Crossing Assessment Report

Kirby Road Widening Class EA

Jane Street to Dufferin Street

City of Vaughan

June 3, 2022

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1 Introduction

The City of Vaughan retained HDR to conduct a Municipal Class Environmental Assessment study for Kirby Road between Jane Street and Dufferin Street referred to as the Kirby Road Widening EA (Jane to Dufferin). The purpose of the study is to reconfirm the recommendations from the City's North Vaughan and New Communities Transportation Master Plan (NVNCTMP, 2019) and complete Phases 3 and 4 of the Municipal Class EA process for Schedule 'C' projects as outlined in the Municipal Engineers Association (MEA) guidelines (October 2000, as amended in 2007, 2011 and 2015). Specifically, the Kirby Road Widening EA Study will reconfirm the need to widen Kirby Road from two to four lanes between Jane Street and Dufferin Street, grade separate the Barrie Go Rail line at Kirby Road and eliminate the jog at the intersection of Kirby Road and Jane Street.

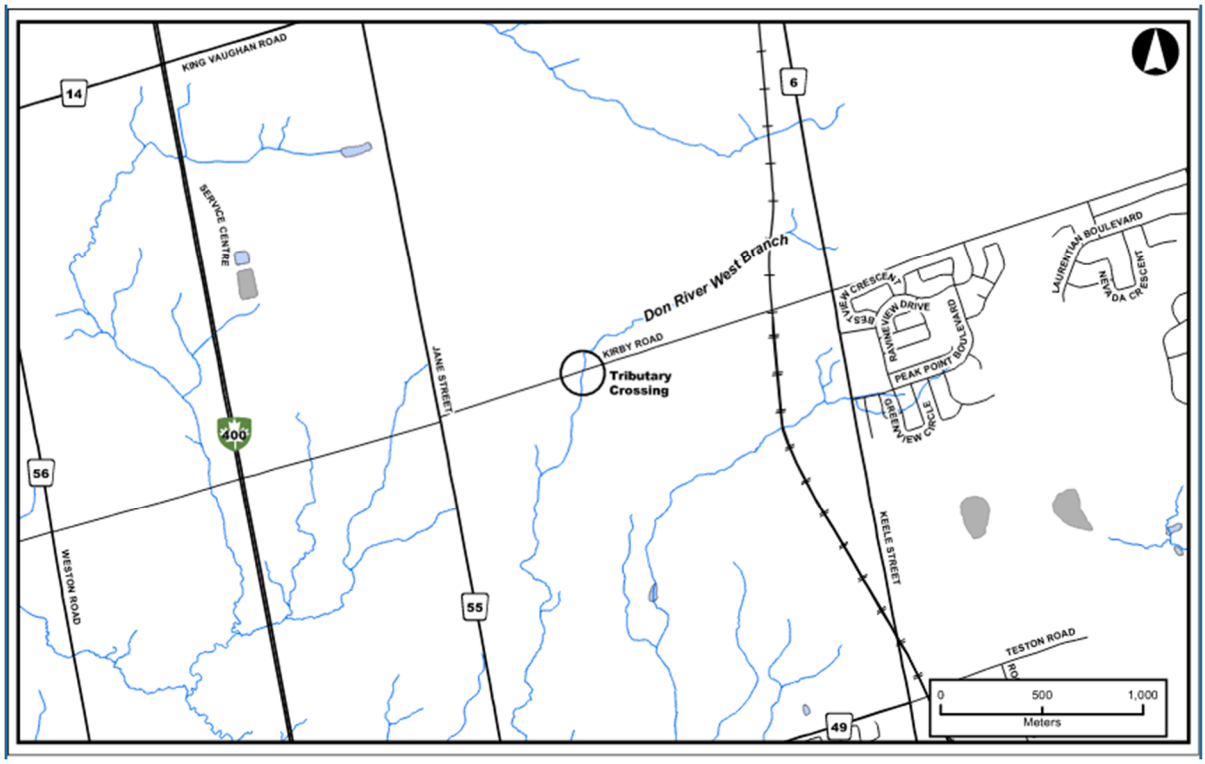
This Crossing Assessment Report is prepared as part of the EA study to address the identified needs and opportunities, alternatives and evaluations and recommendations at the three crossing locations in the Kirby Road Widening EA corridor. The three locations are:

1. West Don River Tributary Crossing, located approximately 750m east of Jane Street
2. Barrie GO Rail Corridor Crossing, located west of Keele Street
3. Wildlife Corridor Crossing, located west of Dufferin Street

2 West Don River Tributary Crossing

The Kirby Road Widening EA study corridor includes a crossing of the West Don River Tributary across Kirby Road. At the crossing, there are existing twin corrugated steel pipe (CSP) culverts located under Kirby Road, approximately 750m east of Jane Street. According to the survey results there is an existing abandoned CSP culvert adjacent to the twin CSP culverts.

Key Plan



Existing Conditions

HDR's project team conducted a site visit on October 30, 2020. The existing twin CSP culverts located under Kirby Road are each 600mm in diameter and approximately 21.0m in length, the existing abandoned single CSP culvert is approximately 450mm in diameter and 33.6m in length. No rust, holes, or deterioration was observed on the exterior of the twin culverts and they appear to be new and in good condition. The existing abandoned single CSP culvert adjacent to the twin CSP culverts were not visible from the road. High bushes and trash were present in the vicinity of the twin culverts. The twin culverts appeared to have been replaced recently. Photos of the twin culverts can be found below in Figure 1 through Figure 3.

Figure 1 North side of the twin culverts. Trash and high vegetation surround the culvert.

Figure 2 South side of the twin culverts. High bushes and vegetation surround the culverts.

Figure 3 Looking north from the twin culverts.

