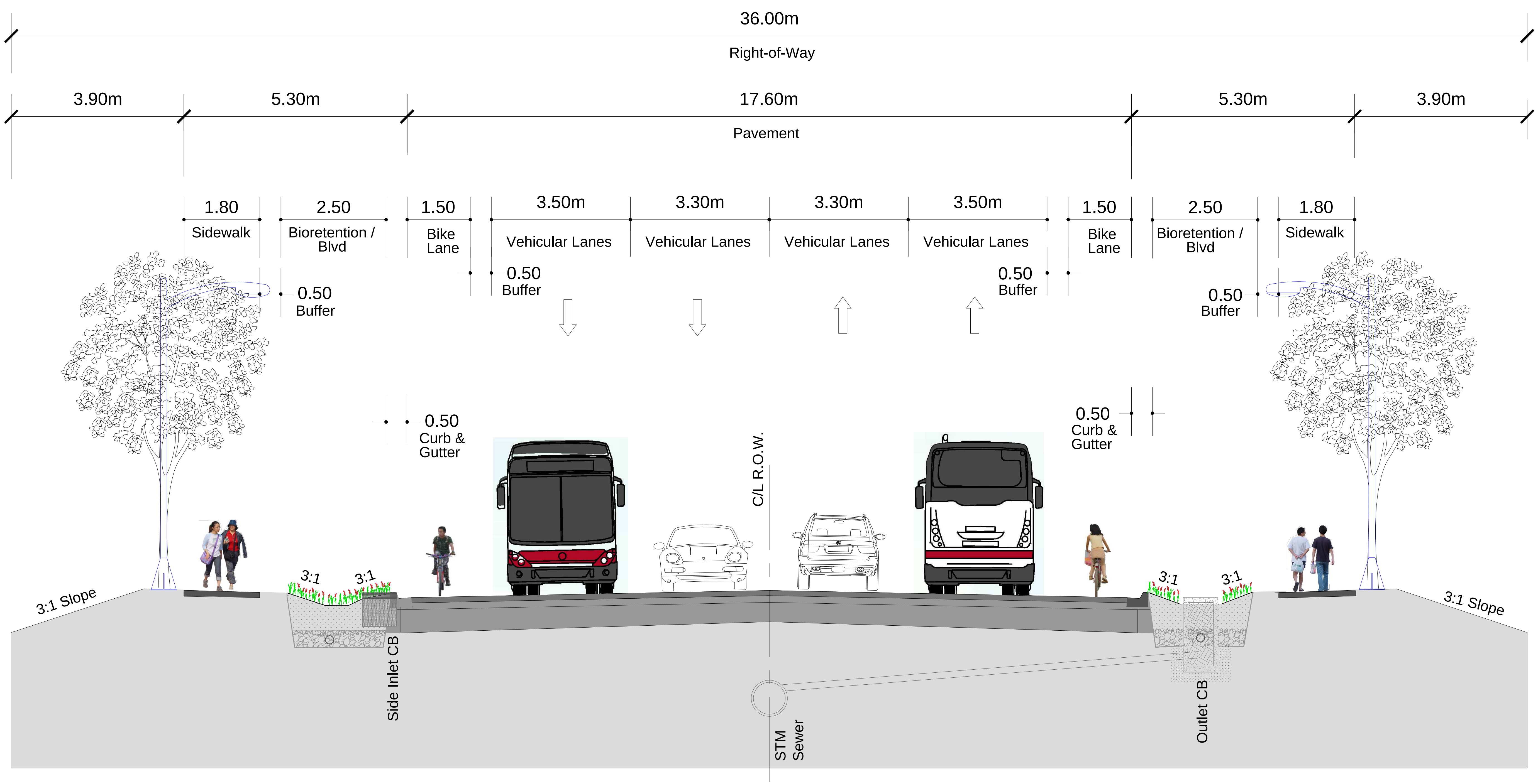
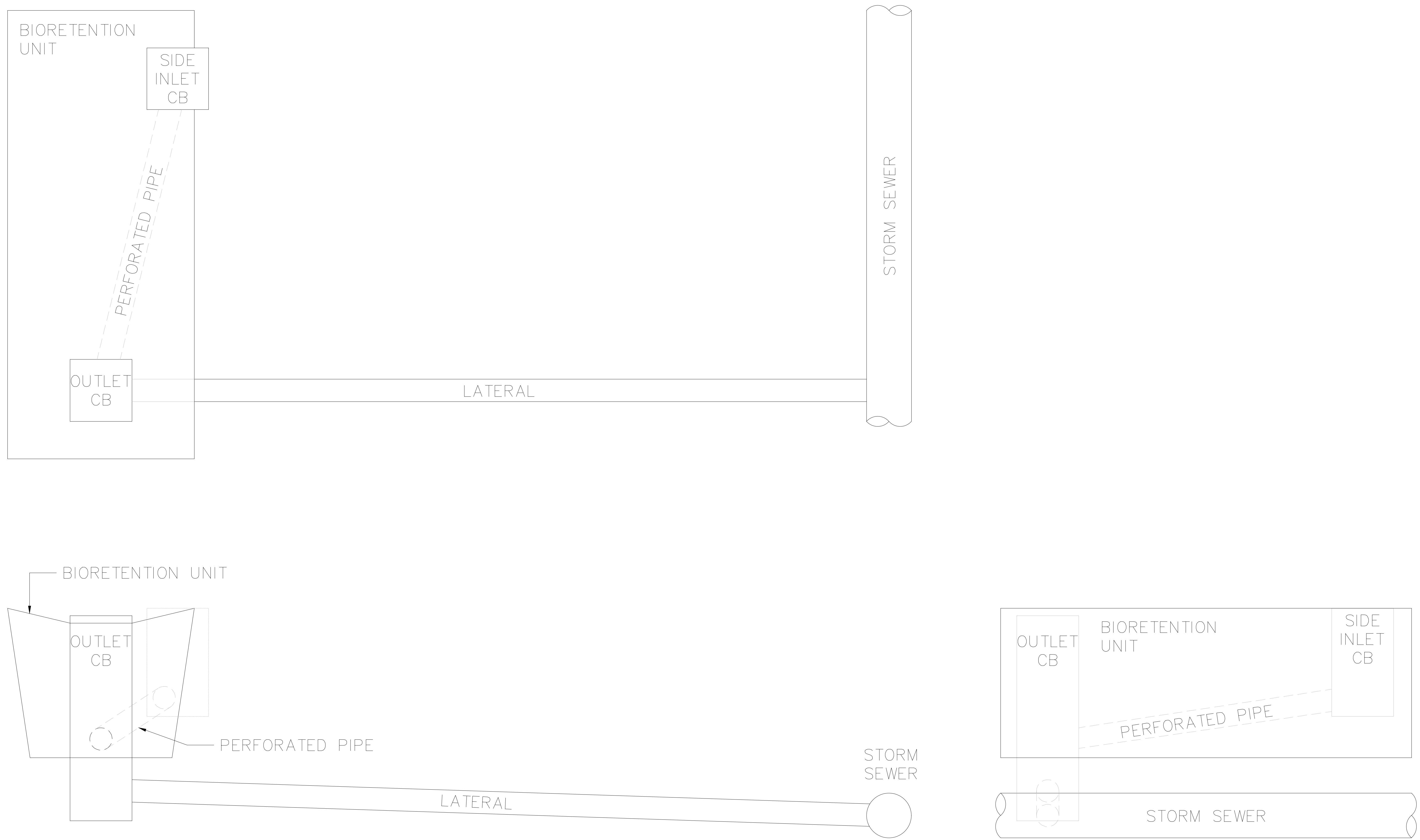


Figure 3
Brampton EW Connection Mid-Block Typical Cross-Section (with Bioretention) (Oct 2019)
(2017 TAC Recommended Lane Width)
Brampton East-West Connection EA *Refer to Fig 4 for Bioretention Layout

141-15409_CrossSection_20191030.dwg_Opt 2_bio swale (2)
Modified: 10/30/2019 2:17 PM By: vivian.mak Plot Date: 2019/10/30



