Appendix K – Stormwater Management Report

Kennedy Road Environmental Assessment between Steeles Avenue and Major Mackenzie Drive

Kennedy Road Class Environmental Assessment

Steeles Avenue to Major Mackenzie Drive

City of Markham

Drainage and Stormwater Management Report

Regional Municipality of York

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1 Introduction

The Regional Municipality of York is initiating a Schedule C Municipal Class Environmental Assessment (EA) Study to review the current and future transportation needs for Kennedy Road, from Steeles Avenue to Major Mackenzie Drive. HDR has been retained by York Region to conduct the Kennedy Road Class EA Study.

This Drainage and Stormwater Management Report has been prepared in support of the Class EA Study and complies with the Ministry of the Environment, Conservation and Parks (MECP), Toronto Region Conservation Authority (TRCA), Regional Municipality of York, and City of Markham's Policies and Standards. The Kennedy Road Class EA study limits are illustrated in **Figure 1**.

Figure 1: Study Area and Study Corridor

The Kennedy Road Class EA study limits span approximately 9 km of regional road in the City of Markham. Kennedy Road is a major four-lane north-south arterial road within the project limits, and intersects with a number of existing and future local roads, highways and entrances. The existing right-of-way and land use varies throughout the study corridor.

There are two watercourses that cross Kennedy Road within the project limits, namely the Rouge River and an unnamed tributary to the Rouge River.

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

- Identify and evaluate existing drainage patterns and transverse culvert and bridge locations;

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

1.1 Background information

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

1. York Region Road Design Guidelines, 2019;
2. Ministry of the Environment (MECP) Stormwater Management Practices Planning and Design Manual, March 2003;
3. Ministry of Transportation (MTO) Highway Drainage Design Standards, January 2008;
4. Toronto and Region Conservation Authority (TRCA) Stormwater Management Criteria, August 2012;
5. Toronto and Region Conservation Authority (TRCA) and Credit Valley Conservation (CVC) Low Impact Development Stormwater Management Planning and Design Guide, 2010;
6. Toronto and Region Conservation Authority (TRCA) Rouge River Watershed Hydrology Study Update, prepared by Wood, September 2018;
7. City of Markham Stormwater Management Guidelines, October 2016;
8. City of Markham Design Criteria, Section E Storm - Drainage & Stormwater Management, June 2016 (Rev.3);
9. Fluvial Geomorphic Assessment, prepared by Golder Associates, January 2019;
10. Natural Environment Report – Existing Conditions, prepared by LGL Limited, May 2, 2018;
11. Geotechnical and Hydrogeological Desktop Study Report, prepared by Golder Associates, Feb. 1, 2018;
12. Hydrogeological Assessment Report, prepared by Golder Associates Limited, October 2019;
13. Structural Assessment Report for Kennedy Road EA, prepared by HDR, August 2017;
14. South Unionville Environmental Master Drainage Plan, prepared by Cosburn Patterson Mather Limited and Gartner Lee Limited, November 1996;
15. South Unionville Square Functional Servicing Report, prepared by Masongsong Associates Engineering Limited, August 2009;
16. MECP Response to Notice of Commencement Letter dated May 2017; and
17. Unionville SPA 2D Study and Floodplain Mapping update, prepared by Valdor Engineering Inc., February 2019.

2 Existing Drainage Conditions

2.1 Watershed and Subwatershed

The Toronto and Region Conservation Authority (TRCA) has jurisdiction with respect to drainage and stormwater management of the Rouge River Watershed within the Kennedy Road Class EA project limits. The study area also falls under the jurisdiction of the Ministry of Natural Resources and Forestry (MNRF) Aurora District. There are a total of two (2) major water crossings within the study limits, both located within the TRCA regulated Rouge River Watershed. The Rouge River Watershed encompasses approximately 340 km^2 of land area. Refer to the Environmental Assessment Drainage Plan in **Appendix A** for watercourse crossing locations.

2.2 Land Use

Based on the site investigation and the available information, the existing land use for the adjacent properties along Kennedy Road varies along the study corridor and includes commercial, industrial and residential properties.

2.3 Hydrogeological Conditions

A Hydrogeological Assessment was completed for Kennedy Road EA by Golder Associates Ltd. in October, 2019. As part of this investigation, thirteen (13) boreholes were drilled and five (5) monitoring wells were installed within the study corridor to measure groundwater levels and soil material properties. The monitoring wells were installed at the GO Rail Crossing at Clayton Drive, CN Rail Crossing, Highway 407, Rouge River Tributary, Rouge River, and GO Rail Crossing at Austin Drive locations.

The Hvorslev method was used to estimate the hydraulic conductivity of the soil material at the watercourse crossing locations based on the results of single monitoring well response tests (SWRT). The resulting estimated hydraulic conductivity was 5×10^{-9} m/s at the Rouge River Tributary crossing and 7×10^{-5} m/s at the Rouge River crossing. Taking the average of the two hydraulic conductivities, the value of 3.5×10^{-5} m/s was utilized for further calculation purposes. The hydraulic conductivity of 3.5×10^{-5} m/s approximately corresponds to an infiltration rate of 96 mm/hr, as per Table C1 of Appendix C of the CVC/TRCA LID SWM Planning and Design Guide (2010). Considering the size of the catchment areas, the method used to determine the hydraulic conductivity, and the soil texture, a safety correction factor of 3 was applied to estimate the soil infiltration rate at the base of the proposed BMPs. Using an infiltration rate of 96 mm/hr and a safety factor of 3, the percolation rate of the native soil is estimated to be 32 mm/hr.

As part of the Hydrogeological Investigation, groundwater levels were measured from the monitoring wells at the crossing locations in December 2018 and January 2019. According to the results, the groundwater at the Rouge River Tributary crossing was 4.6 m below the ground surface, and at the Rouge River crossing location was 3.4 m below the ground surface. Throughout the entire project corridor, the groundwater levels ranged from 1.4 to 10.8 m below the ground surface.

During the detailed design stage, a hydrogeotechnical investigation including in-situ infiltration rate measurements should be completed at all proposed LID locations to confirm the soil infiltration rates and groundwater levels.

2.4 Existing Drainage Patterns

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

Table 2-1: Summary of Existing Drainage Conditions

Drainage Area ID	Description	Drainage Area (ha)	From Station	To Station	Discharge Location	Ultimate Outfall
A-1	From Steeles Ave. to 130 m north of Clayton Dr.	2.54	10+093	10+655	Existing storm sewer system (Kennedy Rd. south of Steeles Ave)	Beyond study limits (Kennedy Rd. Storm Sewer)
A-2	From 130 m north of Clayton Dr. to GO Rail	0.83	10+655	10+810	Existing storm sewer system (Kennedy Rd. south of Steeles Ave)	Beyond study limits (Kennedy Rd. Storm Sewer)
A-3	From GO Rail to 90 m south of Gorvette Dr.	0.80	10+810	10+990	Existing storm sewer system (Denison Street)	Beyond study limits (Fenton Rd. Storm Sewer)
A-4	From 90 m south of Gorvette Dr. to 250 m south of Highglen Ave.	3.08	10+990	11+673	Existing storm sewer system (Denison Street)	Beyond study limits (Fenton Rd. Storm Sewer)
A-5	From 250 m south of Highglen Ave. to 130 m south of 14th Ave.	2.40	11+673	12+225	Existing storm sewer system (Fresno Court)	Beyond study limits (Fenton Rd. Storm Sewer)
A-6	From 130 m south of 14th Ave. to14th Ave.	0.64	12+225	12+361	Existing storm sewer system (14th Avenue)	Rouge River Tributary
A-7	From 14th Ave. to Hwy. 407 Bridge	3.12	12+361	13+144	Existing storm sewer system (along Main St. Unionville / former Kennedy Rd. right-of-way)	Rouge River Tributary
A-8	From Hwy. 407 Bridge to Helen Ave.	1.39	13+144	13+505	Existing storm sewer system (along Main St. Unionville / former Kennedy Rd. right-of-way)	Rouge River Tributary
A-9	From Helen Ave. to 180 m north of Helen Ave.	0.82	13+505	13+677	Culvert crossing at the Rouge River Tributary	Rouge River Tributary
A-10	From 280 m north of Helen Ave. to Avoca Dr.	2.92	13+677	14+311	Existing storm sewer system discharging to the Rouge River Tributary	Rouge River Tributary
A-11	From Avoca Dr. to Hwy. 7	1.89	14+311	14+693	Existing storm sewer system (Hwy. 7)	Rouge River
A-12	From Hwy. 7 to GO Rail crossing 90 m north of Austin Dr.	2.01	14+693	15+197	Rouge River	Rouge River
A-13	From GO Rail crossing 90 m north of Austin Dr. to Carlton Rd.	1.31	15+197	15+498	Existing storm sewer system (Austin Dr.) discharging to a SWM pond	Rouge River
A-14	From Carlton Rd. to 330 m north of Carlton Rd.	1.28	15+498	15+825	Existing storm sewer system (Carlton Rd.)	Bruce Creek
A-15	From 330 m north of Carlton Rd. to 60 m north of The Bridle Tr.	2.11	15+825	16+364	Existing storm sewer system (The Bridle Tr.)	Bruce Creek
A-16	From 60 m north of The Bridle Tr. To 16th Ave.	1.94	16+364	16+883	Existing storm sewer system (Rosemead Close)	Bruce Creek
A-17	From 16th Ave. to Wilfred Murison Ave.	2.47	16+883	17+493	Existing storm sewer system (16th Ave.)	Bruce Creek
A-18	From Wilfred Murison Ave. to Castlemore Ave.	4.67	17+493	18+540	Existing SWM pond west of Kennedy Rd. discharging to Bruce Creek	Bruce Creek
A-19	From Castlemore Ave. to Major Mackenzie Dr.	1.70	18+540	18+922	Existing storm sewer system (Major Mackenzie Dr.)	Bruce Creek