Preliminary Assessment and Recommendations

Kirby Road between Jane Street and Dufferin Street is identified to be widened to four lanes, urbanized and will accommodate continuous and dedicated active transportation facilities and streetscaping. Within the study corridor, located approximately 750m east of Jane Street is the existing twin CSP culverts that carry the West Don River Tributary crossing at Kirby Road. Adjacent to the twin culverts is the single abandoned single CSP culvert.

A review was undertaken to determine key factors that would affect the design of this watercourse crossing in order to deliver preliminary recommendations at the crossing, to accommodate the proposed improvements and address existing deficiencies at the crossing. The assessment considered existing structural conditions, hydraulics, geotechnical and hydrogeological considerations, the natural environment (terrestrial habitat, fish, wildlife passage) and fluvial geomorphology, with the aim of improving the conditions at the crossing and addressing existing deficiencies. **Table 1** summarizes the key considerations from the respective technical disciplines, preliminary recommendations by discipline and an overall recommendation. Additional details can be found in the respective technical studies.

Table 1 Preliminary Recommendations for the Culvert

Criteria	
Structural ▪ Type and condition of existing structure and proposed structure	The twin culverts at the watercourse crossing seem to be new and in good condition. Based on HDR's site visit on October 30th 2020, the culverts appear to have been recently replaced. No rust, holes or deterioration was observed on the exposed segment of the existing twin culverts. The interior of the twin culverts was not visible due to the high vegetation and trash surrounding the inlet and outlet of the culverts.

Criteria	
	Adjacent to the twin culverts, the existing abandoned single culvert identified during survey, was not visible during the site visit. To accommodate the proposed road widening of Kirby Road to four lanes and continuous active transportation facilities, the existing culverts will either need to be extended or replaced. **Recommendation:** Based on the existing structural conditions of the culverts, the culverts are in good condition and do not require replacement. However, due to the widening of the Kirby Road corridor, grading requirements and hydraulic requirements, the culverts will need to be replaced.
Hydraulics ▪ Conveying the Regional Flow without overtopping is not a requirement; however, ensuring there are no impacts to the Regional Floodlines upstream and downstream of the crossing is a requirement	A review of the Toronto and Region Conservation Authority (TRCA) hydraulic model, indicates that the twin culvert crossing at the Don River West Branch do not meet the MTO freeboard criterion and the road is overtopped by the Regional flood at this location. **Recommendations:** Replacement with a larger opening to meet the MTO freeboard criterion and accommodate the Regional flood at the water crossing is required to address existing hydraulic capacity.
Geotechnical and Hydrogeological ▪ Bearing capacity of soil ▪ Groundwater and Dewatering Requirements	Based on the geotechnical and hydrogeological investigations one borehole (Borehole 20-03) was drilled at the location of the existing CSP's located approximately 750 m east of Jane Street. The subsurface stratigraphy encountered in this borehole consisted of a pavement structure, granular fill layer and 0.2 m thick layer of organic material underlain by native silty clay till at 2.2 m depth (Elev. 270.5), a dense silt and sand layer from 5.6 to 7.2 m depth (Elev. 267.1 to 265.6), and firm silty clay to the exploration depth of 8.2 m. Groundwater was measured at a highest level of 4.4 m (Elev. 268.4). **Recommendation(s):** An extension of the existing CSP's or a new CSP or box culvert should be placed on the firm to hard silty clay. A minimum 300 mm thick layer of Granular A bedding material should be provided under the base of the new CSP or box culvert. Alternatively, an open footing culvert may be supported on spread footings founded on very stiff native clay till at or below 3.0 m depth (Elev. 269.7) and designed using factored geotechnical resistances of 375 kPa at ULS and 250 kPa at SLS. Construction dewatering is not expected to be an issue provided excavations are maintained within the clay till above

Criteria	
	the surface of the water-bearing silt and sand layer, and temporary stream diversion measures are provided seasonally as required.
Natural Environment ▪ Passage of wildlife (openness ratio) ▪ Fish (if identified) movement upstream and downstream	In consideration of wildlife movement, the existing crossing conveys flow with agricultural lands located north and south of Kirby Road. This location currently accommodates the passage of small sized mammals (e.g. cottontails, squirrels, chipmunks, and raccoons) and amphibians which is identified as sufficient for the corridor at this location The watercourse has not been identified as habitat for fish. **Recommendation:** Culvert opening size should accommodate passage of small sized mammals as per existing conditions. The Openness Ratio for the recommended design can be calculated to confirm this.
Fluvial Geomorphology ▪ Meander Belt Assessment	The existing crossing has poor channel definition, limited erosion potential associated with swale features, and little to no erosion was observed during field reconnaissance. Therefore, a theoretical meander belt was calculated. The theoretical meander belt at the water crossing in question runs from 5-7 meters depending on model. The existing structure is installed at a skew. **Recommendation:** Given the nature of the reaches upstream and downstream of the existing crossing, any proposed crossing modification or replacement should address hydraulics and ecological requirements. It should be noted that the opening size should incorporate velocity limitations through the proposed structure If a replacement crossing is proposed to be installed, consideration should be given to form a perpendicular crossing to Kirby Road. This approach would be consistent with TRCA (2015) and CVC (2015 and 2019) crossing guidelines. A local feature realignment would also be required to accommodate the proposed replacement crossing if placed perpendicular.
Recommendation	Replacement of the culvert with a larger opening to address hydraulic capacity requirements is identified.

The recommendation for the culvert replacement type was determined based on an evaluation of three options as listed in **Table 2**.