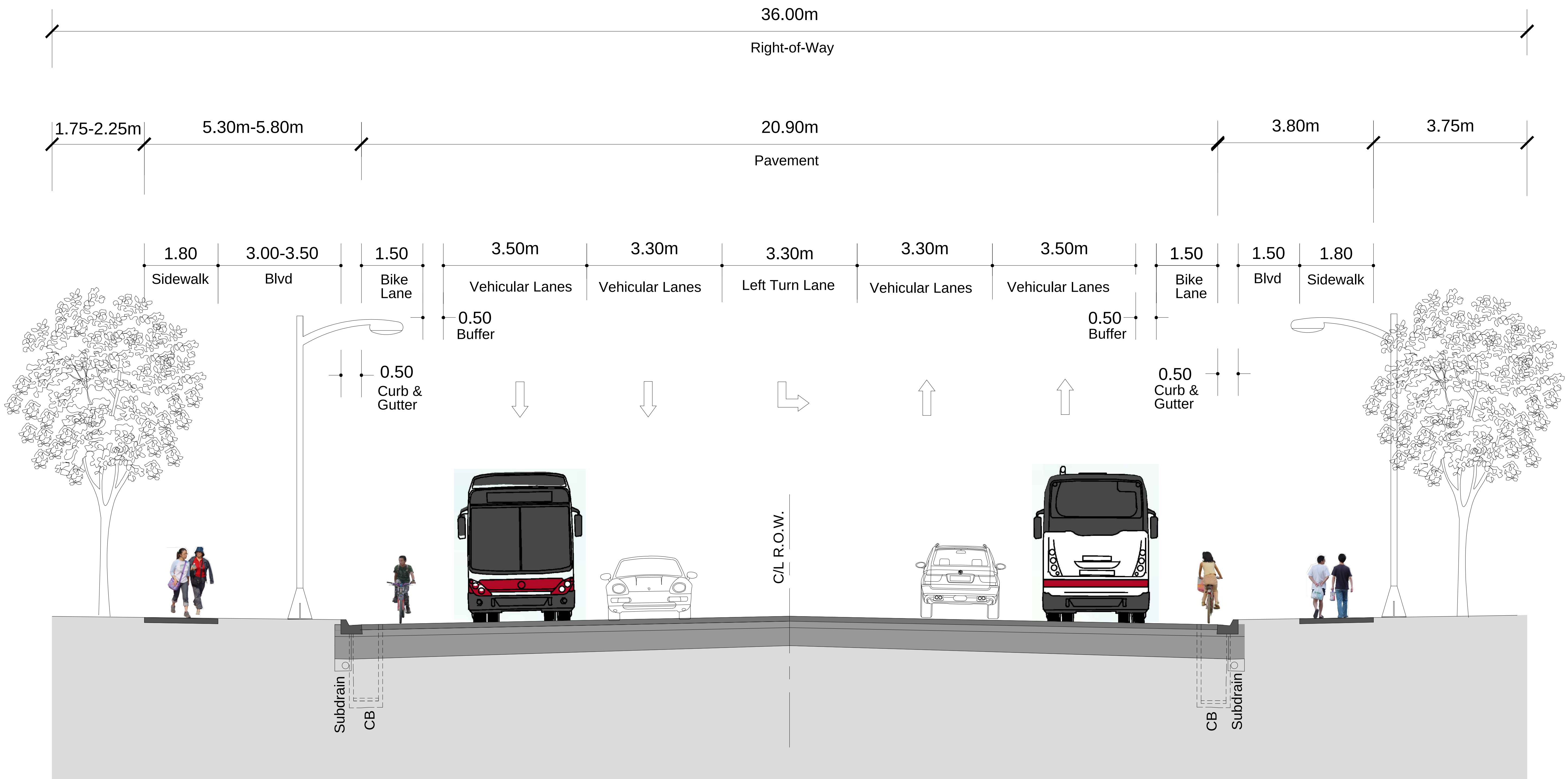
BIORETENTION UNIT SCHEMATIC

CITY OF BRAMPTON EA STUDY - EAST-WEST CONNECTION

EXHIBIT

4

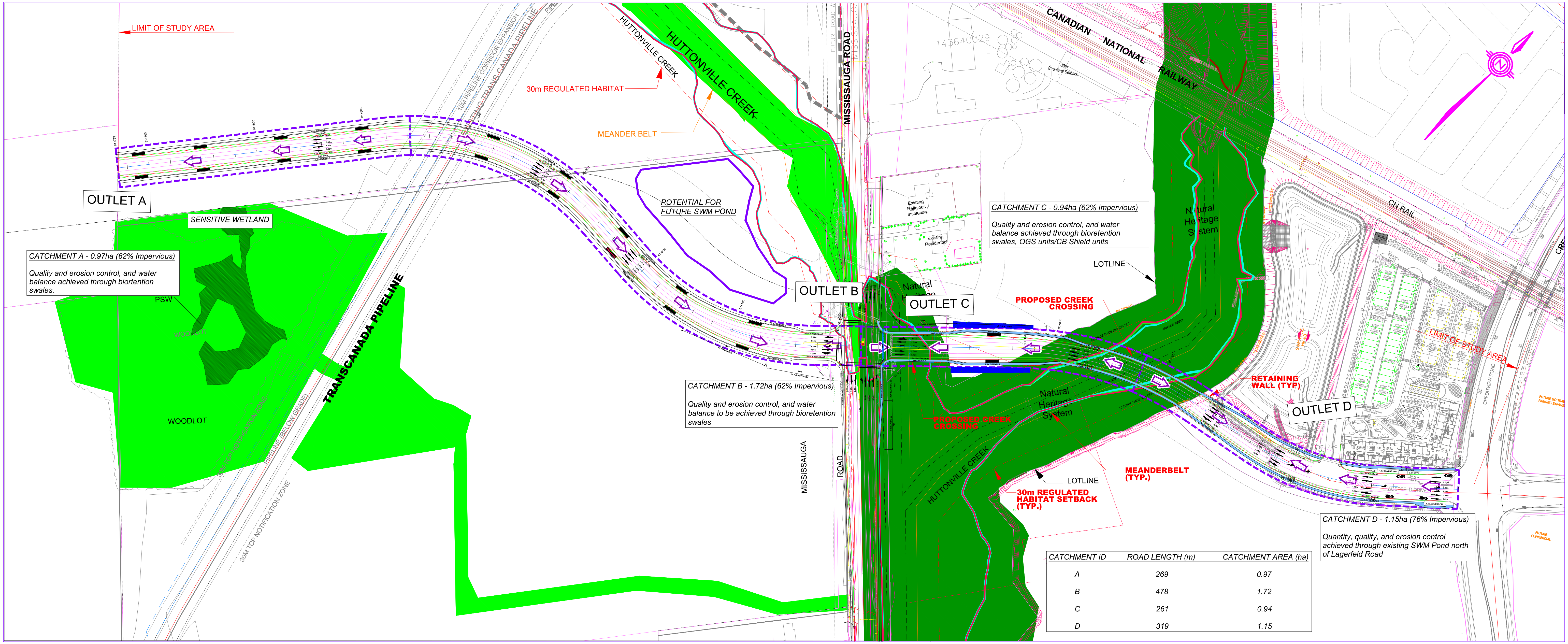
DRAWING NAME: \\CAMRK1DAT03\ENTRA\CURRENT FILES\ACTIVE PROJECTS\2014 PROJECTS\141-15409 BRAMPTONLAGERFELDEA-RESTORED\141-15409 DATADRAWINGSANALYSIS\DRAINAGE\BIORETENTION UNIT DETAIL.DWG MODIFIED: Feb. 07, 2020 4:42 PM



Note:
Where permitted, a double row of trees staggered can be considered as part of detailed design.

Z:\Current Files\Active Projects\2014 Projects\141-15409 BramptonLagerfeldEA-Restored\141-15409 DataDrawingsAnalysis\Design

Figure 5
Brampton EW Connection Mid-Block Typical Cross-Section (along existing cul-de-sac) (Sep 2019)
(2017 TAC Recommended Lane Width)
Brampton East-West Connection EA



CATCHMENT ID	ROAD LENGTH (m)	CATCHMENT AREA (ha)
A	269	0.97
B	478	1.72
C	261	0.94
D	319	1.15

LEGEND

- PROPOSED PROFILE
- EXISTING FLOODLINE
- PROPOSED FLOODLINE
- PROPOSED DRAINAGE AREA
- OVERLAND FLOW ROUTE
- POTENTIAL BIORETENTION LOCATION (2.5m x 11.3m)

LEGEND:

NATURAL HERITAGE SYSTEM
- Natural Heritage System Area
- Provincial Significant Wetland (PSW)

RESIDENTIAL
- Low / Medium Density
- Medium Density

INFRASTRUCTURE
- TransCanada Gas Pipeline
- SWM Stormwater Management Facility

RETAIL
- District Retail

OTHER
- Mixed Use Area
- 1-2 Special Policy Area 1-2
- Osmington Special Policy Area (Mixed Use Centre)

INSTITUTIONAL
- PS Public Secondary School Site

BRAMPTON Flower City
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Public Works

EAST-WEST CONNECTION RD (LAGERFELD RD) MOUNT PLEASANT GO STATION TO \ WEST OF MISSISSAUGA ROAD CLASS EA

BIORETENTION LOCATION PLAN

SURVEYED BY: xxxxxx	DATE: AUGUST 31, 2016	FILE NO.	xxxxx		
DRAWN BY: VM	CHECKED BY: MD	DRAWING NO.	SHEET NO.		
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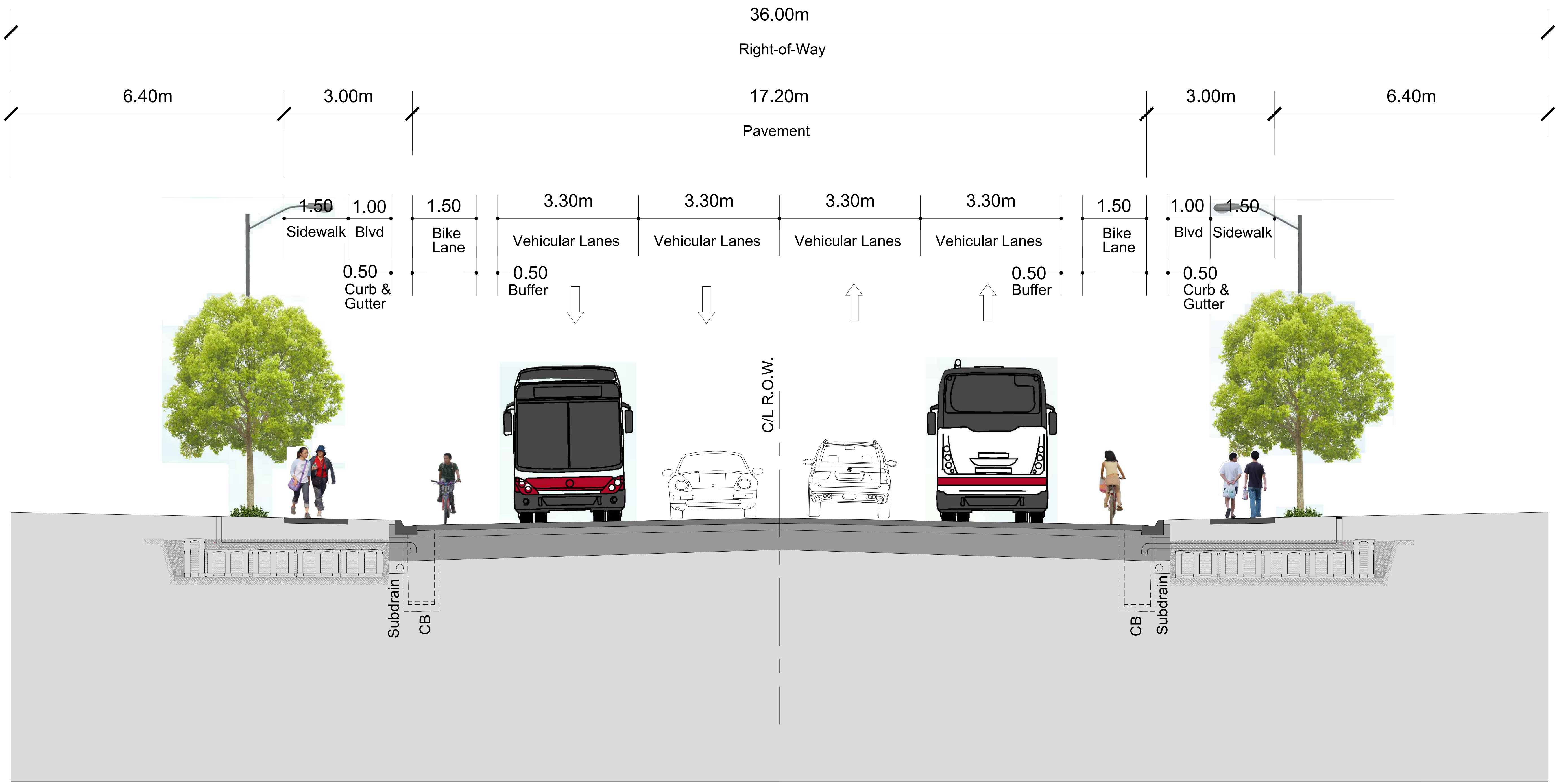


DRAFT - for discussion

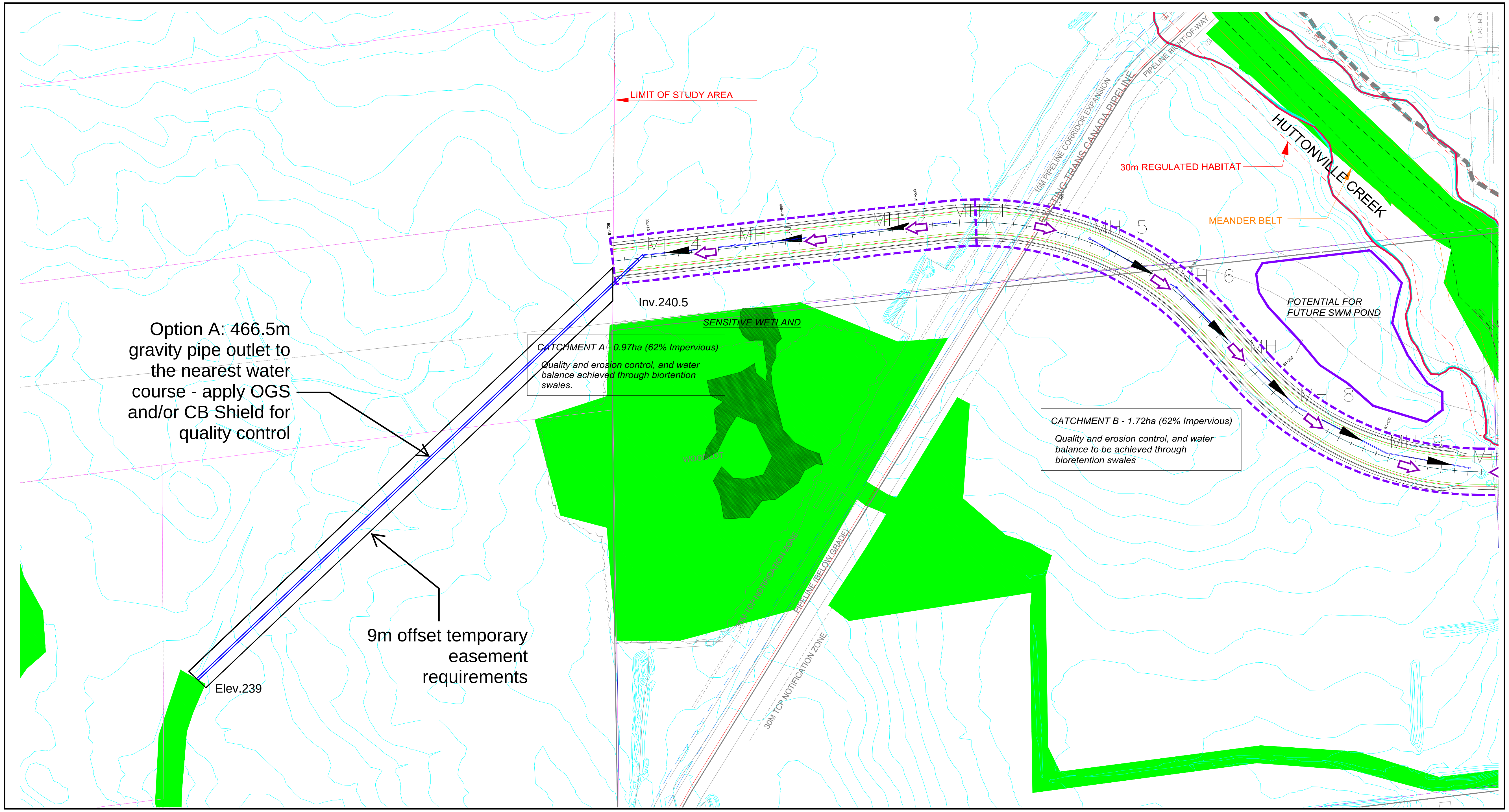
\\CAMRK1DAT03\Entra\Current Files\Active Projects\2014 Projects\141-15409 BramptonEastWestConnectionMountPleasantEA\141-15409 DataDrawingsAnalysis\Drainage