Drainage Area A-7 discharges south of the Highway 407 Bridge to an existing 700 mm storm sewer crossing Highway 407, which increases in diameter to 825mm and 900mm further downstream. Drainage Area A-8 discharges to the same storm sewer north of the Highway 407 Bridge. The 900mm storm sewer runs along the former Kennedy Road right-of-way, which is now known as Main Street Unionville.

2.5 Aquatic Resources

The two watercourses that exist within the project limits are under the jurisdiction of the Toronto and Region Conservation Authority (TRCA) and the Ministry of Natural Resources and Forestry (MNRF). The watercourse crossings identified within the study area include an unnamed tributary to the Rouge River ("Rouge River Tributary"), which is classified as a warmwater riverine habitat in its timing window (July 1 to March 31), and the main reach of the Rouge River, which is also classified as a warmwater riverine habitat.

Through the aquatic habitats and communities analysis, Redside Dace was identified as a species at risk. In a meeting with MNRF on June 27, 2018, MNRF confirmed that Rouge River crossing at Kennedy Road is considered a contributing habitat of Redside Dace and not historic/potential habitat. It was clarified that contributing habitat does not require Species At Risk permitting during construction. The Rouge River Tributary crossing is not identified as regulated habitat for Redside Dace.

2.6 Transverse Drainage Crossings

There are two watercourse crossings within the Kennedy Road EA study corridor, which are the Rouge River Tributary and the Main Reach of the Rouge River. Both crossings are located within the Rouge River watershed, which is regulated by the TRCA. **Table 2-2** summarizes the size, type, and location of the culvert and bridge structures. Refer to the Drainage Plans provided in **Appendix A** for additional details.

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

Watercourse Crossing	Location of Crossing	Culvert/Bridge Cross-Sectional Dimensions (m) (Width x Height) (Span)	Culvert/Bridge Description	Crossing Length (m)
Rouge River Tributary	500m north of Highway 407	2 - 1.43 x 0.90	Twin CSP* Arch Culverts	47.5
Rouge River	350m north of Highway 7	30.5	Single-span Bridge	18.9

*CSP – Corrugated Steel Pipe

2.6.1 Existing Condition Summary

The Structural Assessment Report by HDR dated August 2017, provides detailed information regarding the existing condition of the Rouge River Bridge. A site visit was conducted by HDR structural staff on June 8, 2017. Structural assessment was not conducted for the twin CSP arch culverts at the Rouge River Tributary, as these culverts are not considered to be structural culverts (under 3.0m span).

Table 2-3 describes the structural conditions of the existing watercourse crossing at Rouge River.

Table 2-3: Summary of Transverse Crossings Condition Assessment

Watercourse Crossing	Material/ Crossing Type	Existing Conditions*
Rouge River	Single-span Concrete Girder Bridge	Good condition requiring maintenance rehabilitation

*Per Structures Assessment Report by HDR (August 2017)

2.6.2 Assessment Criteria

In view of the proposed improvements, a hydraulic assessment of the existing transverse crossings within the Kennedy Road Class EA study corridor were undertaken in accordance with the Ontario Ministry of Transportation's Highway Drainage Design Standards (2008) and the York Region Road Design Guidelines (2019).

Design Flows

Based on the MTO Drainage Standard WC-1, the design flow for structures crossings Freeway & Urban Arterial roadways with spans less than 6.0 m is the 50-year flow. For structures with spans greater than 6.0 m, the design flow is the 100-year flow. The Check Flow for Freeway and Urban Arterial roadways is specified as 130% of the 100-year flow.

Freeboard

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

The minimum required freeboard for bridge crossings of Freeway & Urban Arterial roadways is specified to be a minimum of 1.0 m between the design high water level and the edge of the travelled lane as per MTO Drainage Standard WC-2: Freeboard and Clearance at Bridge Crossings.

As per the MTO Drainage Standard WC-7, the upstream water level generated by the Check Flow shall not exceed the elevation of the edge of the traveled lane.

Clearance

The minimum required clearance for bridge crossings of Freeway & Urban Arterial roadways is specified to be a minimum of 1.0 m between the design high water level and the lowest point of the soffit as per MTO Drainage Standard WC-2.

For open footing culverts, a minimum clearance of 0.3 m between the design high water level and the top of the culvert opening is specified as per MTO Drainage Standard WC-7. For closed footing culverts with a maximum diameter or rise of 3.0 m on Freeways, Arterials, and Collector roadways a maximum ratio of flood depth to the diameter or rise of the culvert (HW/D) of 1.5 is specified as per WC-7.

Minimum Culvert Sizes

The minimum culvert size for an entrance culvert is 500 mm diameter and the minimum culvert size for roadway crossings is 800 mm diameter as per the York Region Road Design Guidelines.

2.6.3 Hydraulic Assessment of Existing Transverse Crossings

A hydraulic analysis was conducted for the crossings within the study corridor to assess their hydraulic capacity under the existing conditions. A HEC-RAS hydraulic model was obtained from the Toronto and Region Conservation Authority (TRCA) for the Rouge River crossing. A hydraulic model was not available for the Rouge River Tributary crossing.

Design Flows

Since a hydraulic model is not available for the Rouge River Tributary, the peak flows at this crossing were calculated using the Rational Method, which is most appropriate for catchment areas smaller than 100 ha, according to the MTO Drainage Design Manual. The Drainage Area Plan and associated calculations are included in **Appendix B**. In this method, the peak flow is calculated using the following formula:

$$Q = C \times i \times A$$

where *C* is the weighted runoff coefficient for the catchment area, *i* is the rainfall intensity (mm/hr) corresponding to the catchment time of concentration, and *A* is the drainage area (ha).

The drainage area was delineated using the information provided in the South Unionville Environmental Master Drainage Plan prepared by Cosburn Patterson Mather Limited and Gartner Lee Limited (November, 1996), the South Unionville Square Functional Servicing Report prepared by Masongsong Associates Engineering Limited (August, 2009), as well as additional subdivision record drawings and drainage plans. The drainage area was determined to be 63.4 ha, consisting of flows from lands and a subdivision south of Highway 407, a portion of the Highway 407 roadway, and residential/commercial developments north of Highway 407. Refer to the Drainage Area Plan in **Appendix B** for the delineation of the contributing area to the Rouge River Tributary crossing.

The runoff coefficient for the drainage area was estimated to be C = 0.49, using aerial maps and based on runoff coefficients for various land uses as per the City of Markham Stormwater Management Guidelines (October, 2016). Since the runoff coefficient is greater than 0.40, the time of concentration (t_c) was calculated to be 98.2 minutes using the Bransby William formula:

$$t_c = 0.057 \times L \times S_w^{-0.2} \times A^{-0.1}$$

where *L* is the flow length, S_w is the slope, and *A* is the catchment area. The rational method was then applied to calculate the peak flow rates for the various storm events at the tributary crossing using the York Region Intensity-Duration-Frequency (IDF) curves.

The peak flows for various storm events at the main reach of the Rouge River were obtained from the existing TRCA HEC-RAS model.

It is recommended that during detailed design, the assessment results be reviewed and verified to confirm any changes to the land-use and associated hydrologic information that may affect the peak flow presented in this Class EA study. A summary table of the storm design peak flows of the transverse crossing is presented in **Table 2-4**.