Table 2 Evaluation of West Don River Tributary Crossing Culvert Modification / Replacement Options

West Don River Tributary	Option 1 - Extend Culverts	Option 2 - Replace culvert with twin concrete culverts	Option 3 - Replace culvert with 2 single concrete culverts
Description	The existing CSP culverts will be extended	The existing CSP culverts will be replaced with twin concrete box culverts with a larger hydraulic opening, a slight raise in the road profile and perpendicular crossing.	The existing CSP culverts will be replaced with 2 new precast concrete single-cell culverts a larger hydraulic opening, a slight raise in road profile and perpendicular crossing.
Capital Cost	N/A	$782,460	$869,400
Life Cycle Cost		Slightly less rehabilitation cost in the future.	Slightly more rehabilitation cost in the future due to 2 culverts needing repair.
Utilities	No difference in impact to utilities compared to other options	No difference in impact to utilities compared to other options	No difference in impact to utilities compared to other options
Environmental - Species-at-Risk	No impact	No impact	No impact
Environmental - Fluvial	Does not address the fluvial recommendations	Addresses the fluvial recommendations	Addresses the fluvial recommendations
Environmental - Hydraulics	Not recommended by hydraulics. Existing twin CSP opening size is not sufficient and does not meet the MTO freeboard criterion. The road is overtopped by the Regional flood at this location. Further extension of the culvert has the potential to decrease hydraulic capacity.	Increased hydraulic capacity addresses hydraulic concerns to meet the MTO freeboard criterion and eliminates the upstream Regional flood level to improve the overall safety of the crossing, pending opening size.	Increased hydraulic capacity addresses hydraulic concerns to meet the MTO freeboard criterion and eliminates the upstream Regional flood level to improve the overall safety of the crossing, pending opening size.
Constructability	Common construction materials and techniques.	This option results in insufficient cover over the box culvert from a road structure perspective.	Sufficient cover is provided from a road structure perspective. Common construction materials and

West Don River Tributary	Option 1 - Extend Culverts	Option 2 - Replace culvert with twin concrete culverts	Option 3 - Replace culvert with 2 single concrete culverts
		Common construction materials and techniques. Temporary stream water diversions and dewatering will be required during construction.	techniques. Temporary stream water diversions and dewatering will be required during construction.
Future Infrastructure Consideration	No difference in impact to future infrastructure compared to other options	No difference in impact to future infrastructure compared to other options	No difference in impact to future infrastructure compared to other options
Durability / Maintenance	Existing culverts look like they were recently replaced, they are in good condition. The twin culverts would not need to be replaced for another 5 to 10 years	Conventional maintenance requirements. Existing maintenance requirements significantly increased to accommodate road widening and significant span increase requirements. Structure will not require rehabilitation for a minimum of 15 yrs.	Conventional maintenance requirements. Existing maintenance requirements significantly increased to accommodate road widening and significant span increase requirements. Structure will not require rehabilitation for a minimum of 15 yrs.
TECHNICALLY PREFERRED ALTERNATIVE	Not recommended.	Not recommended.	**Recommended option.**

Recommended Culvert Sizing

Culvert replacement with two single concrete culverts (Option 3) was identified as the recommended design alternative to carry forward for improvements at the West Don Tributary Crossing.

Under existing conditions, the twin CSP culvert crossing is overtopped by the Regional Storm event by approximately 0.44 m and the MTO freeboard criteria is not met. To identify the preliminary culvert sizing for the replacement, a hydraulic analysis was undertaken and is documented in the Drainage and Stormwater Management Report prepared for the EA study. An option to slightly raise the road profile in addition to increasing the hydraulic capacity is recommended. In this scenario replacement with two Single Concrete Box culverts with dimensions of 3.9m x 1.2m x 33.6m on the east side and 3.6m x 0.9m x 33.6m on the west side,

crossing perpendicular to Kirby Road will result in eliminating the existing overtopping depth, and avoid the effect on the upstream Regional flood level, and the MTO freeboard criteria would be met.

As documented in the Natural Heritage Assessment Report, a minor linkage for small wildlife may occur crossing under Kirby Road via the existing twin corrugated steel pipe culverts. This minor linkage corresponds with the Greenbelt Plan Natural Heritage System corridor that crosses Kirby Road in this location however, this corridor is tilled for agriculture within the immediate vicinity of Kirby Road and it is unlikely that wildlife would specifically use this as a movement path. This crossing is also not identified for fish habitat.. The proposed replacement culvert on the east side of the crossing will have an openness ratio of 0.14, with a width and height of 3.9m and 1.2m, respectively. The proposed replacement culvert on the west side of the crossing will have an openness ratio of 0.10, with a width and height of 3.6m and 0.9m, respectively. Both culverts will have a length of 33.6m. Based on these dimensions, the culvert will accommodate passage of small and medium-sized wildlife (CVC 2017).

The Fluvial Geomorphology Report indicated that the existing feature at this crossing is generally a poorly defined swale feature with no riparian zone. The crossing was stable with little or no erosion. The existing culvert is installed on a skew. Any proposed crossing modification or replacement should address hydraulics and ecological requirements, and the opening size should incorporate velocity limitations through the proposed structure. Upstream of the crossing the reach had a width and depth of 0.8 m and 0.25 m, respectively. There was no defined feature upstream of the crossing through the agricultural field, although a shallow depression was observed from a distance through the agricultural field. Downstream of the crossing the reach did not contain a discernable flow path through an agricultural field and lacked natural riparian vegetation. Typically a crossing that spans 3 times the bankfull width (0.8 m x 3 = 2.4 m) would be recommended. The 3.9m wide span proposed to address hydraulic requirements exceeds three times the bankfull width and given the limited channel definition and limited evidence of erosion, the proposed crossing span is adequate from a fluvial geomorphological perspective.

The recommended culvert replacement is for two Single Concrete Box culverts (3.9m x 1.2m and 3.6m x 0.9m respectively) with a perpendicular crossing of Kirby Road to require a culvert length of 33.6m. The proposed reduction in the skew of the culvert will reduce the overall culvert length, which is favourable from both geomorphic and ecological perspectives. Given the current skew of the culvert and the watercourse alignment upstream and downstream of the crossing, localized realignment would be required. The recommended culvert replacement size and type addresses the hydraulic requirements, ecological passage and fluvial geomorphic considerations at the crossing location.