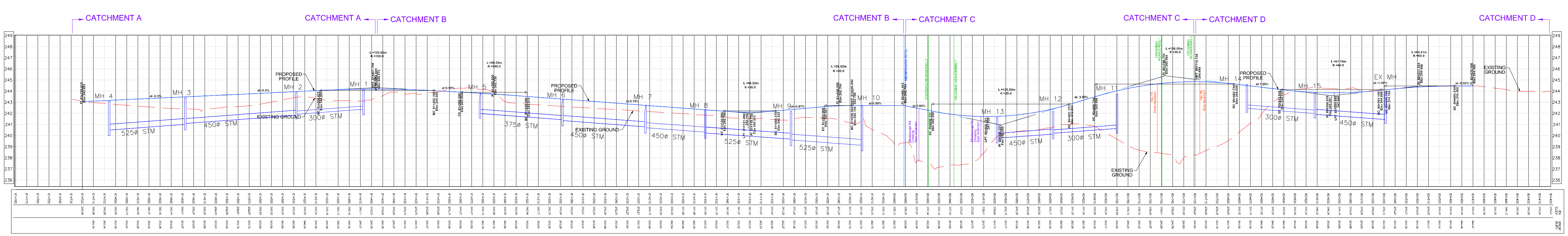
Silva Cell Option Figure 7
Brampton EW Connection Mid-Block Typical Cross-Section (Mar 12, 2018)
(2017 TAC Recommended Lane Width)
Brampton East-West Connection EA

WSP

141-15409_CrossSection_20180226.dwg_Typical w Silva Cell

Modified: 11/28/2018 3:44 PM By: GrahamCo Plot Date: 2018/11/28





BRAMPTON Flower City

Planning and Infrastructure Services

Public Works

wsp

EAST-WEST CONNECTION RD (LAGERFELD RD) MOUNT PLEASANT GO STATION TO \ WEST OF MISSISSAUGA ROAD CLASS EA

PRELIMINARY RECOMMENDED DRAINAGE PLAN

SURVEYED BY: xxxxxx	DATE: AUGUST 31, 2016	FILE NO. xxxxx	
DRAWN BY: xxxxxx	CHECKED BY: xxxxxx	DRAWING NO. Appendix A-1	SHEET NO. 8
DESIGNED BY: xxxxxx	CHECKED BY: xxxxxx		
SCALE: 1:90	DATE: JULY 03, 2020		

Catchment A Interim Solution

LEGEND:

- *Existing Ground*
- *Proposed Profile*
- *Existing Floodline*
- *Proposed Floodline*
- *Proposed Drainage Area*
- *Overland Flow Direction*

NATURAL HERITAGE SYSTEM

- *Natural Heritage System Area*
- *Provincial Significant Wetland (PSW)*

RESIDENTIAL

- *Low / Medium Density*
- *Medium Density*

INFRASTRUCTURE

- *TransCanada Gas Pipeline*
- SWM *Stormwater Management Facility*

RETAIL

- *District Retail*

OTHER

- *Mixed Use Area*
- 1-2 *Special Policy Area 1-2*
- *Osmington Special Policy Area (Mixed Use Centre)*

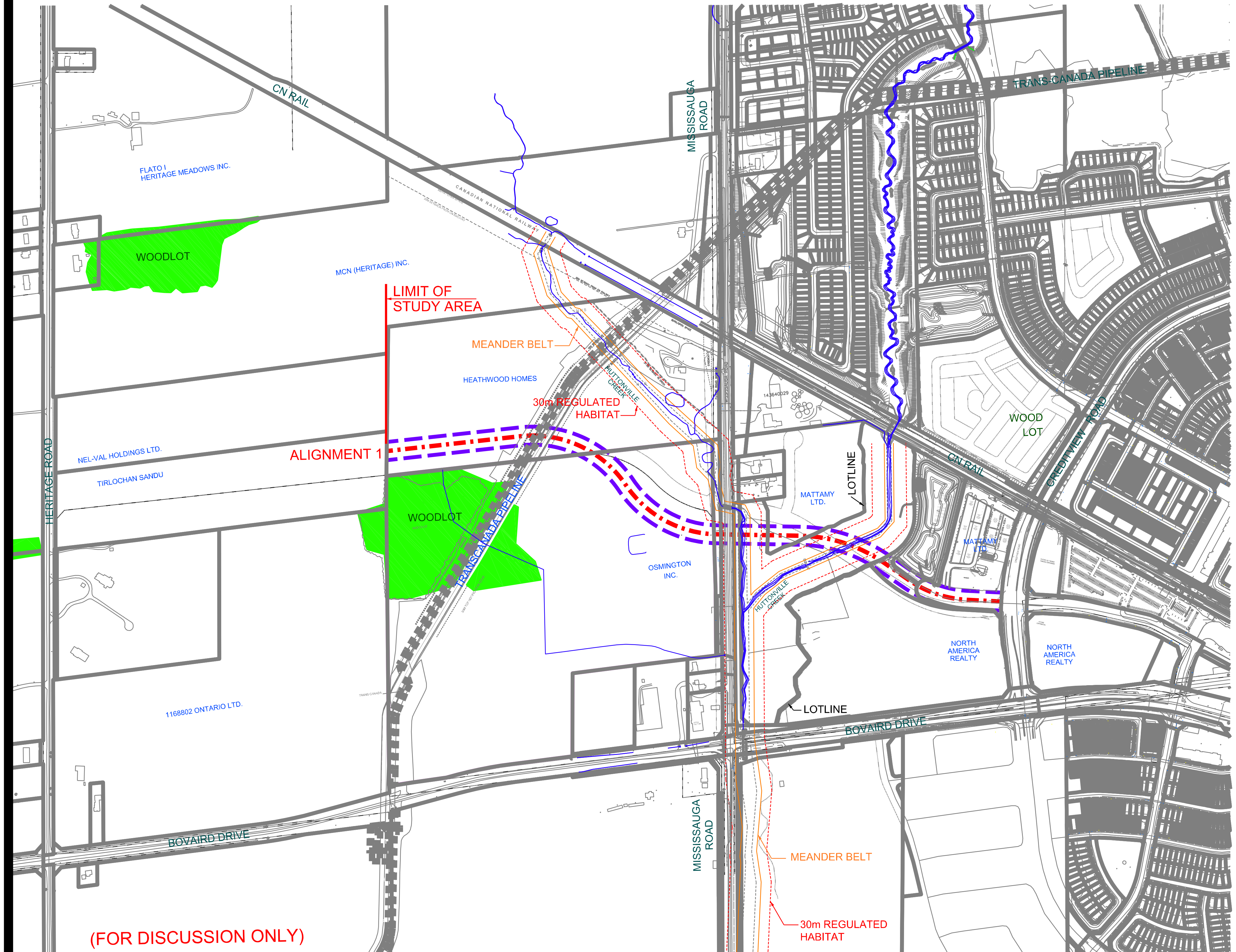
INSTITUTIONAL

- PS *Public Secondary School Site*

Note: Riprap should be considered as erosion control measures beyond the outlet where feasible

APPENDIX

A-2 Alternative Alignments



Comments:
- Address all geometric requirements
- 2 new creek crossings
- Meet minimum distance between signalized intersections
- No impact on woodlots
- Meet sightline requirements
- No impact on structure proposed in Mississauga Road EA

Geometrically Preferred Intersection Window:
- Within the project limits, there is only a window of about 105m, between 330m and 435m north of Bovaird Drive centreline, where the East West Connection can intersect with Mississauga Road and meets the TAC and the Region of Peel standards, while avoiding the Huttonville Creek Bridge. When the East West Connection alignment is within the 105m window, the desirable vertical sight distances can be achieved.

480m 400m 320m 240m 160m 80m 0m 40m 80m

NO.	BY	DATE	REVISIONS	CHECKED

BRAMPTON Flower City
Planning and Infrastructure Services
Public Works

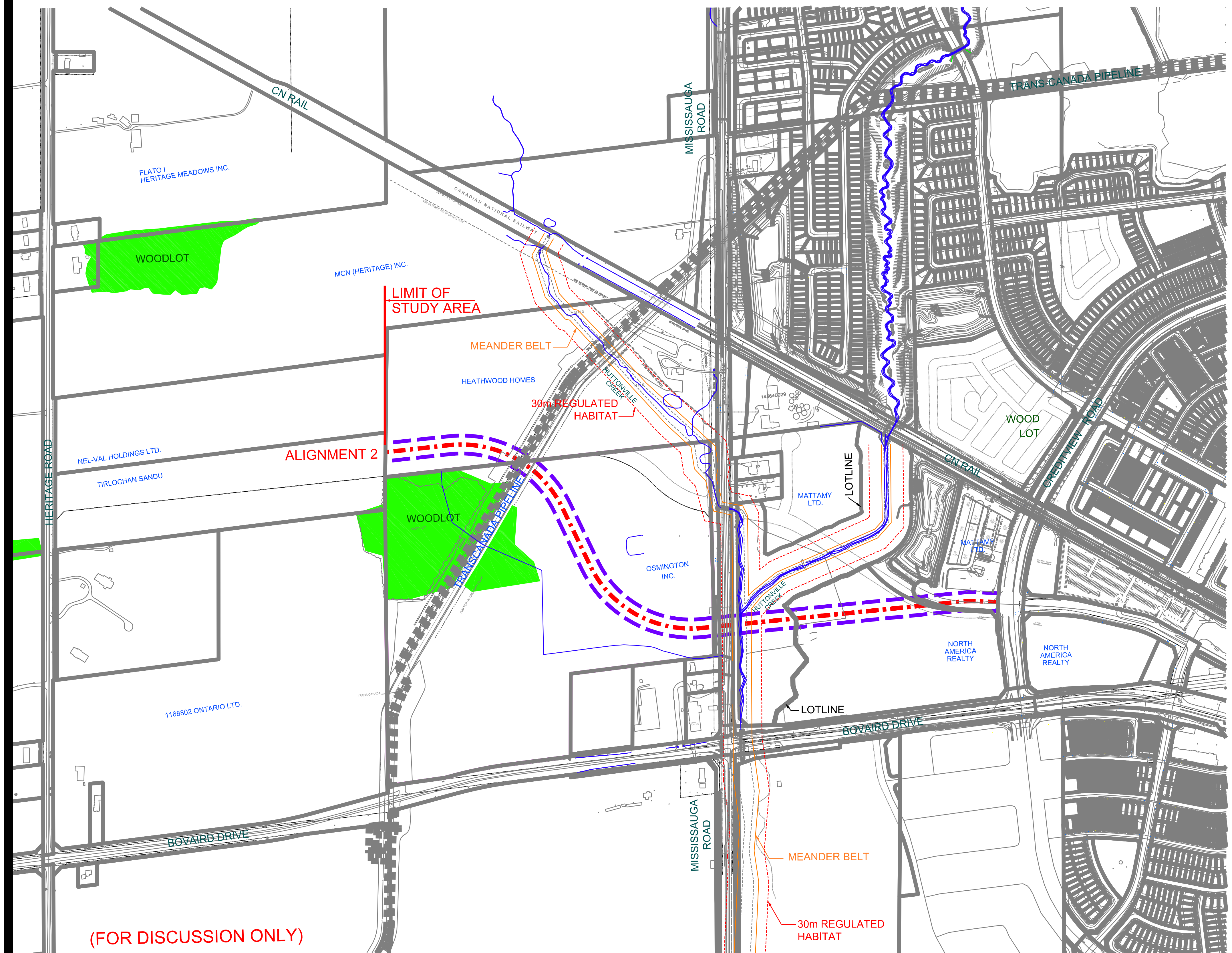
wsp

PROJECT DWG. NO.