Table 2-4: Design Peak Flow for the Transverse Crossings

Watercourse Crossing	Culvert/ Crossing ID	Peak Flow (m^3/s)		
		50 Year Storm	100 Year Storm	Regional
Rouge River Tributary*	C-1	2.97	3.26	--
Rouge River	C-2	139.84	162.23	643.02

*Calculated based on 63.4 ha drainage area with C = 0.49, t_c = 98.2 minutes, and York Region IDF curves

Hydraulic Assessment

For Crossing C-1, the hydraulic analysis was completed using a HY-8 hydraulic model, utilizing the culvert information (size, length, invert elevations and road elevation) obtained from the record drawings and the survey data. For Crossing C-2, the HEC-RAS model for the Rouge River (Main Reach) obtained from the TRCA was reviewed and updated to reflect the existing crossing conditions based on the available survey data completed for this EA study and used to conduct the hydraulic assessment.

As per the MTO Highway Drainage Design Standards, hydraulic capacities were assessed based on the 50-year storm event peak flow for structure with spans less than 6.0 m, and the 100-year design storm event peak flow for structure with spans greater than 6.0 m to determine the available freeboard and clearance.

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

Table 2-5: Hydraulic Analysis Results for the Transverse Culverts (Existing Condition)

Crossing ID	Type	U/S Invert (m)	D/S Invert (m)	Length (m)	Road Elev. (m)	Water Surface Elevation (m)			Free-board (m)	Clearance (m) / HW/D	Remarks
						50-yr	100-yr	Reg./ Check			
C-1	Culvert	173.24	173.00	47.5	175.10	174.22	174.31	174.78 (Check Flow)	0.88	1.09 (HW/D)	Does not meets MTO freeboard criterion Check Flow does not overtop road
C-2	Bridge	167.33 (Channel Bed Elevation)		18.9	172.07	170.72	170.89	173.92 (Reg.)	1.18	-0.05* (Clearance)	Meets MTO freeboard criterion but not clearance, Regional storm overtops road

*Based on the lowest soffit elevation of 170.84

The results presented in Table 2-5 indicate that Crossing C-1 does not meet MTO freeboard criterion, but the water surface level generated by the Check Flow does not overtop Kennedy Road. Crossing C-2 meets the MTO freeboard criterion, however, it does not meet the clearance criterion. The Regional Storm event results in flow overtopping Kennedy Road at Crossing C-2 with a depth of approximately 1.85 m.

3 Proposed Drainage Condition

3.1 Roadway Drainage System

The preferred alternative design concept for Kennedy Road from Steeles Avenue to Major Mackenzie Drive recommends widening the road from four to six lanes, as well as the addition of 3.0 m (2.4 m where there is a constraint) multi-use pathways along the corridor. The preferred design between YMCA Boulevard and Highway 7 is to accommodate the six travel lanes and continuous AT facilities with a wider centre median that will later be converted to a future rapidway when the Ultimate Vision is constructed. Overall, the existing drainage patterns and discharge locations will not be altered as per the proposed roadway improvements, with the exception of the drainage pattern at the proposed underpass at the GO Stouffville Line crossing north of Clayton Drive. The GO rail crossing north of Austin Drive is proposed to remain as an at-grade crossing, and grade separation options will be evaluated as part of a separate, future study.

3.1.1 Minor Drainage System

The storm sewer system for the ultimate roadway configuration is to be designed for a 10-year storm event as per the York Region Road Design Guidelines. The overall drainage pattern will be consistent with the existing conditions, with the exception of the grade separation location, which will be further discussed in **Section 3.3**. To accommodate the proposed roadway widening, storm sewer upsizing and catchbasin relocations are anticipated. Proposed roadway drainage will be collected by a series of catchbasins and will be conveyed by storm sewers to the existing storm outlet locations. There are a number of existing outlets for the runoff from Kennedy Road within the study corridor. For the storm sewer discharge locations, refer to the Environmental Assessment Drainage Plan in **Appendix A**. A summary table listing the right-of-way drainage area characteristic is provided in **Table 2-1**.

3.1.2 Major Drainage System

The roadway design should ensure that the major system runoff up to the 100-year storm event can be safely conveyed to watercourse locations and should allow one lane in each direction to be clear of any flooding. Major system relief will occur at major watercourse crossings and intersections. At these locations, major system inlets will capture the 100-year flow and direct it to the appropriate outfalls. A spread analysis should be completed at the detailed design stage to ensure that the ponding at low points encroaches only onto one lane in each direction.

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

3.2 Transverse Crossings

There are two (2) watercourse crossings within the study corridor. The proposed size, structure, and locations of each crossing was determined based on existing condition assessment, fluvial geomorphologic assessments, proposed roadway geometry, grading impacts, and hydraulic performance, with the objective of improving the drainage condition at each crossing and addressing any existing deficiencies. Replacement of the culvert crossing at the Tributary of the Rouge River and widening of the bridge superstructure at the Rouge River are required to accommodate the proposed roadway improvements. Since widening the bridge at the existing 2% cross fall will result in a lower soffit elevation and a reduced clearance, it is recommended to replace the bridge superstructure with one having a 1% cross fall. Based on the results of the hydraulic assessment of the existing Rouge River Tributary crossing, it is recommended to replace this culvert with a culvert with a larger opening size to ensure compliance with the applicable hydraulic criteria. A summary of the recommended approach for upgrades at each watercourse crossing is provided in **Table 3-1**.

Table 3-1: Watercourse Crossing Recommendations

Crossing ID/ Watercourse	Location	Recommendations for Watercourse Crossing Upgrades
C-1 Rouge River Tributary	Sta. 13+646	Replace existing twin CSP culverts with twin 48.6m long concrete box culverts (2-1.8m span x 1.2m rise with 300mm embedment each)
C-2 Rouge River	Sta. 14+980	Widen bridge and replace superstructure with a 1% cross fall to accommodate roadway widening

3.2.1 Hydraulic Assessment of Proposed Transverse Crossings

Under the proposed conditions, the drainage boundary and design peak flow values for the transverse crossings are considered to remain unchanged compared to the existing conditions. The increase in pavement area as a result of the corridor improvements is negligible in comparison to the large external drainage areas contributing to each watercourse crossing location. Therefore, the design peak flows based on the current land use conditions are used to assess the hydraulic performance of the proposed crossings.

The hydraulic assessment for the proposed crossings is based on the preliminary proposed horizontal road design and vertical centerline profile design. Note that the proposed inverts, length, and slope of the culvert are to be confirmed during detailed design to accommodate the road design and the roadside ditch grading.

Rouge River Tributary Crossing

The hydraulic assessment of the proposed crossings was completed based on the assessment criteria described in **Section 2.5.2** and using a HY-8 hydraulic model to determine the freeboard and clearance for the proposed culvert replacement at Crossing C-1.

The assessment indicates that under proposed conditions for the 50 year storm event, the freeboard will be 1.0 m, and the Check Flow will not overtop the roadway. Consequently, Crossing C-1 will meet the required freeboard criteria based on the proposed culvert replacement.

Rouge River Crossing

Under the proposed conditions, the existing bridge over the Rouge River needs to be widened in order to accommodate the proposed roadway widening. The span of the bridge will remain at 30.5 m and the crossing length of the structure will be increased to 31.0 m. However, widening the bridge with the existing 2% cross fall will result in a larger negative clearance under the design flow because of the lowered soffit elevation.

The existing bridge does not meet the clearance criterion, as the clearance is negative, and further reducing the clearance is not recommended. Therefore, replacement of the superstructure with the same superstructure depth and a reduced cross fall of 1% is recommended in order to prevent lowering the existing soffit elevation. Under proposed conditions, the bridge will meet the freeboard criteria, and the Regional Storm event will overtop the crossing by 1.83m, which is 0.02m less compared to the existing conditions. Under proposed conditions, the maximum increase in the water surface elevation upstream of the crossing is 0.01m under the 50-year storm event, which is considered a negligible difference.

A preliminary hydraulic assessment using the updated TRCA HEC-RAS model showed that increasing the bridge span will not result in any considerable decrease in the water surface elevation upstream of the bridge. Therefore, to meet the MTO clearance criterion and reduce the Regional flood depth over Kennedy Road, one option would be to raise the roadway profile. However, the hydraulic assessment showed that any raise in the road profile will result in an increase of the upstream Regional flood levels, since Kennedy Road acts as a weir conveying the flow during the Regional storm event. Raising the road profile means raising the weir invert elevation, which will result in an increase in the flow head over the weir. This is not acceptable to TRCA. Therefore, raising the road profile at the Rouge River crossing is not recommended and increasing the span at this bridge will not be beneficial. Based on these results, it is not feasible to meet the MTO design criteria at this bridge. An emergency response plan will need to be developed for this location to close access to this section of Kennedy Road during the Regional storm event, due to the significant depth of flooding at the road sag.