Recommended Structure

Two Single Concrete Box culverts (3.9m x 1.2m and 3.6m x 0.9m respectively) of 33.6m length is proposed to replace the existing twin CSPs, following a perpendicular crossing of Kirby Road. The proposed crossing angle will result in an overall reduction in the length of the proposed crossing. The perpendicular crossing to Kirby Road is consistent with TRCA (2015) and CVC

(2015 and 2019) crossing guidelines. Pre-cast structures are recommended however depending on the construction schedule and road closure requirements during detailed design, cast-in-place concrete box culverts may be utilized as well.

As the existing crossing is skewed, localized realignment of the drainage feature will be required to accommodate the perpendicular replacement crossing. To ensure long-term stability, during detailed design it is recommended to consider implementing a formalized low flow channel through the crossing, and installing stone cored wetland treatments at the crossing inlet and outlet. In addition, bioengineered bank treatments such as brush mattress or vegetated buttresses should be installed at the crossing inlet and outlet to provide flow training. Given the existing drainage feature has limited form and is vegetation controlled, it is recommended that the realigned feature be replicated as a vegetated swale positioned within the ROW.

To ensure proper implementation of the realigned drainage feature, the following additional recommendations are provided for the Detailed Design stage:

- Confirm the gradient and upstream and downstream tie-in locations for the realigned drainage feature
- Design a formalized low flow channel with natural substrates through the crossing
- Complete hydraulic sizing for any stone to be used within the crossing, upstream and downstream wetlands and bioengineered bank treatments
- Develop a native planting plan for the realigned drainage feature that will complement bioengineered treatments and wetland features
- Establish site access routes, staging and storage areas for construction
- Prepare an erosion and sediment control plan
- Complete instream works during periods of limited to no flow

The following outlines the design requirements of the recommended structure:

Access to the Site
The site is readily accessible from Kirby Road. A traffic staging plan will need to be developed during the detailed design in consultation with York Region.

Property
Property acquisition is anticipated on the south side of the Kirby Road within the project limits.

Design Code
The design of the culverts and retaining wall will be undertaken in accordance with the CAN/CSA-S6—19 Canadian Highway Bridge Design Code (CHBDC), Ministry of Transportation of Ontario’s (MTO) "Structural Manual", York Region standards and all other current directives and standards.

Concrete
All cast-in-place concrete will be class C-1, 30MPa concrete and precast concrete shall be 45 MPa as per CSA A23.I-19 and Section 12 of the MTO Structural Manual 2021.

Reinforcing Steel

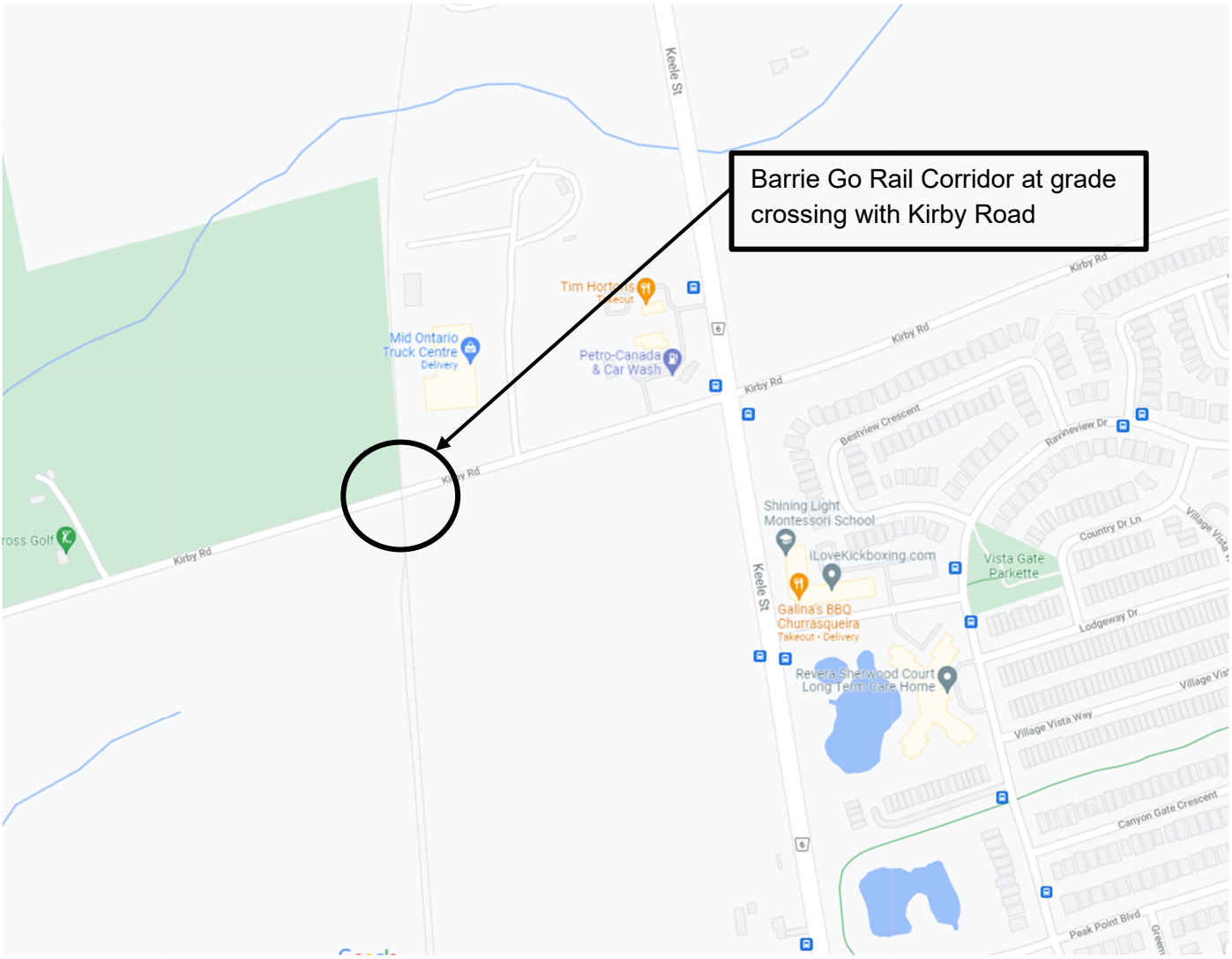
Reinforcing bars shall be in accordance with the requirements of CSA G30.18 Grade 400W or 500W and as specified in Section 8 of CHBDC-2019 and MTO Bridge Office Memorandum dated July 7, 2021 “500MPa Steel Reinforcement”.