BRAMPTON EAST-WEST CONNECTION
MOUNT PLEASANT GO STATION EA
ALTERNATIVE DESIGN CONCEPTS

ALIGNMENT 1

SURVEYED BY:	xxxxxx	DATE:	AUG 09, 2016	FILE NO.	xxxxx
DRAWN BY:	VM	CHECKED BY:	BK	DRAWING NO.	SHEET NO.
DESIGNED BY:	xxxxxx	CHECKED BY:	xxxxxx	Figure 6-1	1
SCALE:	h 1:4000	DATE:	OCT 18, 2017		



Comments:

- Only one new creek crossing
- Does not meet min. standard distance between signalized intersections
- Provide access to Osmington
- Require realignment of cul-de-sac
- Impact on Osmington development
- Does not impact structure proposed in Mississauga Road EA

Geometrically Preferred Intersection Window:

- Within the project limits, there is only a window of about 105m, between 330m and 435m north of Bovaird Drive centreline, where the East West Connection can intersect with Mississauga Road and meets the TAC and the Region of Peel standards, while avoiding the Huttonville Creek Bridge. When the East West Connection alignment is within the 105m window, the desirable vertical sight distances can be achieved.

480m 400m 320m 240m 160m 80m 0m 40m 80m

NO.	BY	DATE	REVISIONS	CHECKED

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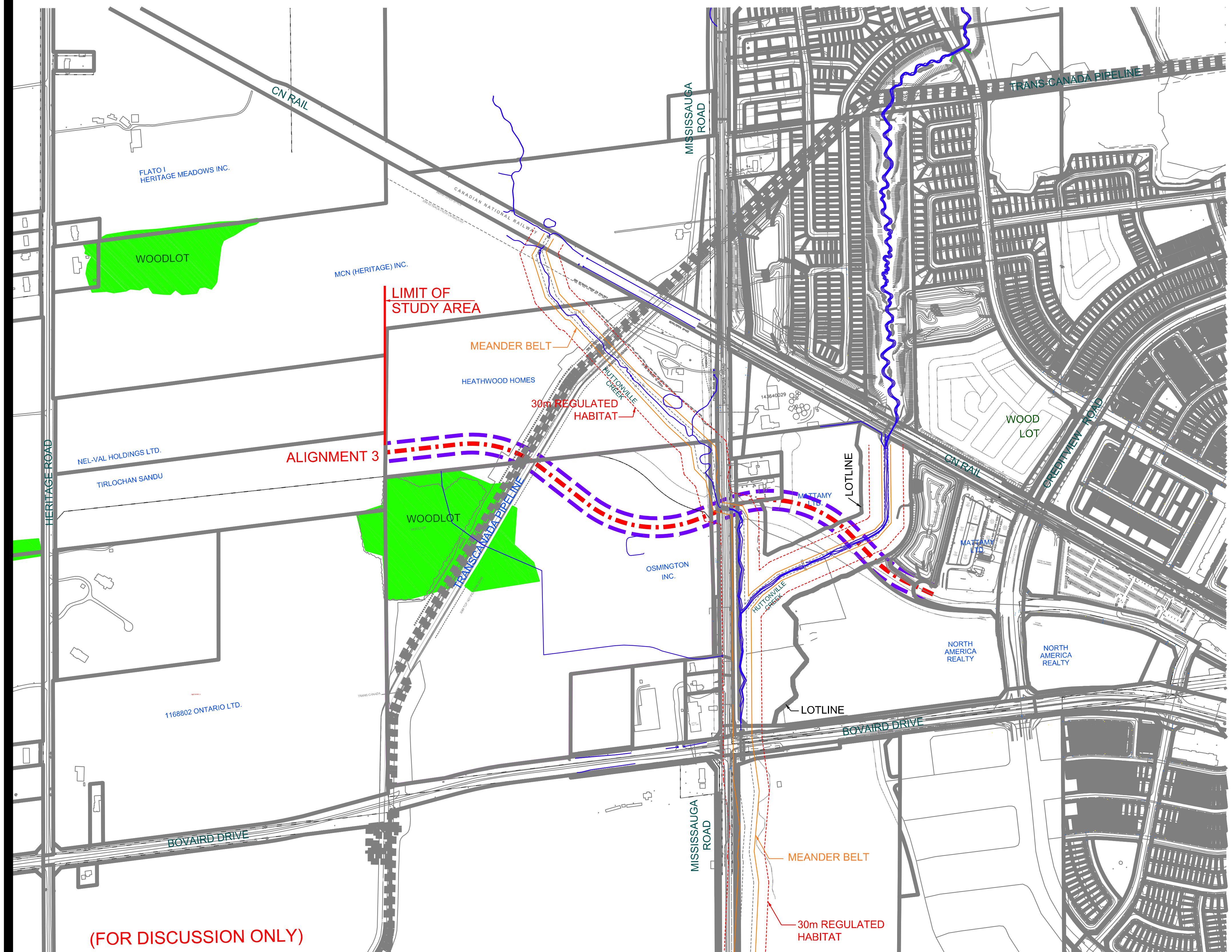
Planning and Infrastructure Services
Public Works

PROJECT DWG. NO.

BRAMPTON EAST-WEST CONNECTION
MOUNT PLEASANT GO STATION EA
ALTERNATIVE DESIGN CONCEPTS

ALIGNMENT 2

SURVEYED BY: xxxxxx	DATE: AUG 09, 2016	FILE NO. xxxxx	
DRAWN BY: VM	CHECKED BY: BK	DRAWING NO. Figure 6-2	SHEET NO. 2
DESIGNED BY: xxxxxx	CHECKED BY: xxxxxx		
SCALE: h 1:4000	DATE: OCT 18, 2017		



Comments:
- Only one new creek crossing
- Creek crossing of Mississauga Road requires structure modification
- Impact on property (Joyce & Keith Martin)
- Meet required min. spacing between signalized intersections
- Insufficient sight distance
- Insufficient tangent length east of Mississauga Road intersection

Geometrically Preferred Intersection Window:
- Within the project limits, there is only a window of about 105m, between 330m and 435m north of Bovaird Drive centreline, where the East West Connection can intersect with Mississauga Road and meets the TAC and the Region of Peel standards, while avoiding the Huttonville Creek Bridge. When the East West Connection alignment is within the 105m window, the desirable vertical sight distances can be achieved.

480m 400m 320m 240m 160m 80m 0m 40m 80m

NO.	BY	DATE	REVISIONS	CHECKED

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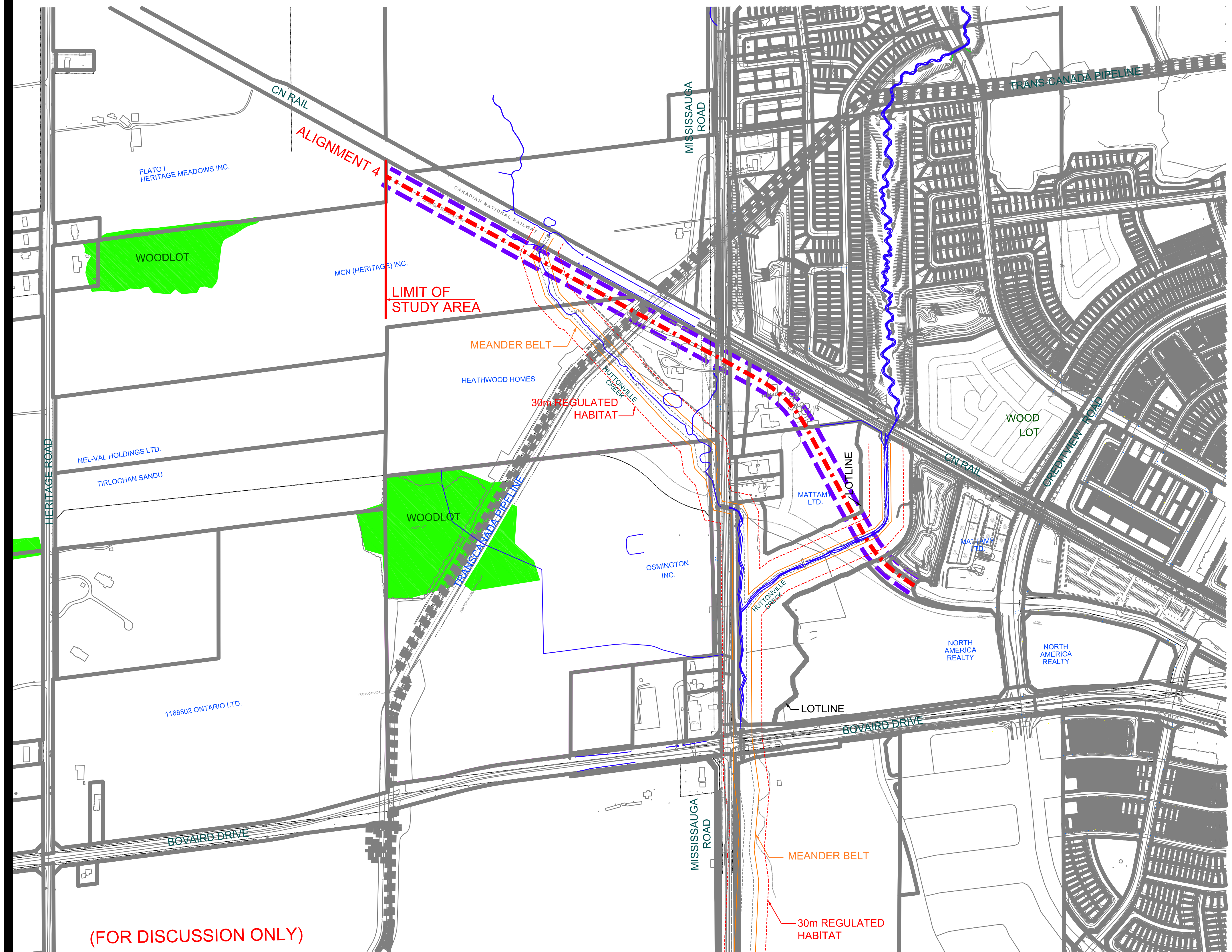
PROJECT DWG. NO.

BRAMPTON EAST-WEST CONNECTION
MOUNT PLEASANT GO STATION EA
ALTERNATIVE DESIGN CONCEPTS

ALIGNMENT 3

SURVEYED BY: xxxxxx	DATE: AUG 09, 2016	FILE NO. xxxxx			
DRAWN BY: VM	CHECKED BY: BK	DRAWING NO.	SHEET NO.		
DESIGNED BY: xxxxxx	CHECKED BY: xxxxxx	Figure 6-3	3		
SCALE: h 1:4000	DATE: OCT 18, 2017				



Comments:
- 2 creek crossings
- No intersection with Mississauga Road
- Utilize proposed slip road (Mississauga Road EA)

Geometrically Preferred Intersection Window:
- Within the project limits, there is only a window of about 105m, between 330m and 435m north of Bovaird Drive centreline, where the East West Connection can intersect with Mississauga Road and meets the TAC and the Region of Peel standards, while avoiding the Huttonville Creek Bridge. When the East West Connection alignment is within the 105m window, the desirable vertical sight distances can be achieved.