Updates to the hydraulic modelling, floodplain assessment and revisions to TRCA floodplain mapping shall be completed during detailed design to reflect the final design and grading footprint of the crossing. Additional coordination with both the City of Markham and the TRCA shall be carried out to finalize the preliminary design of the bridge and to minimize impacts to the watercourse. Additionally, as the existing bridge structure is located within the 100 year erosion limits, the bridge abutments must be protected from scour. As part of Detailed Design, additional analysis should be conducted to ensure that sufficient scour/erosion protection will be provided.

As the study area is located within the 2D hydraulic model area (Unionville SPA 2D Study and Floodplain Mapping update, 2019), a 2D hydraulic model update may be required to determine the extent of the impact at the detail design stage.

Details of the proposed bridge and culvert crossings hydraulic performance are provided in **Table 3-2**, and hydraulic assessment output files are provided in **Appendix C**.

Table 3-2: Hydraulic Analysis Results for the Transverse Crossing (Proposed Condition)

Crossing ID	Type	U/S Invert (m)	D/S Invert (m)	Length (m)	Road Elev. (m)	Water Surface Elev. (m) 50 Yr	100 Yr	Reg./ Check Flow	Freeboard (m)	Clearance (m) / HW/D	Remarks
C-1	Culvert	173.23*	173.00*	48.6	175.00	174.00	174.05	174.19 (Check Flow)	1.0	0.86 (HW/D)	Meets MTO design criteria Check flow does not overtop the road
C-2	Bridge	167.33 (Channel Bed Elevation)		31.0	172.07	170.73	170.89	173.90	1.18	0.02** (Clearance)	Meets MTO freeboard criterion but not clearance Regional storm overtops road

*Invert at the top of the embedment
**Based on lowest soffit elevation of 170.91

3.3 Metrolinx GO Crossings

3.3.1 Grade Separation North of Clayton Drive

A grade separation is proposed at the Stouffville GO line crossing north of Clayton Drive, which will result in Kennedy Road being constructed as an underpass at the crossing. This will result in the disruption of the existing drainage pattern at this location, as the roadway profile will be lowered by approximately 7 metres. Under proposed conditions, the runoff generated from Drainage Areas A-2 and A-3 will flow towards the underpass sag and will be collected by a series of catchbasins. Based on the available information of the existing storm sewer profile and outlet location, the surface runoff generated within the underpass area cannot be drained to the downstream Steeles Avenue regional storm sewer system by gravity. Therefore, a separate storm sewer system, comprised of over-sized storm pipes and a pumping station, will be required for storage and conveyance of both minor and major flows. Further design details, including required water quality and quantity control measures, are to be provided in the detailed design of the underpass.

Metrolinx has initiated the study of this crossing and further information of the drainage requirements will be provided in the Metrolinx study.

3.3.2 At-Grade Crossing North of Austin Drive

The EA recommended design for the GO rail crossing north of Austin Drive is for an at-grade crossing widened to six lanes and AT facilities. As part of the Ultimate Vision, grade separation options will be evaluated as part of a separate future study to be undertaken by Metrolinx. It is understood from preliminary grade separation concepts that the future grade separation options (both underpass and overpass) will require the Rouge River Bridge to be replaced. This will be reviewed and confirmed through the separate future grade separation study for this crossing and subsequent Detailed Design.

4 Stormwater Management Strategy

4.1 Stormwater Management Criteria

The stormwater management plan for the Kennedy Road Class EA Study shall be developed to comply with the MECP Stormwater Management Practices Planning and Design Manual, York Region Road Design Guidelines, City of Markham Stormwater Management Guidelines, and the Toronto Region Conservation Authority Stormwater Management Guidelines.

4.1.1 Water Quality Control

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

Stormwater management (water quality) measures within the study limits will be designed to provide "Enhanced" water quality treatment, as a minimum, for the increased pavement area as a result of roadway widening/improvements.

4.1.2 Water Quantity Control

Watercourse Crossings

TRCA has established quantity control targets for the watersheds under its jurisdiction (TRCA Stormwater Management Criteria and The Rouge River Hydrology Study Update). For the Rouge River watershed, TRCA has no quantity control requirements for storm outfalls to the main branch of the Rouge River located downstream of Major Mackenzie Drive. For the Rouge River Tributary, TRCA requires post-development peak flows to be controlled to pre-development levels for all storms up to and including the 100 year storm event (i.e. 2, 5, 10, 25, 50, and 100 year storm events). For Bruce Creek, TRCA requires post-development peak flows to be controlled to pre-development levels, established by a Unitary Discharge relationship and storage volume to be provided according to a Unitary Storage relationship (Rouge River Hydrology Update, Wood, 2018). However, given the limited space within the ROW of linear infrastructure, it will be difficult to satisfy these criteria; therefore, a best efforts approach to provide sufficient storage to attenuate the post-development peak flow to the pre-development level for all design storm events is recommended.

Municipal Storm Sewer Systems

Within the project limits, the stormwater runoff from Kennedy Road discharges either into existing municipal storm sewers or outlets at watercourse crossings. For locations where the runoff discharges into an existing system, the minor system design storm (10 year storm) peak flows must be controlled to the existing peak flows, for which the receiving system was designed. The receiving storm sewer systems within the project limits are either municipal systems (City of Markham), which would have been designed based on a 5 year storm event, or Regional systems (York Region), which would have been designed based on a 10 year storm event.

For catchments that discharge to existing storm sewer systems, where the ultimate outfall is either the Rouge River Tributary or Bruce Creek, the calculated overall storage volume requirement is considered the larger of:

- The volume required to control the minor system design storm (10 year storm) to the design capacity of the receiving storm system; and
- The volume required to control the major system design storm (100 year storm) from proposed to existing level.

4.1.3 Water Balance

The TRCA criteria for water balance and erosion control requires retention of the first 5 mm of rainfall. This criteria is applicable to increased pavement area as a result of roadway widening/improvements.

4.2 Hydrologic Modeling

A hydrologic analysis has been conducted using the Rational Method to calculate the surface runoff under the 2 to 100 year storm events for both the existing and proposed condition scenarios. The Modified Rational Method was then used to calculate the storage volumes required to control the post-development peak flows for the design storm events to the allowable release rates.

City of Markham and York Region Intensity Duration Frequency (IDF) curves were applied to calculate the existing peak flows and York Region IDF curves were applied to calculate the peak flows under proposed conditions, using a minimum inlet time (T_c) of 10 minutes. Details of the hydrologic analysis are provided in **Appendix E**.

4.3 Pavement Area Analysis

A pavement area analysis was performed to determine the increase in impervious surface which will result from the roadway widening from 4 to 6 lanes and the construction of new 3.0 m (2.4 m where there is a constraint) wide multi-use paths.

As a Low Impact Development (LID) measure, it is recommended that the boulevard areas outside of the active transportation facilities, as well as roadway medians, be surface-treated with permeable material (e.g. grass, permeable pavement, etc.) to minimize the overall increase in impervious area along the Kennedy Road corridor. Since these are not load bearing surfaces, the use of permeable material will not impact the functionality of the proposed design but will provide water quality and quantity benefits through reduced runoff. Therefore, the proposed stormwater strategy was developed considering the boulevard and median areas as being pervious. Additional details and specifications for the permeable material are to be included in the detailed design stage.

It was determined that the proposed roadway improvements will result in an additional 6.72 ha increase in pavement area within the Kennedy Road study corridor. A summary of the existing and proposed pavement areas along the EA study corridor are provided in **Table 3-2**.

Table 4-1: Pavement Area Analysis

Study Corridor	Existing Pavement Area (ha)	Proposed Pavement Area (ha)	Increased Pavement Area (ha)	Percentage Increase (%)
Kennedy Road	22.43	29.15	6.72	30

4.4 Stormwater Best Management Practice Options

Various Best Management Practices (BMPs) for stormwater management were reviewed and assessed for their applicability to this project. Due to the nature of this facility (i.e. linear transportation corridor) and the limited space within the roadway right-of-way, a series of infiltration trenches parallel to storm sewers are proposed to provide quality treatment and water balance for catchments discharging immediately to a watercourse. For the catchment areas that do not directly discharge into a watercourse, quality treatment using Oil-Grit Separator (OGS) units is recommended. To provide quantity control throughout the Kennedy Road corridor, online storage pipes are proposed.