Refer to **Appendix A** for the General Arrangement Drawing of the proposed culvert replacement at the West Don Tributary Crossing.

3 Barrie GO Rail Corridor Crossing

The Kirby Road Widening EA study corridor includes an existing at-grade crossing of the Barrie Go Rail Corridor, approximately 300m west of Keele Street. See **Figure 4.**

Figure 4: Key Plan at Barrie GO Rail Crossing



Existing Conditions

Kirby Road between Keele Street and Jane Street is a two-lane, east-west rural arterial road. The level at-grade crossing is a single-track of the Barrie Go Rail Corridor, with crossing gates and signal lights. The crossing is located between the Maple Go Station and King City Go Station. Approximately 50m south of the crossing, the single-track splits into two tracks.

On the northwest side of the rail crossing is the Carrick Macross Golf course. Approximately 80m and 110m from the rail crossing on the northeast side, are two driveway accesses leading to the

Mid-Ontario Truck Centre and to service the undeveloped lands at the second entrance. There are commercial buildings housing a Tim Hortons, an A&W Canada and Petro Canada gas station approximately 250m from the crossing and an access to the gas station from Kirby Road. On both the southwest and southeast side of the rail crossing there is farmland with wetlands on the southwest corner of the crossing.

Grade Separation

The City's Kirby GO Transit Hub Sub-Study, 2016, identified a need for grade separation of Kirby Road at the Barrie GO Rail line and preliminary recommendations to accommodate a GO station access at Kirby Road. The recommendation was made to enhance safety, reduce traffic delay, and accommodate increased transit frequency of the GO line. In addition, the Transportation and Traffic Analysis Report completed for this Kirby Road Widening EA reviewed the need for the grade separation. As part of the assessment the exposure index at the crossing was computed, which followed the "Inventory Manual: Municipal Roads and Railway Level Crossings, Ontario Ministry of Transportation", a document traditionally used in Ontario as a baseline for determining if a grade separated crossing is warranted. The calculated train exposure index, based on the daily AADT and trains at the crossing, is not met today for current volumes; however, by 2031 and 2041 the exposure index is more than ten times as large as the warranted value for a grade separation. As a result, grade separation of the crossing is recommended. Refer to the EA study's Transportation and Traffic Assessment Report for more information.

Identification of Alternatives

To address the preferred solution at the Barrie GO Rail Crossing the following alternative design concepts were considered. Each alternative includes the widening of Kirby Road and continuous active transportation facilities.

1. Alternative 1 – At-Grade Crossing (maintain the at-grade rail crossing with widened Kirby Road)
2. Alternative 2 – Underpass (Road Under Rail)
3. Alternative 3 – Overpass (Road Over Rail)
4. Alternative 4 – Hybrid (Hybrid Underpass: Raised rail with lowered road / Hybrid Overpass: Lowered rail with raised road)

Alternative 1 – At-Grade Crossing, was screened out at a high level as it does not address potential conflict points at the rail crossing with the proposed active transportation facilities and vehicular traffic. It also results in greater delays and queues associated with additional time for crossing arms and signals to accommodate the increased GO train traffic planned for the future. The planned service along the Barrie GO Rail Corridor resulted in the calculated exposure index to be more than ten times as large as the warranted value for a grade separation in the 2031 and 2041 horizon years.

Alternative 4 was screened out at a high level based on the geometrics of the rail corridor and in consultation with Metrolinx. It was noted that changes to the profile of the rail which would be required for a Hybrid option would be too impactful for the length of the rail corridor. This is due to the length of rail upstream and downstream of the Kirby Road crossing that would be required

to be raised / lowered to accommodate a grade change Kirby Road, the impacts to the rail curvature south of the Kirby Road crossing, and high groundwater table for potential options to lower the rail.

Alternative 2 - Underpass and Alternative 3 - Overpass were therefore carried forward for detailed assessment. Conceptual profiles for Alternatives 2 – Underpass and Alternative 3 – Overpass were prepared to inform the evaluation of the alternatives and are provided in **Appendix B** .

The proposed structural alternatives for the Underpass option considered both an Underpass with Retaining Walls along Kirby Road (Alternative 2A) as well as an Underpass without Retaining Walls along Kirby Road (Alternative 2B). Detailed descriptions of the structural alternatives carried forward for detailed evaluation are listed below:

Alternative 2: Underpass

Alternative 2A: Underpass with Retaining Walls along Kirby Road

This alternative proposes to construct a depressed corridor along the section of Kirby Road under the railway track to by-pass the existing Barrie GO Rail crossing. The roadway has a maximum of 7% grade and the sidewalk and boulevard cycle tracks has a maximum of 3.85% grade as it would be elevated where feasible, which complies with AODA standards. The depressed corridor consists of a concrete base slab and retaining walls on both sides of the concrete base slab forming a U shaped structure. The retaining walls and concrete base slab are approximately 465m in length and the concrete base slab varies in width from 27.75m to 31.3 m. Due to the high ground water level indicated in the geotechnical report, waterproofing around the structure is recommended. The design speed for Kirby Road is 80km/hr.