480m 400m 320m 240m 160m 80m 0m 40m 80m

NO.	BY	DATE	REVISIONS	CHECKED

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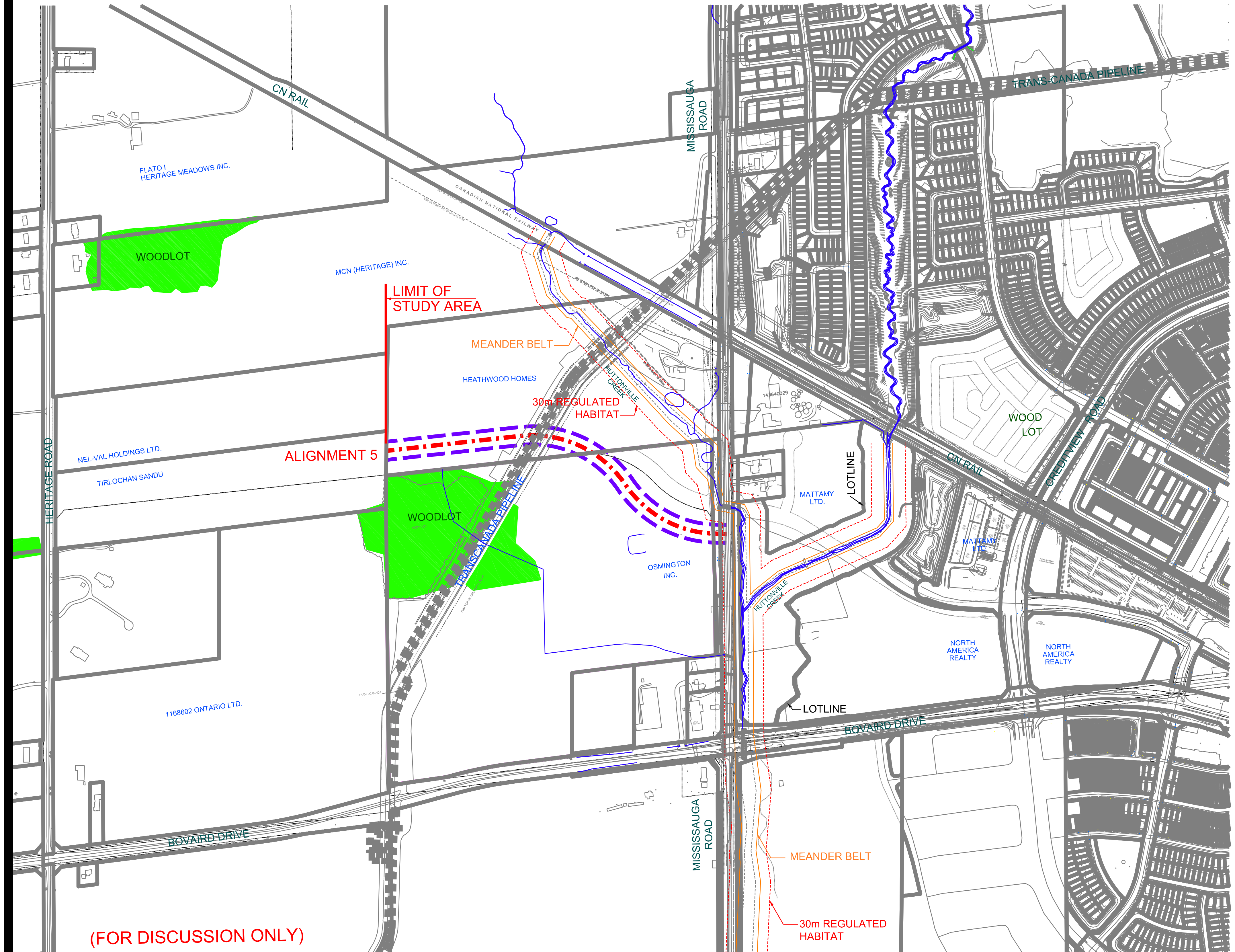
PROJECT DWG. NO.

BRAMPTON EAST-WEST CONNECTION
MOUNT PLEASANT GO STATION EA
ALTERNATIVE DESIGN CONCEPTS

ALIGNMENT 4

SURVEYED BY:	xxxxxx	DATE:	AUG 09, 2016	FILE NO.	xxxxx
DRAWN BY:	VM	CHECKED BY:	BK	DRAWING NO.	SHEET NO.
DESIGNED BY:	xxxxxx	CHECKED BY:	xxxxxx	Figure 6-4	4
SCALE:	h 1:4000	DATE:	OCT 18, 2017		



Comments:
- Extend from west of Mississauga Road, does not connect with GO Station
- Clear vertical sight distance for assumed 1.1m creek crossing parapet wall north of intersection
- Address all geometric requirements
- No new creek crossings
- Meet minimum distance between signalized intersections
- No impact on woodlots
- Meet sightline requirements
- Does not impact structure proposed in Mississauga Road EA

Geometrically Preferred Intersection Window:
- Within the project limits, there is only a window of about 105m, between 330m and 435m north of Bovaird Drive centreline, where the East West Connection can intersect with Mississauga Road and meets the TAC and the Region of Peel standards, while avoiding the Huttonville Creek Bridge. When the East West Connection alignment is within the 105m window, the desirable vertical sight distances can be achieved.

480m 400m 320m 240m 160m 80m 0m 40m 80m

NO.	BY	DATE	REVISIONS	CHECKED

BRAMPTON Flower City
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Public Works

wsp

PROJECT DWG. NO.

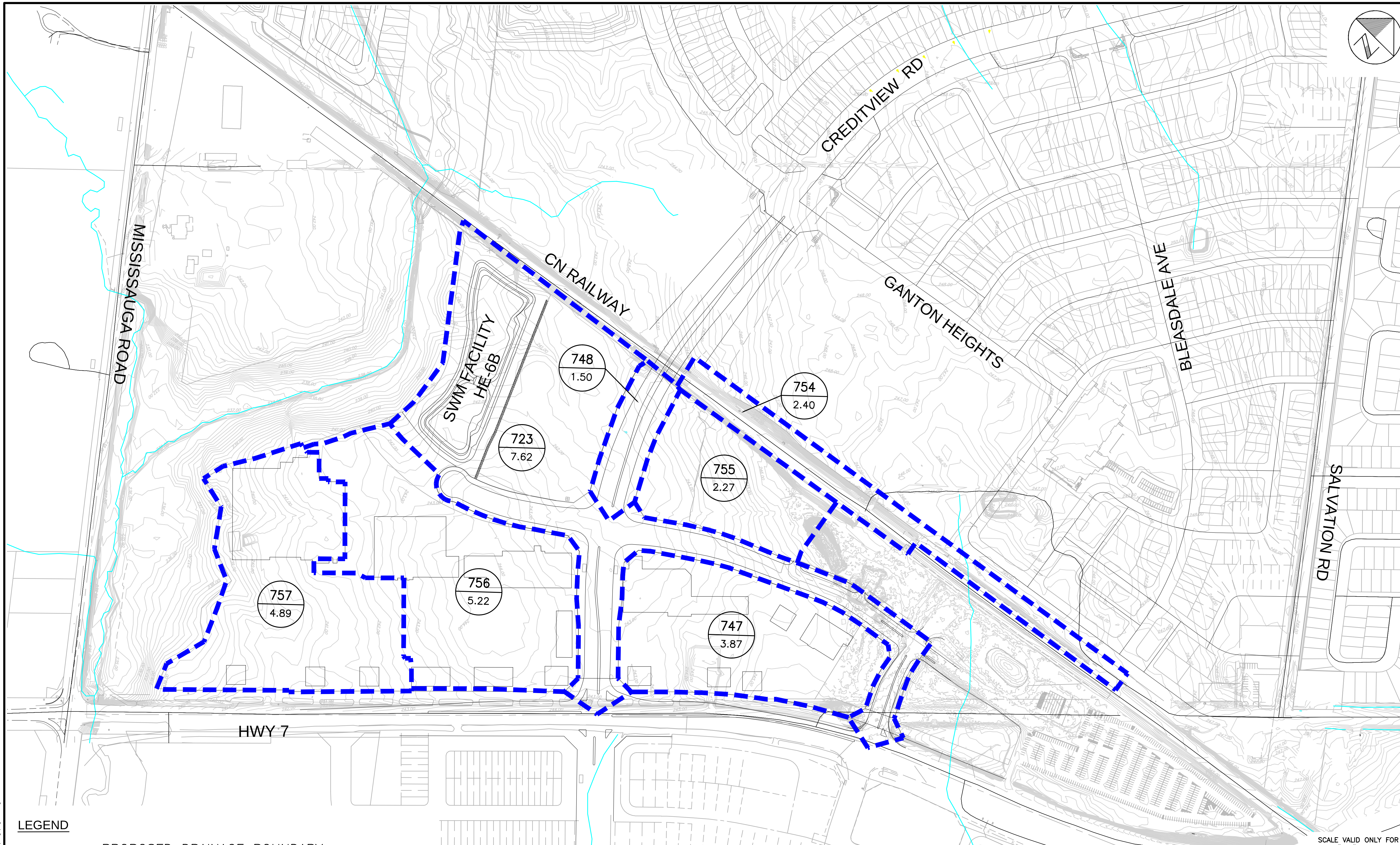
BRAMPTON EAST-WEST CONNECTION
MOUNT PLEASANT GO STATION EA
ALTERNATIVE DESIGN CONCEPTS

ALIGNMENT 5

SURVEYED BY:	xxxxxx	DATE:	AUG 09, 2016	FILE NO.	xxxxx
DRAWN BY:	VM	CHECKED BY:	BK	DRAWING NO.	SHEET NO.
DESIGNED BY:	xxxxxx	CHECKED BY:	xxxxxx	Figure 6-5	5
SCALE:	h 1:4000	DATE:	OCT 18, 2017		

APPENDIX

A-3 Existing Pond Drainage Boundary



LEGEND

PROPOSED DRAINAGE BOUNDARY

757 / 4.83 — PROPOSED DRAINAGE BOUNDARY ID
PROPOSED DRAINAGE BOUNDARY AREA (ha)

SCALE VALID ONLY FOR 24"x36" VERSION

HYDROLOGIC VERIFICATION OF SWM FACILITY HE-6B CITY OF BRAMPTON	PROPOSED DRAINAGE BOUNDARY PLAN	amec	Scale 2000 (0 25 50 75) Consultant File No. TP113011 Figure No. 1

P:\Work\TP113011\water\dwg\Fig-1.dwg

Feb 26/13 – josh.seraj

APPENDIX

B

Reference Reports: Hydraulic Modelling of Alternative Alignments

MEMO

TO: Daniel Nalliah, Manager, Municipal Roads, WSP

FROM: Sherif Iskandar, Drainage Lead, WSP

SUBJECT: **City of Brampton E-W Connector (Lagerfeld Dr.) Project – Floodplain Assessment under Different Alignments**

DATE: **July 3, 2020**

INTRODUCTION

As requested by CVC staff, WSP was instructed by the City of Brampton Project Manager to undertake HEC RAS hydraulic analysis and floodplain assessment for a full range of road alternatives for the E-W Connector (Lagerfeld Dr.), City of Brampton.

ORIGINAL MODELS AND BACKGROUND INFORMATION

There were two HEC RAS hydraulic models obtained from CVC. The first model was called "Heritage Heights", which showed the Huttonville Creek along Mississauga Road from Bovaird Drive to CNR. The other model was for East Huttonville Creek located east of Huttonville Creek that eventually joins Huttonville Creek. This model was called "East Huttonville".

Also, an approved and stamped Regional floodline map covering the Huttonville Creek from south of Bovaird Drive to south of the Mississauga Road Crossing (currently at 60% Design phase) was also provided to WSP. This floodline map presented floodline delineation under both existing and proposed Bovaird Drive crossing structure.

EXISTING UPDATED MODELS

During the project meeting dated September 8th, 2017, CVC requested that WSP staff combine the 2 hydraulic models (the Heritage Heights mode and the East Huttonville Creek model) into one hydraulic model and update the Bovaird Drive Structure in this model. Also, it was

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requested that new cross sections be cut and coded in the East Huttonville Creek using the available contour maps and survey information to update the existing model. CVC also recommended that the existing Mississauga Road Crossing (and not the 60% Design Crossing) be maintained in the existing model. The model will then be considered as "Updated Existing Condition Model".

The following summarizes the updates that WSP staff applied to create the Existing Updated Model:

- Added junction 8 to combine Huttonville Creek and East Huttonville Creek reaches
- Updated cross sections on East Huttonville Creek (HV4-2) as they were not georeferenced. These cross sections are as follow: 4, 5, 6, 7 and 8
- Added cross sections 480 and 490 in Reach HV3-1 to be bounding cross sections for Alignment 1A-West
- Added levees for cross sections adjacent to Mississauga Road to reflect the retaining wall on the east side of Mississauga Road and coded the Mississauga Road in cross sections located east of Mississauga Road.

CVC reviewed the model, made some adjustments and sent it back to WSP to proceed with alternative alignments modeling. This model is called: "Existing_CVC2017"

Summary of changes from CVC is presented below:

- Model result is based on HEC-RAS 5.0.1 simulation.
- Model updates are based on currently approved existing condition model as part of the Mississauga Road EA (2016). Nothing in the existing condition model was changed. This includes Reaches HV3, HV8-1 and HV1.
- Reach H4-2 is added based on the model provided by WSP for the City of Brampton's East West Connector/Lagerfield Road EA project.
- Used the existing 5m span bridge at Mississauga Road crossing (not the 60 percent designed bridge)

After WSP staff received this model we recommended the followings:

- At cross sections 245.7111 and 193.3116 (Reach HV5-1), the Mississauga Road was not shown on the right side of the cross sections and the cross sections were not extended enough to contain the 50, 100 and Regional flows. Therefore, WSP staff were not able to model Alignment 2 between them.
- WSP coded two cross sections (480 and 490) in this reach in order to code Alignment 1 on Mississauga Road. In CVC model, since they used the original model for this reach, these two cross sections don't exist. We needed these 2 cross sections to code Alignment 1.