4.4.1 Infiltration Trenches

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

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

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

Where *P* is the infiltration rate of the native soils, which was estimated to be 32 mm/hr within the project limits based on the Hydrogeological Investigation (**Section 2.3**); *T* is time to drain, which is recommended to be 48 hours; and *n* is void space ratio of the aggregate used, which is typically 0.4 for clear stone. Accordingly, the maximum allowable depth of the reservoir can be calculated to be d_{max} = 3840 mm.

For this project, 1.7 m wide by 0.5 m deep infiltration trenches are proposed, except for Drainage Areas A-10 and A-18, where the trenches are 1.5m wide due to roadway layout constraints. Conceptual plan and profiles of the proposed infiltration trenches are provided in **Appendix D**. The footprint area of the infiltration trenches can be calculated using the following formula:

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

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

The bottom of the infiltration trench should be one (1) metre above the seasonally high water table. According to the Hydrogeological Investigation (**Section 2.3**), the groundwater table ranges from 1.4 m to 10.8 m below the existing ground within the project corridor, and are 4.6 m and 3.4 m below existing ground at the Rouge River Tributary and the Rouge River, respectively. This should provide adequate separation of the groundwater table from the bottom of the proposed facilities. Further investigation should be completed during the detailed design stage to confirm the adequate separation at each location. In accordance with the CVC/TRCA LID SWM Guide (2010), for locations where the native soil percolation rates do not exceed 15 mm/hr, an underdrain can be incorporated in the design of the infiltration trenches to ensure adequate performance. Further investigation of the percolation rates at the infiltration trench locations is recommended during detailed design.

The infiltration trenches are proposed for Drainage Areas A-8, A-9, A-10, A-12, A-13, and A-18, where runoff discharges immediately into natural watercourses or into stormwater management facilities (i.e. SWM ponds) that outlet directly into natural watercourses. The infiltration trenches provide erosion control and thermal mitigation benefits to the receiving watercourses. In addition to providing 'Enhanced' level protection (80% TSS removal), the provided storage volume within the infiltration trenches includes the volume required to retain the first 5 mm of rainfall to meet the TRCA water balance and erosion control target. For the catchment areas that do not directly discharge into a watercourse, quality treatment using Oil-Grit Separator (OGS) units is recommended. Pre-treatment of the runoff using catchbasin inserts (e.g. CB Shield, Goss Trap) is recommended throughout the study corridor.

Based on the information available on York Region's land information mapping service, there are no wellhead protection areas located within the project limits but there are areas designated as Highly Vulnerable Aquifers along the Kennedy Road corridor. Further investigation should be completed during the detailed design stage to confirm that infiltration of the roadway runoff from the proposed infiltration trenches or other infiltration facilities will not result in groundwater contamination. For areas where a potential risk for groundwater contamination is identified, the option to wrap the infiltration trench in an impermeable liner to provide filtration, instead of infiltration, should be investigated. In such cases, the filtration of runoff will not contribute towards meeting the water balance target.

For catchment areas discharging to Rouge River (Drainage Areas A-12 and A-13), which is identified as Redside Dace contributing habitat, 100% of the pavement areas are proposed to be treated due to the sensitivity of the receiving watercourse. Overall, the infiltration trenches are designed to provide water quality treatment for pavement areas exceeding the total increase in pavement area along the Kennedy Road study corridor, in accordance with direction received from MECP.

Table 4-2 lists the details of the infiltration trenches proposed along the Kennedy Road study corridor. For locations of the proposed infiltration trenches, refer to the Drainage Plans provided in **Appendix A**. Detail calculations are provided in **Appendix E**.

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

Drainage Area ID	Existing Pavement Area (ha)	Additional Pavement Area (ha)	Required Water Quality Volume (m^3)	Required Water Balance Storage* (m^3)	Proposed Length (m)	Treated Area** (ha)	Provided Storage Volume (m^3)
A-8	1.04	0.15	10	8	51	0.15	15
A-9	0.47	0.07	4	18	103	0.35	35
A-10	1.81	0.37	20	102	680	2.04	204
A-12	1.20	0.48	66	84	372	1.68	126
A-13	0.68	0.36	39	52	426	1.04	145
A-18	2.67	0.66	35	85	567	1.70	170
Total	**7.88**	**2.09**	**174**	**348**	**2199**	**6.96**	**696**

*Based on the retention of the first 5 mm of rainfall

**Based on a 20:1 pavement to infiltration trench area ratio

Drainage Areas A-12 and A-13 both outlet to the Rouge River, but due to the physical constraints of the roadway layout, the required infiltration trench length for Drainage Area A-12 cannot be accommodated in the design. Consequently, the infiltration trench length provided for Drainage Area A-13 is increased beyond the required length such that the total required infiltration trench length for water quality treatment to the Rouge River can be achieved.

During the detailed design stage, the location and performance characteristics of the infiltration trenches will need to be confirmed to ensure that all infiltration trench design criteria can be met.

4.4.2 Online Storage Pipes

At existing municipal storm system connections, consideration should be given to providing over-sized storage pipes upstream of the discharge location to provide storage volume and peak flow control. Quantity control is not required for the Rouge River based on the TRCA stormwater management criteria, but is required for the Rouge River Tributary.

The required storage volumes to achieve the quantity control targets for each catchment are summarized in **Table 4-3**. Online storage pipes shall be designed to provide the required storage at the detailed design stage. Detailed calculations are provided in **Appendix E**.

Table 4-3: Summary of Proposed Water Quantity Treatment Strategy

Drainage Area ID	Drainage Area (ha)	Existing Pavement Area (ha)	Additional Pavement Area (ha)	Target Release Rate (m^3/s)	Corresponding Storm Event Return Period*	Required Storage (m^3)
A-1	2.54	1.45	0.41	0.59	10-yr	60
A-2	0.83	0.29	0.21	0.15	100-yr	273**
A-3	0.80	0.36	0.21	0.72	100-yr	
A-4	3.08	1.75	0.57		5-yr	79
A-5	2.40	1.39	0.50	0.46	5-yr	134
A-6	0.64	0.42	0.11	0.23	100-yr	22
A-7	3.12	1.96	0.53	0.63	5-yr	160
A-8	1.39	1.04	0.15	0.32	5-yr	63
A-9	0.82	0.47	0.07	0.27	100-yr	15
A-10	2.92	1.81	0.37	1.00	100-yr	74
A-11	1.89	1.24	0.18	0.48	10-yr	27
A-13	1.31	0.68	0.36	0.24	5-yr	83
A-14	1.28	0.72	0.28	0.24	5-yr	72
A-15	2.11	1.17	0.45	0.40	5-yr	118
A-16	1.94	1.27	0.35	0.40	5-yr	104
A-17	2.47	1.51	0.53	0.83	100-yr	107
A-18	4.67	2.67	0.66	0.90	5-yr	212
A-19	1.70	1.03	0.29	0.57	100-yr	60
Total	**35.90**	**21.23**	**6.24**	**-**	**-**	**1663**

*Based on the capacity of the receiving storm sewer system or TRCA requirements
**For the proposed underpass

4.4.3 Supplemental BMP Measures

Through discussions with MNRF and TRCA, opportunities to implement supplemental stormwater best management practice measures to augment the treatment proposed by the infiltration trenches are to be considered.

The supplemental BMP measures shall be designed based on the site conditions and further geotechnical and hydrogeological investigations undertaken during the next phase of design. Any low impact development measures shall meet the design criteria as per the CVC/TRCA Low Impact Development Stormwater Management Planning and Design Guide (2010).

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

Bioretention Systems

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

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

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

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

Vegetated Filter Strips and Plunge Pool

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

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

Vegetative filter strips and plunge pools should be considered at watercourse outfall locations to disperse the energy of the flow and to provide additional water quality control in series with infiltration trenches as a treatment train system.

Oil-Grit Separators

Oil/grit separator (OGS) units combine a storage chamber for sediment trapping and oil separation with drainage inlets for intercepting or receiving roadway stormwater runoff. At locations where the roadway drainage area is less than 2.0 ha, oil-grit separator units can be used for water quality control. It should be noted that TRCA recognizes that oil-grit separator (OGS) units can provide a maximum sediment removal efficiency of 50%. Consequently, additional mitigation measures shall be considered in series with each oil-grit separator to achieve the “Enhanced” protection (Level 1) water quality target, if they are to be considered in the detail design stage.