A two (2) span concrete slab on steel girders (deck plate girder) bridge is recommended for the railway track crossing. Based on preliminary borehole data, the geotechnical engineer suggested considering driven piles or augered caissons as foundation for the substructure. The foundation of the substructures shall be refined during Detailed Design. Vertical clearance between the bottom flange of the steel girder and the roadway shall not be less than 5.3 m. The proposed bridge should be designed in accordance with the latest AREMA Manual and Metrolinx Guidelines. The bridge should be designed to carry Cooper E-80 live loading plus diesel vehicle impact, with a service life of 100 years. This alternative proposes to maintain the existing Barrie Go Railway crossing at the same elevation and widen Kirby Road to accommodate the new Cycle tracks, Sidewalks and traffic lanes.

As per the Metrolinx General Guidelines for Design of Railway Bridges and Structures (Metrolinx Guidelines), Part 1, Section 8, semi-integral and integral abutment bridges will not be permitted unless there is written approval from the Rail Corridor Infrastructure Senior Manager Track and Structures. Semi-integral connections between superstructure and substructure can eliminate the need for costly maintenance more common with expansion joint connections. Per Metrolinx Guidelines, Part 2A, Section 1.2, the superstructure of proposed railway bridges shall be simply-supported spans.

The Barrie Go Railway crossing underpass has a moderate improvement to traffic congestion by reducing delays caused by at-grade train crossing and thus improve the access to businesses and surrounding developments. It is also expected that the underpass will have a minor impact to the visual aesthetics to the surrounding residences, as the road is below the railway bridge.

The constructability of this option is complex, this is due to the extensive coordination with Metrolinx, York Region, the City of Vaughan, utility companies and stakeholders of properties adjacent to the Go Barrie Railway crossing. Vehicular (2 lanes in each direction) and train traffic must be maintained at all times. It is expected that construction of the underpass could take multiple years to complete. A significant area around the railway crossing will be required to be closed during construction. This option will require relocation of the existing utilities.

A temporary railway line may be required for the construction of the railway bridge underpass, this will depend on the construction staging planned during Detailed Design. The temporary railway line could result in substantial project schedule risk due to rail operational coordination factors; for example, rail traffic and operations must be substantially maintained daily during construction.

Significant excavation with temporary shoring will be required for this option to construct the substructure, this has the possibility of disturbing existing contaminated soils. In turn this may require environmental clean-up of the contaminated soils. The depressed corridor will also require underground catch basins and drainage to collect stormwater and ground water runoff from the roadway to prevent flooding. Water collected by the catch basins shall be drained to the wet area on the west side of the structure.

The preliminary cost estimate for Alternative 2A is $63.99M.

Alternative 2B – Underpass without retaining wall along Kirby Road

This alternative proposes to construct a depressed corridor along the section of Kirby Road under the railway track to by-pass the existing Barrie GO Rail crossing. The embankment slopes will be graded along Kirby Road with the intention of eliminating the need for retaining walls.

The Barrie Go Railway crossing underpass has a moderate improvement to traffic congestion by reducing delays caused by at-grade train crossing and thus improve the access to businesses and surrounding developments. It is also expected that the underpass will have a minor impact to the visual aesthetics to the surrounding residences, as the road is below the railway bridge.

The constructability of this option is complex, this is due to the extensive coordination with Metrolinx, York Region, the City of Vaughan, utility companies and stakeholders of properties adjacent to the Go Barrie Railway crossing. Vehicular (2 lanes in each direction) and train traffic must be maintained at all times. It is expected that construction of the underpass could take multiple years to complete. A significant area around the railway crossing will be required to be closed during construction. This option will require relocation of the existing utilities.

A significant quantity of grading will be required for this option. Due to the need to acquire a large amount of land adjacent to Kirby Road for grading purposes, this option is not feasible since there are existing buildings close to Kirby Road.

The preliminary cost estimate for Alternative 2B is $21.54M. This cost estimate does not include costs associated with acquiring additional land or any utility relocation costs.

Alternative 3 – Overpass

This alternative proposes to construct a single span bridge over the existing Barrie Go Rail crossing. The proposed structure is a slab on CPCI girder bridge supported on integral abutments. The bridge will be approximately 25 m long and 36m wide with a design speed of 80 km/hr.

The substructure consists of reinforced concrete abutments and wingwalls supported on one (1) row of piles at each abutment.

The overpass bridge has a moderate improvement to traffic congestion by reducing delays caused by at-grade train crossings and thus improve the access to businesses and surrounding developments. Although the overpass has many benefits, the bridge is a minimum of 7.595 m above the top of the highest rail. Permanent closure of direct accesses to Kirby Road will be required for the Overpass option due to steep grades that result from executing this option. There will be significant visual aesthetic impact to the surrounding businesses.

The constructability of Alternative 3 is less complex compared to Alternative 2. It is expected that the Barrie GO Railway line can be maintained and has minimal impact to the daily rail operation throughout the construction. In addition, the construction of the overpass bridge can be completed within two (2) construction seasons. A moderate area around the railway crossing will be required for closure during the construction.

Excavation to the existing ground is minimal for this alternative since it is proposed to have an integral abutment and minimal foundation excavation will be required. This will reduce the potential of contaminating the soil ground water. The water table will likely not be affected and drainage from the roadway run off can be easily drained.

The preliminary cost estimate for Alternative 3 is $21.31M.

Evaluation of Alternatives

The evaluation criteria used to assess the alternative design concepts at the Barrie GO Rail Crossing are listed in **Table 3.** Each category that was evaluated was summarized using the following rankings.

Not Preferred (Does not meet objectives)	**Less Preferred** (Partially meets objectives)	**Preferred** (Meets objectives)

The evaluation of Alternatives 2 and 3 is provided in **Table 4** and **Table 5.** Based on the findings of the assessment **Alternative 2A: Underpass (Rail over Road) with Retaining Walls along Kirby Road** is the recommended rail crossing alternative.