In response to these two recommendations, CVC added cross sections 480 and 490 to the model and agreed that WSP staff can add the road profile to cross sections 245.7111 and 193.3116. This model is called Existing_CVC2017

ALIGNMENT 1 (A AND B)

Alignment 1A:

Under Alignment 1A, two (2) water crossings are proposed as follows:

- Crossing 1A-East is located on East Huttonville Creek (HV4-2) between cross sections 5 and 6
- Crossing 1-West is located on Huttonville Creek (HV3-1) between cross sections 490 and 480

Alignment 1B:

Under Alignment 1B, two (2) water crossings are proposed as follows:

- Crossing 1B-East is located on East Huttonville Creek (HV4-2) between cross sections 5 and 6
- Crossing 1-West is located on Huttonville Creek (HV3-1) between cross sections 490 and 480

ALIGNMENT 2

Under Alignment 2, there is only one proposed water crossing located on Huttonville Creek (HV5-1) between cross sections 245.7111 and 193.3116

ALIGNMENT 3 (A AND B)

Alignment 3A:

Under Alignment 3A, two (2) water crossings are proposed as follows:

- Crossing 3A-East is located on East Huttonville Creek (HV4-2) between cross sections 5 and 6
- Crossing 3-West is on Huttonville Creek (HV3-1) between cross sections 519.2031 and 496.1559. This crossing is located at the existing Mississauga Road crossing but with different skew angle. The cross sections and the bridge coding was updated to reflect the proposed Alignment 3-west and assess its impact.

Alignment 3B:

Under Alignment 3B, two (2) water crossings are proposed as follows:

- Crossing 3B-East is located on East Huttonville Creek (HV4-2) between cross sections 5 and 6
- Crossing 3-West is on Huttonville Creek (HV3-1) between cross sections 519.2031 and 496.1559. This crossing is located at the existing Mississauga Road crossing but with different skew angle. The cross sections and the bridge coding was updated to reflect the proposed Alignment 3-west and assess its impact.

FLOODLINE DELINEATION AND IMPACTS

Regarding the floodline mapping for Brampton EW connector, the steps that were taken are as follows:

WSP received the updated existing HEC-RAS model from CVC. They made some adjustments in the model to be able to add the proposed alignments in it. A horizontal constant to cross sections 6 and 7 in reach HV4-2 were added (This adjustment does not affect the results of the run). Also, the Mississauga Rd profile was added in the cross sections 245.7111 and 193.3116. In the model that CVC had sent, the road was not assumed in the geometry of these cross sections

and after explaining to CVC, it was agreed that WSP staff should add the road in these cross sections.
Different alignments were added to the model and ran. Based on the new water surface elevations in the model, the new floodline was drawn and compared with the existing floodline. Three layouts were created:

- Existing vs Alignments 1A and 1B
- Existing vs Alignment 2
- Existing vs Alignments 3A and 3B

Also, a comparison table (presented below) was created to show floodline differences between existing condition and all proposed conditions. In this table, values are the horizontal distance between existing and respective proposed alignment. Positive values indicate that the existing floodline is wider than the proposed floodline. Zero values indicate that the existing floodline are either coincide with or narrower than the proposed floodline in that area.

Under Alignment 3, floodlines have significantly improved upstream of the Mississauga crossing compare to the existing crossing (the existing 5 m span bridge). For other alignments, the impact is insignificant. It can be seen in the following table.

It should be noted that the proposed crossings under different alignments have adequate capacity to convey the regional storm event without overtopping the Lagerfeld Dr. extension. However, Mississauga Road is flooded due to the inadequate capacity of the existing culvert.

Sherif Iskandar, M.Sc., P.Eng.,
Water Resources Engineer, WSP

WSP

PROJECT: 141-15049-00 (BRAMPTON EA)
DATE: 03 JULY 2020
DESIGN: S.I.
DRAWN: R.Z.

ALIGNMENT 1 VS. EXISTING

wsp

PROJECT: 141-15049-00 (BRAMPTON EA)
DATE: 03 JULY 2020
DESIGN: S.I.
DRAWN: R.Z

ALIGNMENT 2 VS. EXISTING

wsp

PROJECT: 141-15049-00 (BRAMPTON EA)
DATE: 03 JULY 2020
DESIGN: S.I.
DRAWN: R.Z

ALIGNMENT 3 VS. EXISTING

Maximum Horizontal Increase at each Cross Section (m)

HEC-RAS Station ID location			Max horizontal increase at each cross-section (m)				
Reach	Cross section ID	E/W side	Alignment 1AE-1AW	Alignment 1BE-1AW	Alignment 2	Alignment 3AE-3AW	Alignment 3BE-3AW
HV3-1	1155.7830	West	0.0	0.0	0.0	-5.2	-5.2
		East	0.0	0.0	0.0	-9.4	-9.4
	1057.8680	West	0.0	0.0	0.0	-12.5	-12.5
		East	0.0	0.0	0.0	-26.5	-26.5
	969.9424	West	0.0	0.0	0.0	-23.1	-23.1
		East	0.0	0.0	0.0	-21.6	-21.6
	856.9374	West	0.0	0.0	0.0	-37.4	-37.4
		East	0.0	0.0	0.0	-110.0	-110.0
	749.2748	West	0.0	0.0	0.0	-69.6	-69.6
		East	0.0	0.0	0.0	-172.1	-172.1
	710	West	0.0	0.0	0.0	-5.1	-5.1
		East	0.0	0.0	0.0	-172.6	-172.6
	519.2031	West	0.0	0.0	0.0	-209.4	-209.4
		East	0.0	0.0	0.0	0.0	0.0
	496.1559	West	0.0	0.0	0.0	0.0	0.0
		East	0.0	0.0	0.0	0.0	0.0
	490	West	0.0	0.0	0.0	0.0	0.0
		East	0.0	0.0	0.0	0.0	0.0
	480	West	0.0	0.0	0.0	0.0	0.0
		East	0.0	0.0	0.0	0.0	0.0
	331.0246	West	0.0	0.0	0.0	0.0	0.0
		East	0.0	0.0	0.0	0.0	0.0
HV4-2	8	West	0.0	0.0	0.0	0.0	1.0
		East	0.0	0.0	0.0	0.0	1.0
	7	West	0.0	0.0	0.0	0.0	1.5
		East	0.0	0.0	0.0	0.0	1.0
	6	West	0.0	0.0	0.0	0.0	1.0
		East	0.0	0.0	0.0	0.0	1.0
	5	West	0.0	0.0	0.0	0.0	0.0
		East	0.0	0.0	0.0	0.0	0.0
	4	West	0.0	0.0	0.0	0.0	0.0
		East	0.0	0.0	0.0	0.0	0.0
HV5-1	245.7111	West	0.0	0.0	0.0	0.0	0.0
		East	0.0	0.0	0.0	0.0	0.0
	193.3116	West	0.0	0.0	0.0	0.0	0.0
		East	0.0	0.0	0.0	0.0	0.0

Maximum Vertical Increase at each Cross Section (m)

HEC-RAS Station ID location		Max vertical increase at each cross section (m)										
Reach	Cross section ID	Existing	Alignment 1AE-1AW	Diff	Alignment 1BE-1AW	Diff	Alignment 2	Diff	Alignment 3AE-3AW	Diff	Alignment 3BE-3AW	Diff
HV3-1	1155.783	242.78	242.77	-0.01	242.77	-0.01	242.77	-0.01	242.14	-0.64	242.14	-0.64
	1057.868	242.76	242.75	-0.01	242.75	-0.01	242.75	-0.01	241.53	-1.23	241.53	-1.23
	969.9424	242.76	242.75	-0.01	242.75	-0.01	242.75	-0.01	240.99	-1.77	240.99	-1.77
	856.9374	242.76	242.75	-0.01	242.75	-0.01	242.75	-0.01	240.26	-2.50	240.26	-2.50
	749.2748	242.76	242.75	-0.01	242.75	-0.01	242.75	-0.01	239.49	-3.27	239.49	-3.27
	710	242.76	242.75	-0.01	242.75	-0.01	242.75	-0.01	239.11	-3.65	239.11	-3.65
	519.2031	242.70	242.68	-0.02	242.68	-0.02	242.68	-0.02	238.96	-3.74	238.96	-3.74
	496.1559	238.96	238.99	0.03	238.99	0.03	238.88	-0.08	238.90	-0.06	238.90	-0.06
	490	238.70	238.39	-0.31	238.39	-0.31	238.70	0.00	238.70	0.00	238.70	0.00
	480	237.81	237.81	0.00	237.81	0.00	237.81	0.00	237.81	0.00	237.81	0.00
	331.0246	237.38	237.38	0.00	237.38	0.00	237.45	0.07	237.38	0.00	237.38	0.00
HV4-2	8	240.35	240.31	-0.04	240.31	-0.04	240.35	0.00	240.34	-0.01	240.29	-0.06
	7	239.61	239.69	0.08	239.70	0.08	239.61	0.00	239.62	0.01	239.75	0.14
	6	239.35	239.59	0.24	239.58	0.24	239.35	0.00	239.29	-0.06	239.51	0.16
	5	238.41	238.47	0.06	238.53	0.06	238.41	0.00	238.48	0.07	238.59	0.18
	4	237.33	237.33	0.00	237.33	0.00	237.39	0.06	237.33	0.00	237.33	0.00
HV5-1	245.7111	237.04	237.04	0.00	237.04	0.00	237.08	0.04	237.04	0.00	237.04	0.00
	193.3116	236.94	236.94	0.00	236.94	0.00	236.93	-0.01	236.94	0.00	236.94	0.00

APPENDIX

C

Storm Sewer Design Sheets

STORM DESIGN SHEE1

CITY OF BRAMPTON

Planning and Infrastructure Services

STREET / STATION	AREA NO.	UPSTREAM MH	UPSTREAM INV	DOWNSTREAM MH	DOWNSTREAM INV	NO. OF HECTARES Paved	Grassed	TOTAL	AREA x STORM CO-EFF. 0.25	0.5	0.75	0.95	A x C	TOTAL IN AREA	TOTAL	I_5	I_10	Q_5	Q_10	PIPE LENGTH m	SIZE mm	GRADE	CAPACITY	VEL.	TIME	PIPE CLASS	(NOTE 1) ROAD TYPE	GRADE	CAPACITY
									0.00	0.00	0.00	0.00																	
DESCRIPTIOI									0.00	0.00	0.00	0.00																	
81+477 to 81+538	A	1	242.360	2	241.907	0.13	0.08	0.22	0.02			0.13	0.15	10.00	10.00	105.0	121.9	0.043	0.050	60.4	300	0.75%	0.084	1.18	0.85				
81+538 to 81+637	A	2	241.832	3	241.082	0.22	0.14	0.58	0.03			0.21	0.39	0.85	10.85	99.2	115.2	0.109	0.126	100.0	450	0.75%	0.247	1.55	1.07				
81+637 to 81+706	A	3	241.007	4	240.494	0.15	0.09	0.82	0.02			0.14	0.56	1.07	11.92	92.8	155.4	0.145	0.243	68.4	525	0.75%	0.372	1.72	0.66				
81+272 to 81+299	B	5	241.985	6	241.425	0.17	0.10	0.27	0.03			0.16	0.18	10.00	10.00	105.0	121.9	0.054	0.062	74.7	375	0.75%	0.152	1.37	0.91				
81+299 to 81+223	B	6	241.350	7	240.787	0.17	0.10	0.54	0.03			0.16	0.37	0.91	10.91	98.8	114.8	0.101	0.117	75.0	450	0.75%	0.247	1.55	0.81				
81+223 to 81+170	B	7	240.712	8	240.314	0.12	0.07	0.73	0.02			0.11	0.50	0.81	11.71	94.0	109.3	0.130	0.151	53.1	450	0.75%	0.247	1.55	0.57				
81+170 to 81+092	B	8	240.239	9	239.672	0.21	0.07	1.00	0.02			0.20	0.71	0.57	12.28	90.9	105.7	0.179	0.209	75.7	525	0.75%	0.372	1.72	0.73				
81+092 to 81+029	B	9	239.597	10	239.125	0.17	0.06	1.23	0.01			0.16	0.89	0.73	13.02	87.3	101.5	0.215	0.250	62.9	525	0.75%	0.372	1.72	0.61				
80+800 to 80+857	C	11	240.644	12	240.212	0.15	0.06	0.21	0.02			0.14	0.15	10.00	10.00	105.0	121.9	0.045	0.052	57.6	300	0.75%	0.084	1.18	0.81				
80+857 to 80+908	C	12	240.137	13	239.760	0.13	0.05	0.39	0.01			0.12	0.29	0.81	10.81	99.4	166.2	0.080	0.134	50.3	450	0.75%	0.247	1.55	0.54				
80+684 to 80+622	D	14	242.450	15	241.990	0.17	0.05	0.22	0.01			0.16	0.17	10.00	10.00	105.0	121.9	0.050	0.058	61.3	300	0.75%	0.084	1.18	0.86				
80+622 to 80+559	D	15	241.915	Ex	241.444	0.17	0.06	0.45	0.01			0.16	0.35	0.86	10.86	99.1	165.7	0.096	0.160	62.9	450	0.75%	0.247	1.55	0.68				

SCALE: N.T.S.