4.5 Erosion and Sediment Control during Construction

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

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

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

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

4.6 Stormwater Management Plan Summary

The proposed stormwater management plan for the project has been developed by examining the opportunities and constraints within the entire study corridor. Runoff from the paved roadway areas and 3.0 m (2.4 m where there is a constraint) wide multi-use paths will be conveyed to the proposed infiltration trenches and roadway storm sewer systems and discharge into either existing storm sewer systems or natural watercourses. As per **Section 4.3**, the total roadway pavement area will increase by 6.72 ha, including the multi-use path within the boulevard areas. Water quality, water balance, and erosion control treatment will be provided for 6.96 ha of pavement area. The stormwater management plan for this project is presented on the Environmental Assessment Drainage Plans in **Appendix A**.

Table 4-4 provides a summary of the water quality treatment, water balance, and quantity control strategies proposed to mitigate the increase in impervious surface within the project limits. A series of infiltration trenches parallel to storm sewers are proposed to provide quality treatment and water balance for catchments discharging immediately to a watercourse. For the catchment areas that do not directly discharge into a watercourse, quality treatment using OGS units is recommended. Pre-treatment of the runoff using catchbasin inserts (e.g. CB Shield, Goss Trap) is recommended throughout the study corridor. Online storage pipes are proposed to provide quantity control throughout the study corridor.

Table 4-4: Summary of Stormwater Management Plan

Drainage Area ID	Existing Pavement Area (ha)	Additional Pavement Area (ha)	Pavement Area Receiving Quality[3]/ Balance (ha)	Water Quality/ Balance Storage Volume Provided (m^3)	Target Release Rate (m^3/s)	Corresponding Storm Event Return Period[4]	Quantity Storage Volume Required (m^3)
A-1	1.45	0.41	N/A	N/A	0.59	10-yr	60
A-2	0.29	0.21	N/A	N/A	0.15	100-yr	273
A-3	0.36	0.21	N/A	N/A	0.72	100-yr	
A-4	1.75	0.57	N/A	N/A		5-yr	79
A-5	1.39	0.50	N/A	N/A	0.46	5-yr	134
A-6	0.42	0.11	N/A	N/A	0.26	100-yr	22
A-7	1.96	0.53	N/A	N/A	0.63	5-yr	160
A-8	1.04	0.15	0.15	15	0.32	5-yr	63
A-9[1]	0.47	0.07	0.35	35	0.27	100-yr	15
A-10[1]	1.81	0.37	2.04	204	1.00	100-yr	74
A-11	1.24	0.18	N/A	N/A	0.48	10-yr	27
A-12[2]	1.20	0.48	1.68	168	N/A	N/A	N/A
A-13[2]	0.68	0.36	1.04	104	0.24	5-yr	83
A-14	0.72	0.28	N/A	N/A	0.24	5-yr	72
A-15	1.17	0.45	N/A	N/A	0.40	5-yr	118
A-16	1.27	0.35	N/A	N/A	0.40	5-yr	104
A-17	1.51	0.53	N/A	N/A	0.83	100-yr	107
A-18[1]	2.67	0.66	1.70	170	0.90	5-yr	212
A-19	1.03	0.29	N/A	N/A	0.57	100-yr	60
Total	**22.43**	**6.72**	**6.96**	**696**	**-**	**-**	**1663**

[1] Total pavement area is treated in order to meet MECP requirements of treating the overall increased pavement area in the corridor
[2] Total pavement area is treated due to sensitivity of the receiving watercourse
[3] Areas discharging to municipal systems will be treated using catchbasin inserts and OGS units
[4] Based on the capacity of the receiving storm sewer system or TRCA requirements

5 Conclusions

The Kennedy Road corridor between Steeles Avenue and Major Mackenzie Drive is proposed to be widened from 4 to 6 lanes, including the addition of multi-use paths on both boulevards. The proposed design will also include upgrades to the existing subsurface road drainage system, consisting of storm sewer systems with catchbasins along the curb lines to convey stormwater runoff to the various outfall locations along the corridor.

The study area is within the area regulated by the TRCA and a portion of the corridor is within the regulatory floodplain. A total of two (2) watercourse crossings are located within the project limits. As per the proposed roadway improvements and widening, the Rouge River Tributary culvert crossing is proposed to be replaced with twin 1.8m x 1.2m concrete box culverts, and the Rouge River Main Reach bridge crossing is proposed to undergo a superstructure replacement with a 1% cross fall, since widening the bridge at the existing 2% cross fall will result in a lower soffit elevation and a reduced clearance. Hydraulic analyses were completed for the existing and proposed conditions at the watercourse crossings to ensure that the proposed structures will not negatively impact the upstream flood levels and if feasible, will meet the requirements of the MTO Highway Drainage Design Standards, as well as the York Region Road Design Guidelines.

Based on the results of the hydraulic assessment of the existing Rouge River Tributary crossing, it is recommended to replace this culvert with a culvert with a larger opening size to ensure compliance with the applicable hydraulic criteria.

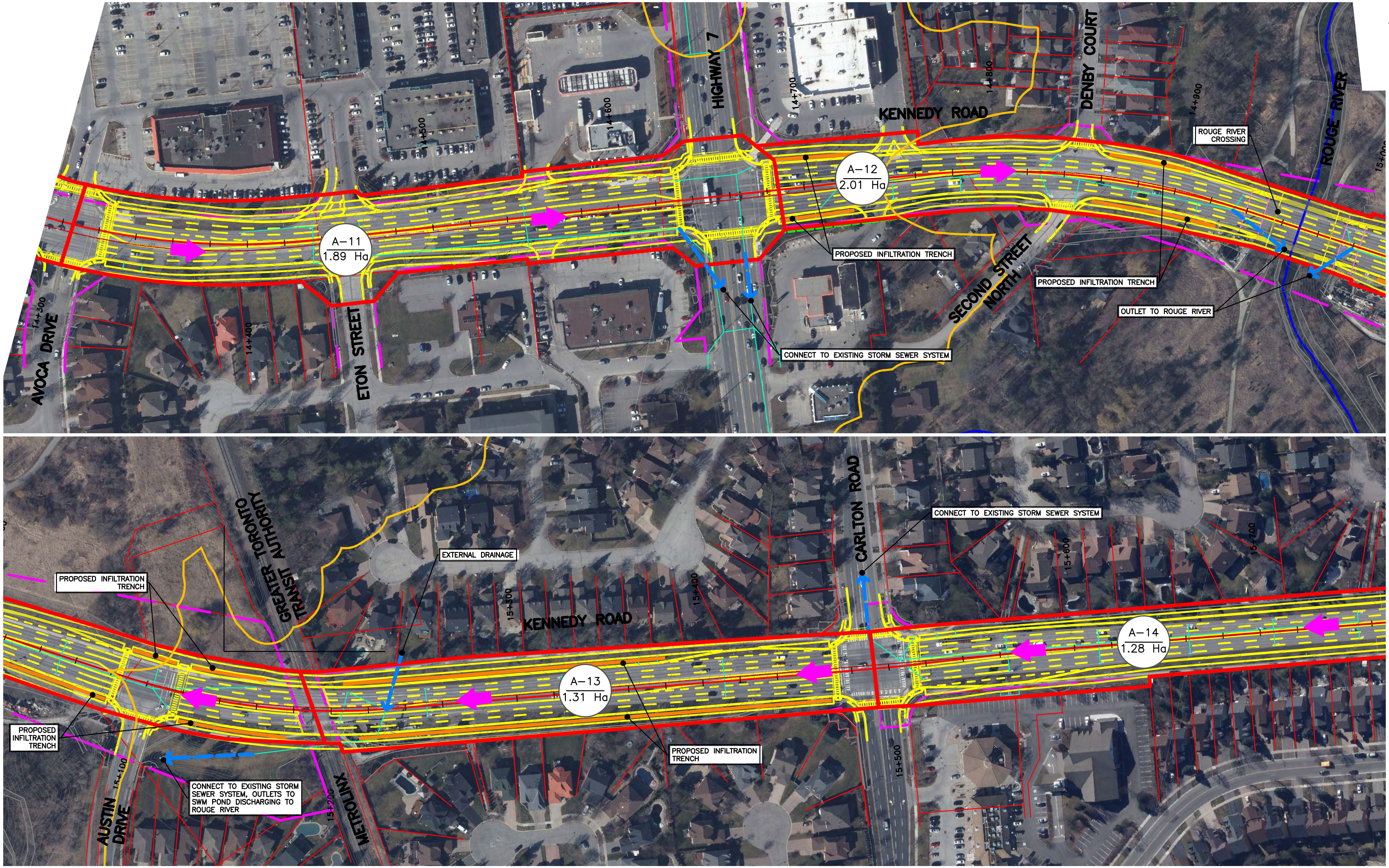
Under proposed conditions, the Rouge River Bridge will meet the freeboard criterion; however, it does not meet the clearance criterion and the Regional Storm event will overtop the road at the crossing. A preliminary hydraulic assessment using the updated TRCA HEC-RAS model showed that increasing the bridge span will not result in any considerable decrease in the water surface elevation upstream of the bridge. Therefore, to meet the MTO clearance criterion and reduce the Regional flood depth over Kennedy Road, one option would be to raise the roadway profile. However, the hydraulic assessment showed that any raise in the road profile will result in an increase of the upstream Regional flood levels, since Kennedy Road acts as a weir conveying the flow during the Regional storm event. Raising the road profile means raising the weir invert elevation, which will result in an increase in the flow head over the weir. This is not acceptable to TRCA. Therefore, raising the road profile at the Rouge River crossing is not recommended and increasing the span at this bridge will not be beneficial. Based on these results, it is not feasible to meet the MTO design criteria at this bridge. An emergency response plan will need to be developed for this location to close access to this section of Kennedy Road during the Regional storm event, due to the significant depth of flooding at the road sag.