Table 3: Evaluation Criteria

Consideration	Criteria
Transportation Service	• Improve Public Transit Service • Reduce Traffic Congestion and Delays • Create a Pedestrian-Friendly Environment • Create a Cyclist-Friendly Environment • Improve Safety for all Travel Modes • Improve Mode Choice • Accommodate Emergency Services
Social Environment	• Minimize Impacts on Existing Residential, Institutional and Recreational Dwellings / Properties • Minimize impacts to Active Agricultural Lands • Minimize Traffic Noise • Preserve Archaeological and Cultural Heritage Features • Improve Visual Aesthetics
Infrastructure Design and Economic Environment	• Minimize Utility Relocation • Accommodate Planned Development and Growth • Minimize Impacts and Improve Access to Businesses • Minimize Property Acquisition • Maximize Construction Value • Minimize Operating Costs • Minimize Disruption due to Construction
Natural Environment	• Protect Designated Areas • Protect Vegetation • Protect Wildlife • Protect Aquatic Habitat • Improve Air Quality • Protect Surface Water and Ground Water • Minimize Effects on Climate Change • Minimize Flooding and Erosion and Protect Slope Stability

Table 4: Barrie GO Rail Crossing - Evaluation of Alternative Design Concepts

CRITERIA	ALTERNATIVE 2 (2A and 2B): UNDERPASS - Kirby Road under Rail	ALTERNATIVE 3: OVERPASS - Kirby Road over Rail
TRANSPORTATION SERVICES		
Improve Public Transit Service	• Road widening, intersection improvements and continuous and dedicated active transportation facilities and grade separation **support Kirby Road as part of the Region's Frequent Transit Network** by providing opportunities for **more efficient transit service and routing**, addition of transit stops / amenities, vehicular and pedestrian/cyclist **access to future Kirby GO Station** and direct access to transit stops from walking and cycling modes • **Reduction in delays to transit service** with elimination of at-grade rail crossing	
Reduce Traffic Congestion and Delays	• **Improvement** to traffic operations by reducing delays caused by at-grade train crossings	
Create a Pedestrian-Friendly Environment	• **Significant improvement** to pedestrian environment with continuous AT facilities on both sides through elevated structure that provides separation from rail crossing **with reduced incline for AT users (5%)** than road grade. • **Direct pedestrian access** to adjacent land use with increased travel distance • **Moderate reduction** to perceived safety due to reduced visibility of pedestrian passage within underpass structure and likely to be noisy	• **Moderate improvement** to pedestrian environment with continuous AT facilities on both sides of elevated structure that provides separation from rail crossing. **Greatest travel distance with wind exposure** and **substantial incline (7%) along west side** • **Reduction in direct pedestrian access** to adjacent land use due to steeper slopes and longer travel distance • **Significant improvement** to perceived safety with elimination of at-grade crossing and clear visibility of pedestrian passage
Create a Cyclist-Friendly Environment	• **Significant improvement** to cyclist environment with continuous AT facilities on both sides through elevated structure that provides separation from rail crossing with **reduced incline for AT users (5%)** than road grade (7%) • **Direct cyclist access** to adjacent land use with increased travel distance • **Moderate reduction** to perceived safety due to reduced visibility of cyclist passage within underpass and likely to be noisy	• **Moderate improvement** to cyclist environment with continuous AT facilities on both sides of elevate structure that provides separate from rail crossing. **Greatest travel distance with wind exposure** and **substantial incline (7%) along west side** • **Limited cyclist direct access** to adjacent land use due to steeper slopes and longer travel distance • **Significant improvement** to perceived safety with clear visibility of cyclist passage
Improve Safety for all Travel Modes	• **Improved safety** with separation of conflict points and road users and rail crossing with grade-separation • **Improved safety** for cyclists and pedestrians with dedicated infrastructure providing greater separation on both sides of Kirby Road	
Improve Mode Choice	• **Improvement** in mode choice with provision of additional travel lanes to support more efficient transit service and routes, dedicated and continuous AT facilities and reduction in conflict points at the at-grade rail crossing	
Accommodate Emergency Services	• **Improvement** in access for emergency services due to increased number of lanes and elimination of delays at rail crossing from passing trains and crossing gates • **Direct access** from Kirby Road anticipated to be maintained to commercial driveways to the north	• **Improvement** in access for emergency services due to increased number of lanes and elimination of delays at rail crossing from passing trains and crossing gates • **Direct access** from Kirby Road anticipated to be maintained to commercial driveways to the north
Summary of Transportation Service	**Preferred**	**Not Preferred**
SOCIAL ENVIRONMENT		
Minimize Impacts on Existing Residential, Institutional and Recreational Dwellings / Properties	• **Property requirement** from golf course lands north of Kirby Road. No change to access	
Minimize Impacts to Active Agricultural Lands	• **No active** agricultural operation identified. • Impacts to common field crop and scrub land south side can be minimized with retaining walls. • **No** Provincially Designated Specialty Crop areas identified	
Minimize Traffic Noise	• Noise level associated with an underpass is anticipated to be **higher** than that associated with an overpass dependent on design of underpass walls • **Potential elimination** of train whistles at the crossing with grade separation	• Noise level associated with an overpass is anticipated to be **lower** than that associated with an underpass • **Potential elimination** of train whistles at the crossing with grade separation