DWG NO.: 342

APPROVED:

CHECKED:

DATE:

REVISION:

REV.: DATE:

FLOW => Q= $\frac{2.78 \text{ A.C.I. (m3/s)}}{1000}$

C = RUNOFF COEFFICIENT; PARKS 0.25, SINGLE & SEMI-DETACHED 0.50 MULTIPLE, INSTITUTIONAL, INDUSTRIAL 0.75 & COMMERCIAL 0.90 OR DETAILED DESIGN

RAINFALL INTENSITY (mm/hr) SEE STD. # 343 Inlet Time = 10min

A = AREA (hectares)

PIPE ROUGHNE: **n =** ________ (0.013)

PIPE

LENGTH = m

SIZE = mm

GRADE = PERCENT (%)

CAPACITY = m3/sec

VELOCITY = m/sec

ROAD TYPE

1. ________ **m IN** ________ **m ROW**
2. ________ **m IN** ________ **m ROW**
3. ________ **m IN** ________ **m ROW**
4. ________ **m IN** ________ **m ROW**
5. ________ **m IN** ________ **m ROW**

NOTES

1. COMPLETE ROAD COLUMNS ONLY WHEN Q100 - PIPE CAPACITY >2.4m3/s
2. PIPE CAPACITY + ROAD CAPACITY > Q100

LOCATION: **East-West Connection**

CAL. BY:	DATE:	CHK. BY:	DATE:	SHEET
RZ	08/01/2019	JM	26/03/2020	1 OF 1

APPENDIX

D

Stormwater Management Calculations

APPENDIX

D-1 Erosion Control

	Stormwater Management Calculations	Project:	East West Connection EA (Lagerfeld Road Extension)	No.: 141-15409-00	
wsp	Abstractions and Water Balance	By:	R.Z.	Date: 27/03/2020	Page:
		Checked:	S.I.	Checked: 27/03/2020	1

Land Use	Area (m^2)	Runoff C
Catchment A		
Impervious	5,982	0.90
Pervious	3,718	0.50
Catchment B		
Impervious	10,607	0.90
Pervious	6,593	0.25
Catchment C		
Impervious	5,797	0.90
Pervious	3,603	0.25
Catchment D		
Impervious	8,689	0.90
Pervious	2,811	0.25
Total Site Area:	**47,800**	**0.69**

Surface Type	Area (m^2)	IA (mm)	Volume Abstracted (m^3)	5 mm Volume (m^3)	Water Balance (m^3)
Catchment A					
Impervious	5,982	0.000	0.00	29.91	29.91
Pervious	3,718	0.005	18.59	18.59	0.00
Catchment B					
Impervious	10,607	0.000	0.00	53.03	53.03
Pervious	6,593	0.005	32.97	32.97	0.00
Catchment C					
Impervious	5,797	0.000	0.00	28.98	28.98
Pervious	3,603	0.005	18.02	18.02	0.00
Catchment D					
Impervious	8,689	0.000	0.00	43.44	43.44
Pervious	2,811	0.005	14.06	14.06	0.00
Total Site Area:	**47,800**	**-**	**83.63**	**239.00**	**155.37**

It is assumed that soft landscaped areas will abstract 5mm of rainfall volume

Therefore, volume of runoff during a 5 mm storm event: **155.37** m^3

APPENDIX

D-2 Bioretention and Urban Tree Root Support System Sizing

WSP	Stormwater Management Calculations	Project:	East West Connection EA (Lagerfeld Road Extension)	No.:	141-15409-00
	Bioretention and Urban Tree Root Support System Calculations	By:	R.Z.	Date:	27/03/2020	Page:
		Checked:	S.I.	Checked:	27/03/2020	1

TABLE C1

Percolation			
Substrate	Hydraulic Conductivity 'K' (cm/s)	Percolation Rate (mm/hr)	Safety Factor
Native Interface	1.40E-04	51	2.5
N/A			
	Ratio	N/A	
Drawdown Time (hrs)			48
Design Infiltration Rate (mm/hr)			20
Max. Reservoir Depth (mm)			972

TABLE C2

Bioretention Layers				
Layer	Depth (mm)	Void Ratio	Storage (mm)	Top Elevation (mASL)
Freeboard	150	0	0	
Ponding	200	1	200	
Mulch	100	0.7	70	
Filter Media	600	0.3	180	
Choking	100	0.4	40	
Clear Stone + Pipe	300	0.4	120	
TOTAL (mm)	1450	0	610	
TOTAL (m)	1.45	0	0.61	

TABLE C3

Abstraction		
Surface	Initial Abstraction (mm)	Rainfall (mm)
Road	1	15
Grass	5	5

TABLE C4

Site Catchment Areas								
Catchment ID	Pavement (m)	Sidewalk / Blvd(m)	Curb & Gutter (m)	Grass / Other (m)	Total Width (m)	Total Area (ha)	Area of Impervious (ha)	Area of Pervious (ha)
A	17.6	3.6	1	13.8	36	0.97	0.60	0.37
B	17.6	3.6	1	13.8	36	1.72	1.06	0.66
C	17.6	3.6	1	13.8	36	0.94	0.58	0.36
D	20.9	5.3	1	8.8	36	1.15	0.87	0.28
					TOTAL	4.78	3.11	1.67

TABLE C5

Urban Tree Root Support System				
Water Quality Volume (m^3)	Soil Void Ratio	Soil Media Volume Required (m^3)	Soil Volume per Tree	Total Number of Trees
155.4	0.3	518	20	26

TABLE C6

Bioretention Sizing for Volume Storage											
Catchment ID	Road Length (m)	% Length of LID Coverage	Road Length of LID Coverage (m)	Catchment Area (ha)	Initial Abstraction (m^3)	Runoff to be Treated (m^3)	Storage Depth (m)	Footprint Required (m^2)	Minimum Width Required (m)	Minimum Width per Road Side (m)	Impervious to LID Ratio
A	269	1.00	269	0.97	18.6	29.9	0.61	49	0.2	0.1	122.0
B	478	0.75	358	1.72	33.0	53.0	0.61	87	0.2	0.1	122.0
C	261	0.25	65	0.94	18.0	29.0	0.61	48	0.7	0.4	122.0
D	319	1.00	319	1.15	14.1	43.4	0.61	71	0.2	0.1	122.0
TOTAL	1,328		1013	4.78		155.4		255			

Note: Catchment D is sized for the 5 mm event for water balance. Water quality and erosion control is taken care of by the SWM pond to the north.

TABLE C7

Bioretention Spacing										
Catchment ID	Road Length (m)	Road Width (m)	Catchment Area (ha)	Initial Abstraction (m^3)	Runoff to be Treated (m^3)	Storage Depth (m)	Footprint Required (m^2)	Pervious Width (m)	Bioretention Width (m)	Bioretention Length (m)
Spacing	75	17.6	0.13	2.6	17.2	0.61	28	6.9	2.5	11.3

APPENDIX

D-3 Water Balance

Table H-1: Pre and Post-Development Water Balance (mm Equivalents)

Longitude	79	degrees	52	minutes	W
Latitude:	43	degrees	38	minutes	N

Weather Station Data: GEORGETOWN WWTP, Brampton, ON (1981-2010)

Data Provided by Environment Canada - Atmospheric Environment Services - data may exhibit round off erroı

PARAMETER		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Pre-Development Conditions														**Per Unit Area**
Agricultural Areas to be Developed														
Soil Moisture Storage (from MECP)	**200** mm													
Average Temperature (C)		-6.3	-5.2	-0.9	6.0	12.3	17.4	20.0	19.0	14.8	8.4	2.8	-2.9	**7**
Precipitation (P) (mm)		67.8	60.0	57.2	76.5	79.3	74.8	73.5	79.3	86.2	68.3	88.5	65.9	**877**
Rainfall (mm)		29.7	28.4	35.2	71.3	79.0	74.8	73.5	79.3	86.2	67.8	79.9	36.4	742
Heat index (i)					1.3	3.9	6.6	8.2	7.5	5.2	2.2	0.4		
TE (calculated)	35													
Thornwait's constant (a)		1.1												
Evapotranspiration (U) mm					28	60	87	100	95	73	40	13		
Adjustment factor (N) - from literature				11.90	13.40	14.65	15.30	15.05	13.95	12.60	11.05	9.75		
Adjustment factor (Nm) - (N/12)				1	1	1	1	1	1	1	1	1		
Potential Evapotranspiration (PET) (mm)				0.0	31.3	73.2	110.4	125.8	110.5	76.6	36.9	10.2		**575**
Actual Evapotranspiration (AET) (mm)				0.0	31.3	73.2	110.4	125.8	110.5	76.6	36.9	10.2		**575**
Soil Moisture (mm)		200.0	200.0	200.0	200.0	200.0	164.4	112.1	80.9	90.5	121.4	191.1	200.0	
Change in Soil Moisture Storage (mm)		0	0	0	0	0	-36	-52	-31	10	31	70	9	
Surplus - available for infiltration/runoff (mm)		67.8	60.0	57.2	45.2	6.1	0.0	0.0	0.0	9.6	31.4	78.3	65.9	**422**
Data for Use with Pre-Development Water Balance														
Precipitation (P) (mm)		67.8	60.0	57.2	76.5	79.3	74.8	73.5	79.3	86.2	68.3	88.5	65.9	**877.3**
Actual Evapotranspiration (AET) (mm)		0.0	0.0	0.0	31.3	73.2	110.4	125.8	110.5	76.6	36.9	10.2	0.0	**574.9**
Surplus - available for infiltration/runoff (mm)		67.8	60.0	57.2	45.2	6.1	0.0	0.0	0.0	9.6	31.4	78.3	65.9	**421.5**
Pasture														
Infiltration (MOE Methodology) (mm)	**i = 0.40**	27.1	24.0	22.9	18.1	2.4	0.0	0.0	0.0	3.8	12.6	31.3	26.4	**168.6**
Runoff (MOE Methodology) (mm)		40.7	36.0	34.3	27.1	3.7	0.0	0.0	0.0	5.8	18.9	47.0	39.5	**252.9**

Total Annual For Site Area	4.78	ha
Infiltration	8,060	m^3
Evapotranspiration	21,786	m^3
Runoff	12,089	m^3

Notes:

1. Monthly climate data were provided by Environment Canada. Evapotranspiration has been determined using Thornthwaite and Mather (1957) equation.
2. Infiltration and Runoff volumes are calculated using the methodology described in the MOE Stormwater Design Manual (2003).
3. There is minor round-off error within the Environment Canada data

Table H-1: Pre and Post-Development Water Balance (mm Equivalents)

Longitude	79	degrees	52	minutes	W
Latitude:	43	degrees	38	minutes	N

Weather Station Data: GEORGETOWN WWTP, Brampton, ON (1981-2010)

Data Provided by Environment Canada - Atmospheric Environment Services - data may exhibit round off erroi