A grade separation is proposed at the Stouffville GO line crossing north of Clayton Drive, which will result in Kennedy Road being constructed as an underpass at the crossing. This will result in the disruption of the existing drainage pattern at this location, as the roadway profile will be lowered. Metrolinx has initiated the study of this crossing and further information of the drainage requirements will be provided in the Metrolinx study.

The Recommended Design for the GO rail crossing north of Austin Drive is for an at-grade crossing widened to six lanes and AT facilities. As the Ultimate Vision, future grade separation options will be evaluated as part of a separate future study. It is understood from preliminary grade separation concepts that the future grade separation options (both underpass and overpass) will require the Rouge River Bridge to be replaced. This will be reviewed and confirmed through the separate future grade separation study for this crossing and subsequent Detailed Design.

Stormwater best management practices, including catchbasin inserts, oil-grit separator units, infiltration trenches, and online storage pipes, are proposed for storm water quality treatment, water balance, erosion control, and quantity control of the roadway runoff from the additional pavement areas. The proposed road improvements will result in an additional pavement area of 6.72 ha. As part of the SWM strategy, a total of 6.96 ha of pavement area will receive quality treatment through the proposed infiltration trenches, which exceeds the MECP requirement of providing treatment to the increased pavement area. A total of 6.24 ha of pavement area will receive quantity control through the proposed online storage pipes. Opportunities to implement supplemental BMP measures to provide additional water quality benefits may be considered during the next phases of design in series with the proposed measures to enhance the overall water quality objectives.

METRIC



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LEGEND

PROPOSED R.O.W
EXISTING R.O.W
PROPOSED WATERCOURSE CROSSING
EXISTING WATERCOURSE CROSSING
PROPOSED CATCHMENT BOUNDARY
STORM SEWER SYSTEM CONNECTION

WATERCOURSE
TRCA REGULATION LIMITS
GRADING
CL EXISTING ALIGNMENT
CL PROPOSED ALIGNMENT
PROPOSED INFILTRATION TRENCH

PROPERTY LINE
A / xx Ha — DRAINAGE AREA
EXISTING STORM SEWER

EXISTING OVERLAND FLOW DIRECTION
PROPOSED OVERLAND FLOW DIRECTION

HDR

York Region Transportation Services

KENNEDY ROAD
(STEELES AVENUE TO MAJOR MACKENIZE DRIVE)
ENVIRONMENTAL ASSESSMENT
DRAINAGE PLAN
STA. 14+290 TO 15+767

SHEET NO.
ST–04

FEBRUARY, 2020

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METRIC

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LEGEND

PROPOSED R.O.W	WATERCOURSE
EXISTING R.O.W	TRCA REGULATION LIMITS
PROPOSED WATERCOURSE CROSSING	GRADING
EXISTING WATERCOURSE CROSSING	CL EXISTING ALIGNMENT
PROPOSED CATCHMENT BOUNDARY	CL PROPOSED ALIGNMENT
STORM SEWER SYSTEM CONNECTION	PROPOSED INFILTRATION TRENCH

PROPERTY LINE

A / xx Ha DRAINAGE AREA

EXISTING STORM SEWER

EXISTING OVERLAND FLOW DIRECTION

PROPOSED OVERLAND FLOW DIRECTION

HDR

York Region Transportation Services

KENNEDY ROAD
(STEELES AVENUE TO MAJOR MACKENIZE DRIVE)
ENVIRONMENTAL ASSESSMENT
DRAINAGE PLAN
STA. 15+767 TO 16+890

SHEET NO.
ST–05

FEBRUARY, 2020

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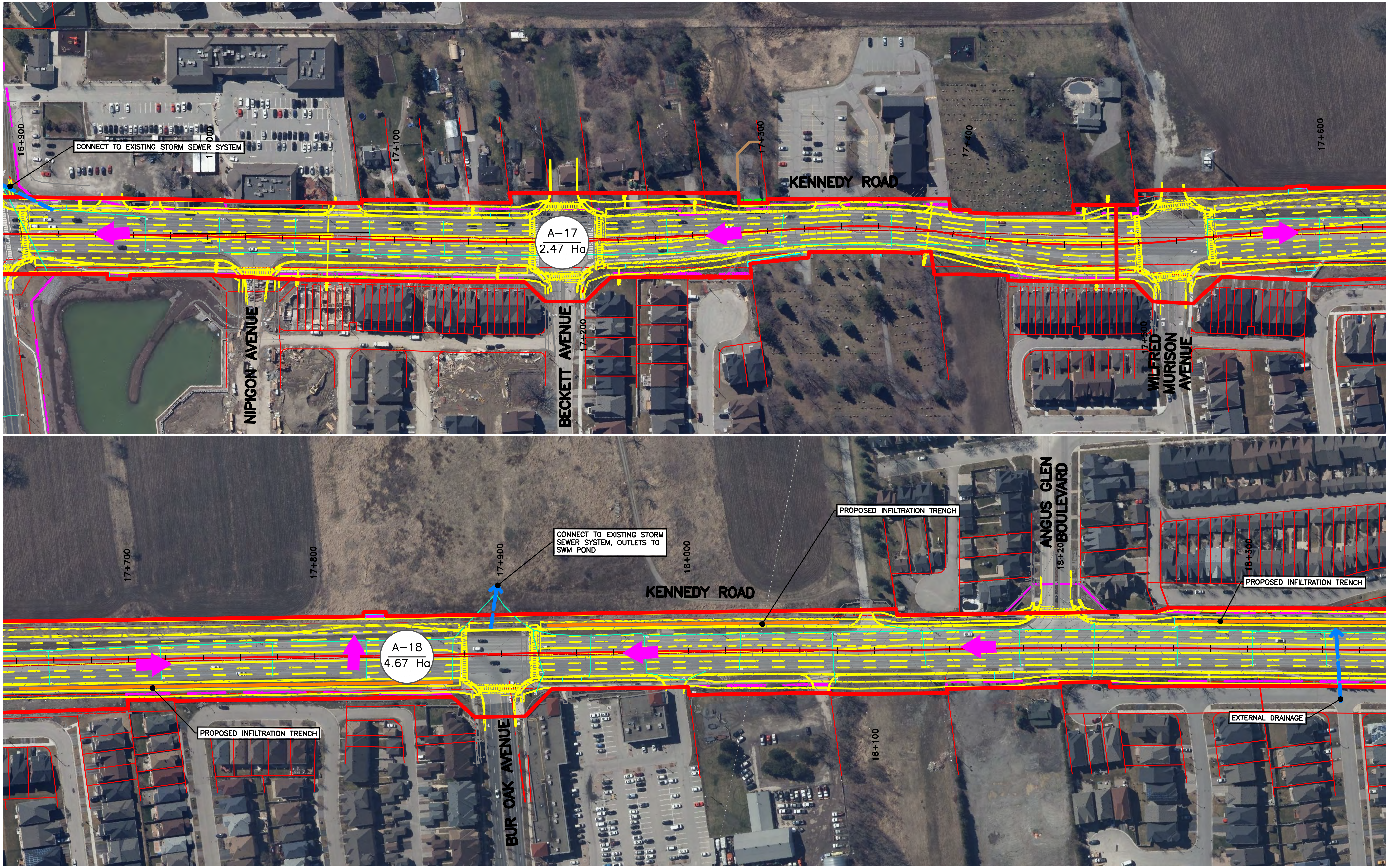