PARAMETER		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Post Development Conditions														**Per Unit Area**
Grassed Boulevard Area														
Soil Moisture Storage (from MECP)	**100** mm													
Average Temperature (C)		-6.3	-5.2	-0.9	6	12.3	17.4	20	19	14.8	8.4	2.8	-2.9	**7**
Precipitation (P) (mm)		67.8	60.0	57.2	76.5	79.3	74.8	73.5	79.3	86.2	68.3	88.5	65.9	**877**
Rainfall (mm)		29.7	28.4	35.2	71.3	79.0	74.8	73.5	79.3	86.2	67.8	79.9	36.4	**742**
Heat index (i)					1.3	3.9	6.6	8.2	7.5	5.2	2.2	0.4		
TE (calculated)	35													
Thornwait's constant (a)		1												
Evapotranspiration (U) mm					28	60	87	100	95	73	40	13		
Adjustment factor (N) - from literature				11.90	13.40	14.65	15.30	15.05	13.95	12.60	11.05	9.75		
Adjustment factor (Nm) - (N/12)				1	1	1	1	1	1	1	1	1		
Potential Evapotranspiration (PET) (mm)				0.0	31.3	73.2	110.4	125.8	110.5	76.6	36.9	10.2		**575**
Actual Evapotranspiration (AET) (mm)				0.0	31.3	73.2	110.4	125.8	110.5	76.6	36.9	10.2		**575**
Soil Moisture (mm)		100	100	100.0	100.0	100.0	64.4	12.1	-19.1	-9.5	75.0	75.0	75.0	
Change in Soil Moisture Storage (mm)		25	0	0	0	0	-36	-52	-31	10	85	0	0	
Surplus - available for infiltration/runoff (mm)		67.8	60.0	57.2	45.2	6.1	0.0	0.0	0.0	9.6	31.4	78.3	65.9	**422**
Data for Use with Post-Development Water Balance														
Precipitation (P) (mm)		67.8	60.0	57.2	76.5	79.3	74.8	73.5	79.3	86.2	68.3	88.5	65.9	**877.3**
Actual Evapotranspiration (AET) (mm)		0.0	0.0	0.0	31.3	73.2	110.4	125.8	110.5	76.6	36.9	10.2	0.0	**574.9**
Surplus - available for infiltration/runoff (mm)		67.8	60.0	57.2	45.2	6.1	0.0	0.0	0.0	9.6	31.4	78.3	65.9	**421.5**
Grassed Boulevard														
Infiltration (MOE Methodology) (mm)	**i = 0.40**	27.1	24.0	22.9	18.1	2.4	0.0	0.0	0.0	3.8	12.6	31.3	26.4	**168.6**
Runoff (MOE Methodology) (mm)		40.7	36.0	34.3	27.1	3.7	0.0	0.0	0.0	5.8	18.9	47.0	39.5	**252.9**

Total Annual For Site Area	4.78	ha
Infiltration	2,816	m^3
Evapotranspiration	10,340	m^3
Runoff	28,779	m^3

Notes:

1. Monthly climate data were provided by Environment Canada. Evapotranspiration has been determined using Thornthwaite and Mather (1957) equation.
2. Infiltration and Runoff volumes are calculated using the methodology described in the MOE Stormwater Design Manual (2003). Calculation of the infiltration factors used in the
3. There is minor round-off error within the Environment Canada data
4. Area Breakdown for Site:

   *Paved ROW Surface (ha): 3.11 Landscaped ROW Surface (ha): 1.67

*Runoff from roadways is assumed 90% of precipitation to account for initial abstraction

Table H-1: Pre and Post-Development Water Balance (mm Equivalents)

Weather Station Data: GEORGETOWN WWTP, Brampton, ON (1981-2010)

Longitude 79 degrees 52 minutes W
Latitude: 43 degrees 38 minutes N

Data Provided by Environment Canada - Atmospheric Environment Services - data may exhibit round off error

PARAMETER	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
Post Development Conditions with Mitigation Measures													**Per Unit Area**
Grassed Boulevard Area													
Soil Moisture Storage (from MECP) 100 mm													
Average Temperature (C)	-6.3	-5.2	-0.9	6	12.3	17.4	20	19	14.8	8.4	2.8	-2.9	7
Precipitation (P) (mm)	67.8	60	57.2	76.5	79.3	74.8	73.5	79.3	86.2	68.3	88.5	65.9	877
Rainfall (mm)	29.7	28.4	35.2	71.3	79.0	74.8	73.5	79.3	86.2	67.8	79.9	36.4	742
Heat index (i)				1.3	3.9	6.6	8.2	7.5	5.2	2.2	0.4		
TE (calculated) 35													
Thornwait's constant (a)	1												
Evapotranspiration (U) mm				28	60	87	100	95	73	40	13		
Adjustment factor (N) - from literature			11.90	13.40	14.65	15.30	15.05	13.95	12.60	11.05	9.75		
Adjustment factor (Nm) - (N/12)			1	1	1	1	1	1	1	1	1		
Potential Evapotranspiration (PET) (mm)			0.0	31.3	73.2	110.4	125.8	110.5	76.6	36.9	10.2		575
Actual Evapotranspiration (AET) (mm)			0.0	31.3	73.2	110.4	125.8	110.5	76.6	36.9	10.2		575
Soil Moisture (mm)	100.0	100.0	100.0	100.0	100.0	64.4	12.1	-19.1	-9.5	75.0	75.0	75.0	
Change in Soil Moisture Storage (mm)	25	0	0	0	0	-36	-52	-31	10	85	0	0	
Surplus - available for infiltration/runoff (mm)	67.8	60.0	57.2	45.2	6.1	0.0	0.0	0.0	9.6	31.4	78.3	65.9	422
Data for Use with Post-Development Water Balance													
Precipitation (P) (mm)	67.8	60.0	57.2	76.5	79.3	74.8	73.5	79.3	86.2	68.3	88.5	65.9	877.3
Actual Evapotranspiration (AET) (mm)	0.0	0.0	0.0	31.3	73.2	110.4	125.8	110.5	76.6	36.9	10.2	0.0	574.9
Surplus - available for infiltration/runoff (mm)	67.8	60.0	57.2	45.2	6.1	0.0	0.0	0.0	9.6	31.4	78.3	65.9	421.5
Grassed Boulevard													
												Area (ha):	1.64
Infiltration (MOE Methodology) (m^3) i = 0.40	27.1	24.0	22.9	18.1	2.4	0.0	0.0	0.0	3.8	12.6	31.3	26.4	168.6
Runoff (MOE Methodology) (m^3)	40.7	36.0	34.3	27.1	3.7	0.0	0.0	0.0	5.8	18.9	47.0	39.5	252.9
Runoff Directed to Bio-Swale - Catchments A, B, C													
												Area (ha):	3.14
Infiltration (MOE Methodology) (m^3) i = 0.90	61.0	54.0	51.5	68.9	71.4	67.3	66.2	71.4	77.6	61.5	79.7	59.3	789.6
Runoff (MOE Methodology) (m^3)	6.8	6.0	5.7	7.6	7.9	7.5	7.3	7.9	8.6	6.8	8.8	6.6	87.7
Runoff Directed to Bio-Swale - Catchment D													
												Area (ha):	0.87
Infiltration (MOE Methodology) (m^3) i = 0.50	61.0	54.0	51.5	68.9	71.4	67.3	66.2	71.4	77.6	61.5	79.7	59.3	789.6
Runoff (MOE Methodology) (m^3)	6.8	6.0	5.7	7.6	7.9	7.5	7.3	7.9	8.6	6.8	8.8	6.6	87.7

Total Annual For Site Area	4.78	ha
Infiltration	34,399	m^3
Evapotranspiration	(137)	m^3
Runoff	7,673	m^3

Notes:

1. Monthly climate data were provided by Environment Canada. Evapotranspiration has been determined using Thornthwaite and Mather (1957) equation.
2. Infiltration and Runoff volumes are calculated using the methodology described in the MOE Stormwater Design Manual (2003). Calculation of the infiltration factors used in the
3. There is minor round-off error within the Environment Canada data
4. Area Breakdown for Site:
   *Paved ROW Surface Catchments A, B, C(ha): 3.11 Landscaped (ha): 1.64 Bioswale Catchments A, B, C (ha): 0.026
   *Paved ROW Surface Catchment D (ha): 0.87 Bioswale Catchment D (ha): 0.000

APPENDIX

E

Visual OTTHYMO 5 Model Output – Regional Storm

Catchments A, B, & C

```
********************************
** SIMULATION:Run 01          **
********************************

--------------------
|    READ STORM    |    Filename: C:\Users\james.michener\AppD
|                  |              ata\Local\Temp\
|                  |              98980464-6e92-4fdc-883b-d4f91c1471ee\bc6288e2
| Ptotal=212.00 mm |    Comments: Hazel
--------------------
                 TIME    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
                  hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
                 1.00    6.00 |  4.00   13.00 |  7.00   23.00 | 10.00   53.00
                 2.00    4.00 |  5.00   17.00 |  8.00   13.00 | 11.00   38.00
                 3.00    6.00 |  6.00   13.00 |  9.00   13.00 | 12.00   13.00

-------------------------------------------------------------------------------

--------------------
| CALIB            |
| STANDHYD (  0001)|   Area    (ha)=   3.38
|ID= 1 DT= 5.0 min |   Total Imp(%)=  59.00   Dir. Conn.(%)=  59.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       1.99          1.39
     Dep. Storage     (mm)=       1.00          1.50
     Average Slope     (%)=       3.00          2.00
     Length            (m)=     334.00          4.00
     Mannings n           =      0.013         0.250

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.


                               ---- TRANSFORMED HYETOGRAPH ----
                 TIME    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
                  hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
                0.083    6.00 | 3.083   13.00 | 6.083   23.00 |  9.08   53.00
                0.167    6.00 | 3.167   13.00 | 6.167   23.00 |  9.17   53.00
                0.250    6.00 | 3.250   13.00 | 6.250   23.00 |  9.25   53.00
                0.333    6.00 | 3.333   13.00 | 6.333   23.00 |  9.33   53.00
                0.417    6.00 | 3.417   13.00 | 6.417   23.00 |  9.42   53.00
                0.500    6.00 | 3.500   13.00 | 6.500   23.00 |  9.50   53.00
                0.583    6.00 | 3.583   13.00 | 6.583   23.00 |  9.58   53.00
                0.667    6.00 | 3.667   13.00 | 6.667   23.00 |  9.67   53.00
                0.750    6.00 | 3.750   13.00 | 6.750   23.00 |  9.75   53.00
                0.833    6.00 | 3.833   13.00 | 6.833   23.00 |  9.83   53.00
                0.917    6.00 | 3.917   13.00 | 6.917   23.00 |  9.92   53.00
                1.000    6.00 | 4.000   13.00 | 7.000   23.00 | 10.00   53.00
                1.083    4.00 | 4.083   17.00 | 7.083   13.00 | 10.08   38.00
                1.167    4.00 | 4.167   17.00 | 7.167   13.00 | 10.17   38.00
                1.250    4.00 | 4.250   17.00 | 7.250   13.00 | 10.25   38.00
                1.333    4.00 | 4.333   17.00 | 7.333   13.00 | 10.33   38.00
                1.417    4.00 | 4.417   17.00 | 7.417   13.00 | 10.42   38.00
                1.500    4.00 | 4.500   17.00 | 7.500   13.00 | 10.50   38.00
                1.583    4.00 | 4.583   17.00 | 7.583   13.00 | 10.58   38.00
                1.667    4.00 | 4.667   17.00 | 7.667   13.00 | 10.67   38.00
                1.750    4.00 | 4.750   17.00 | 7.750   13.00 | 10.75   38.00
                1.833    4.00 | 4.833   17.00 | 7.833   13.00 | 10.83   38.00
                1.917    4.00 | 4.917   17.00 | 7.917   13.00 | 10.92   38.00
                2.000    4.00 | 5.000   17.00 | 8.000   13.00 | 11.00   38.00
                2.083    6.00 | 5.083   13.00 | 8.083   13.00 | 11.08   13.00
                2.167    6.00 | 5.167   13.00 | 8.167   13.00 | 11.17   13.00
                2.250    6.00 | 5.250   13.00 | 8.250   13.00 | 11.25   13.00
                2.333    6.00 | 5.333   13.00 | 8.333   13.00 | 11.33   13.00
                2.417    6.00 | 5.417   13.00 | 8.417   13.00 | 11.42   13.00
                2.500    6.00 | 5.500   13.00 | 8.500   13.00 | 11.50   13.00
                2.583    6.00 | 5.583   13.00 | 8.583   13.00 | 11.58   13.00
                2.667    6.00 | 5.667   13.00 | 8.667   13.00 | 11.67   13.00
                2.750    6.00 | 5.750   13.00 | 8.750   13.00 | 11.75   13.00
                2.833    6.00 | 5.833   13.00 | 8.833   13.00 | 11.83   13.00
                2.917    6.00 | 5.917   13.00 | 8.917   13.00 | 11.92   13.00
                3.000    6.00 | 6.000   13.00 | 9.000   13.00 | 12.00   13.00

     Max.Eff.Inten.(mm/hr)=      53.00         45.93
                over (min)        5.00         10.00
     Storage Coeff.  (min)=       4.88 (ii)     6.86 (ii)
     Unit Hyd. Tpeak (min)=       5.00         10.00
     Unit Hyd. peak  (cms)=       0.22          0.14
                                                             *TOTALS*
     PEAK FLOW       (cms)=       0.29          0.18           0.469 (iii)
     TIME TO PEAK    (hrs)=      10.00         10.00           10.00
     RUNOFF VOLUME    (mm)=     211.00        147.83          185.10
     TOTAL RAINFALL   (mm)=     212.00        212.00          212.00
     RUNOFF COEFFICIENT   =       1.00          0.70            0.87
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***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  74.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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