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LEGEND

PROPOSED R.O.W		WATERCOURSE		PROPERTY LINE		EXISTING OVERLAND FLOW DIRECTION	
EXISTING R.O.W		TRCA REGULATION LIMITS		DRAINAGE AREA (A / xx Ha)		PROPOSED OVERLAND FLOW DIRECTION	
PROPOSED WATERCOURSE CROSSING		GRADING		EXISTING STORM SEWER			
EXISTING WATERCOURSE CROSSING		CL EXISTING ALIGNMENT					
PROPOSED CATCHMENT BOUNDARY		CL PROPOSED ALIGNMENT					
STORM SEWER SYSTEM CONNECTION		PROPOSED INFILTRATION TRENCH					

HDR

York Region

Transportation Services

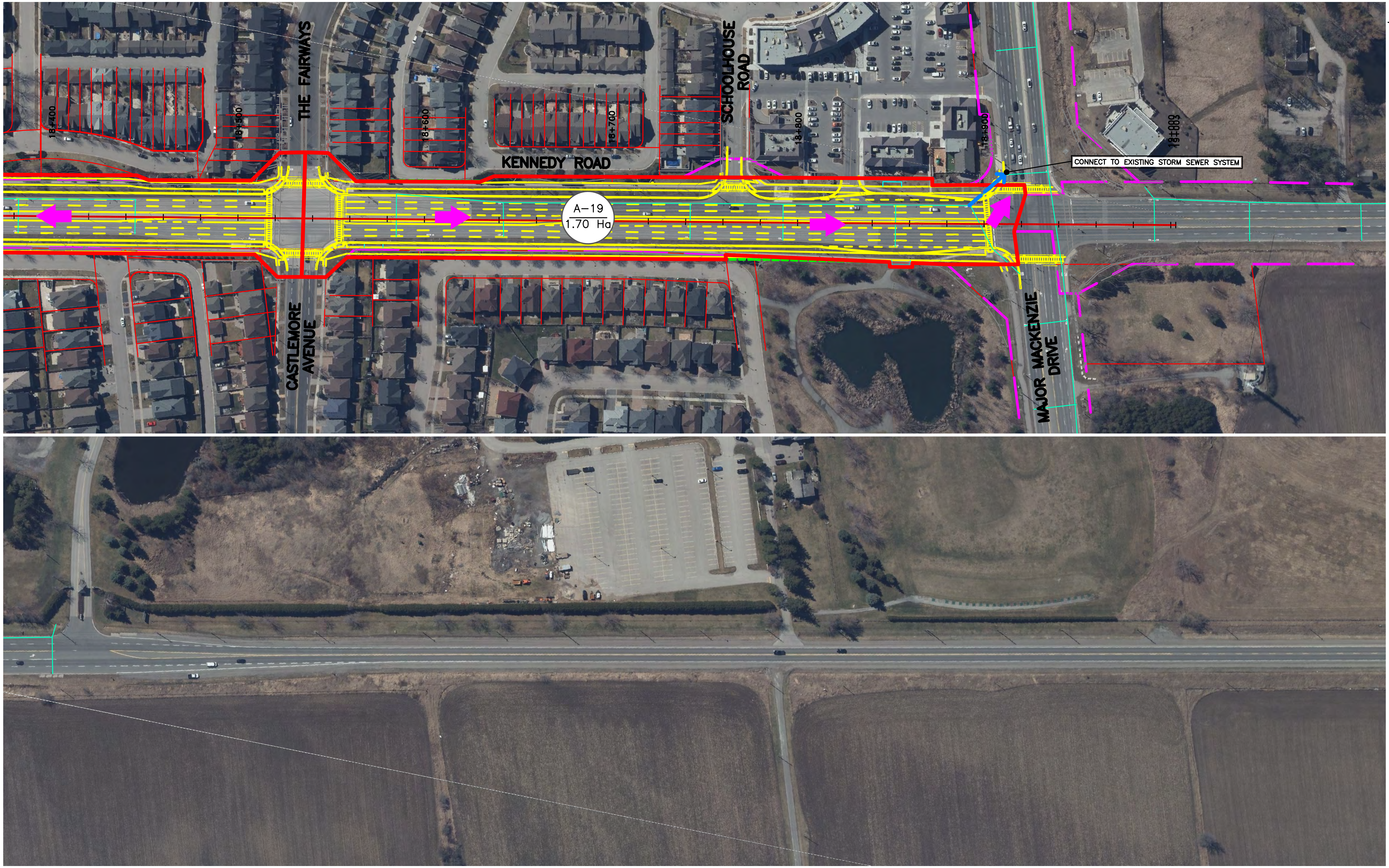
KENNEDY ROAD
(STEELES AVENUE TO MAJOR MACKENZIE DRIVE)
ENVIRONMENTAL ASSESSMENT
DRAINAGE PLAN
STA. 16+890 TO 18+374

SHEET NO.
ST-06

FEBRUARY, 2020

FILENAME: C:\pwworking\canada01\dms45232\10056259-C01-100-SF406.dwg
PLOTDATE: May 05, 2020 – 2:30pm
PLOTTED BY: JLOOK

METRIC



SCALES
1:2000

LEGEND

PROPOSED R.O.W	WATERCOURSE
EXISTING R.O.W	TRCA REGULATION LIMITS
PROPOSED WATERCOURSE CROSSING	GRADING
EXISTING WATERCOURSE CROSSING	CL EXISTING ALIGNMENT
PROPOSED CATCHMENT BOUNDARY	CL PROPOSED ALIGNMENT
STORM SEWER SYSTEM CONNECTION	PROPOSED INFILTRATION TRENCH

PROPERTY LINE

A / xx Ha — DRAINAGE AREA

EXISTING STORM SEWER

EXISTING OVERLAND FLOW DIRECTION

PROPOSED OVERLAND FLOW DIRECTION

HDR

York Region

Transportation Services

KENNEDY ROAD
(STEELES AVENUE TO MAJOR MACKENIZE DRIVE)
ENVIRONMENTAL ASSESSMENT

DRAINAGE PLAN
STA. 18+374 TO 19+000

SHEET NO.
ST-07

FEBRUARY, 2020

FILENAME: C:\pwworking\canada01\dms45232\10056259-C01-100-SF407.dwg
PLOTDATE: May 05, 2020 - 2:37pm
PLOTTED BY: JLOOK

Kennedy Road Environmental Assessment [redacted]

Drainage Area Plan for Rouge River Tributary

(Tributary 5, Twin Culvert Crossing)

Based on the Environmental Master Drainage Plan - OPA 22, South Unionville Secondary Plan (Cosburn Patterson Mather Limited and Gartner Lee Limited, November
and the South Unionville Square Functional Servicing Report (Masongsong Associates Engineering Limited, August 2009). Additional sources: Google Maps, YorkMaps

Project	Kennedy Road Class EA, York Region			
Date	1-May-20	No.	--	Page
By	J. Look	Checked	S. Kashi	

Stormwater Management Calculations

TABLE 1
ROUGE RIVER TRIBUTARY (TRIBUTARY 5) HYDROLOGIC CALCULATIONS

Catchment Properties

Contributing Area 63.4 ha
Runoff Coefficient 0.49

Time of Concentration

Using Bransby William Formula: $tc = 0.057L / (S^{0.2} * A^{0.1})$
Length (L) 1240 m
Slope (Sw) 2.4% %
Time of Concentration 98.2 minutes

Rational Method

Return Period	IDF Parameters (York Region) $i = C_f \times A / (Tc + B)^C$				Rainfall Intensity (mm/hr)	Flow Rate
	A	B	C	C_f		(m^3/s)
5-yr	1045.41	4.9	0.83	1	22.29	1.93
10-yr	1331.42	5.26	0.84	1	27.02	2.34
25-yr	1045.41	4.9	0.83	1.39	30.98	2.68
50-yr	1045.41	4.9	0.83	1.54	34.33	2.97
100-yr	1045.41	4.9	0.83	1.69	37.67	3.26
Check Flow (130% of 100-year flow)						4.24

Note: Analysis based on the Environmental Master Drainage Plan - OPA 22, South Unionville Secondary Plan (Cosburn Patterson Mather Limited and Gartner Lee Limited, November 1996), and the South Unionville Square Functional Servicing Report (Masongsong Associates Engineering Limited, August 2009)