CRITERIA	ALTERNATIVE 2 (2A and 2B): UNDERPASS - Kirby Road under Rail	ALTERNATIVE 3: OVERPASS - Kirby Road over Rail
	• **Significant temporary noise impact** due to construction expected as a result of proximity between detour roadway to commercial buildings adjacent to Kirby Road	• **Significant temporary noise impact** due to construction expected as a result of proximity between detour roadway to commercial buildings adjacent to Kirby Road
Preserve Archaeological and Cultural Heritage Features	• Potential to impact CHL5 Farmscape (Listed on City's Heritage Register), CHL 6 Farmscape and CHL 7 Rail corridor • Lands do not retain archaeological potential	
Improve Visual Aesthetics	• **Moderate reduction** to visual aesthetics for the travelling public on Kirby Road with all road users crossing under the rail • **Opportunity** for tree planting or landscaping in screening buffer and beyond limits of underpass walls • **Temporary reduction in aesthetics** with detour roads	• **Significant reduction** to visual aesthetics due to visual obstruction of new overpass structure anticipated to be 9.58m in height, including potential parapet walls • **Opportunity** for tree planting or landscaping in embankment or by retaining walls • **Temporary reduction in aesthetics** with detour roads
Summary of Social Environment	**Preferred**	**Less Preferred**
INFRASTRUCTURE DESIGN AND ECONOMIC ENVIRONMENT		
Minimize Utility Relocation	• **Moderate** utility conflicts and impacts based on existing utilities. • **Anticipated relocation** of above ground and underground facilities, including telecommunications aerial lines and underground conduits, and gas. Underground utility relocation includes buried facilities.	• **Minor-moderate** utility conflicts and impacts based on existing utilities. • **Anticipated relocation** of above ground and underground facilities, including telecommunications aerial lines and underground conduits, and gas.
Accommodate Planned Development and Growth	• **Supports** approved development in the study area by providing adequate capacity and transportation choices to accommodate planned growth, eases congestion at the rail crossing and supports future Kirby GO Station • **Provides multi-modal future** access to Kirby GO Station from Kirby Road to tie into underpass may result in **steeper access**	• **Supports** approved development in the study area by providing adequate capacity and transportation choices to accommodate planned growth, eases congestion at the rail crossing and supports future Kirby GO Station • **Provides multi-modal future** access to Kirby GO Station from Kirby Road to tie into overpass may result in **steeper access** than Underpass Alternative
Minimize Impacts and Improve Access to Businesses	• **Property requirement** identified from commercial / industrial uses, with potential to reduce grading impacts with retaining walls. • **Moderate impact** to two commercial accesses (Mid Ontario Truck Centre) may result in significant regrading and / or steeper slopes of entrances. • **Minor impact** to existing entrance (Tim Hortons/Gas Station) to tie into underpass design due to little / no road re-profiling • **Potential temporary encroachment** on commercial parking lot as a result of the construction of the detour route • **Improvement** to transit, pedestrian, and cycling access with provision of dedicated facilities	• **Property requirement** commercial / industrial uses, with potential to reduce grading impacts with retaining walls. • **Significant impact** to two commercial accesses (Mid Ontario Truck Centre) resulting in potential access closures / re-alignment, or significant regrading and / or steeper slopes of entrances. • **Minor impact** to existing entrance (Tim Hortons/Gas Station) to tie into overpass design due to little / no road re-profiling • **Potential temporary encroachment** on commercial parking lot as a result of the construction of the detour route • **Improvement** to transit, pedestrian, and cycling access with provision of dedicated facilities
Minimize Property Acquisition	• **Moderate property requirements** with potential to reduce property requirements and grading impacts with retaining walls.	• **Moderate property requirements** with potential to reduce property requirements and grading impacts with retaining walls.
Maximize Construction Value	• **Very significant capital costs** to construct rail bridges, second rail track, retaining walls, detour roads, raised AT facilities, underpass, and drawdown pumping system **(if required)** • Approximate Structure Cost *considers bridge design/construction, rail work, and excavation/retaining wall/U-channel excluding earthworks):* $$$$ *(with retaining walls)* ***OR*** $$$ (without retaining walls, excluding earthworks) • Approximate Pumping Station Cost: $ **(if required)** • Approximate Road Cost due to more excavation: $$	• **Significant capital costs** to construct overpass structure, retaining walls, and detour roads • Approximate Structure Cost *(excluding earthworks):* $$$ • Approximate Road Cost: $$
Minimize Operating Costs	• **Significant increase in operating costs** with rail bridges, retaining walls, raised AT facilities, and drawdown pumping system **(if required)**	• **Moderate increase in operating costs** with retaining walls and overpass

CRITERIA	ALTERNATIVE 2 (2A and 2B): UNDERPASS - Kirby Road under Rail	ALTERNATIVE 3: OVERPASS - Kirby Road over Rail
Minimize Disruption due to Construction	• **Potential moderate disruption** to rail corridor users due to tunneling, support for rail lines and construction of underpass • **Moderate delays** to road corridor users due to potential lane closures, construction of detour roads (potential for at-grade and/or grade-separated), and AT facilities to maintain access throughout construction • **Longer** construction duration - anticipated to be 3 to 4 years • **Significant constructability concerns identified:** o Construction staging and requirement for detour roads (potential for at-grade and/or grade-separated detours) o Multi-level dewatering system required during construction o Internal drainage and pumping system, or long-term groundwater drawdown pumping system required for long-term o Additional second track to be constructed. Track modifications, if required, will require scheduled short duration track outages o Need for construction of concrete base slab and contiguous caisson walls along north and south sides of Kirby Road • **Risk of flooding** if long-term groundwater drawdown system shuts down; however, retaining walls should be designed for full hydrostatic pressure	• **Potential minor disruption** to rail corridor users due to construction of overpass structure • **Moderate delays** to road corridor users due to potential lane closures, construction of detour roads (potential for at-grade and/or grade-separated), and AT facilities to maintain access throughout • **Short** construction duration - anticipated to be 2 year • **Moderate constructability concerns:** o Construction staging and requirement for detour roads (potential for at-grade and/or grade-separated detours) o Approach embankment east and west of the rail line can be constructed with side slopes, or Retained Soil System walls could be constructed to retain the approach embankment • **No change** to risk of flooding
Summary of Infrastructure Design and Economic Environment	**Less Preferred**	**Not Preferred**
NATURAL ENVIRONMENT		
Protect Designated Natural Areas	• **Moderate impact** to Provincially Significant Wetlands (PSWs) on south side • **No impact** to Areas of Natural and Scientific Interest (ANSI) or Environmentally Sensitive Area (ESA) within the study area segment • **No impact** to Greenbelt Plan Area	• **Moderate impact** to Provincially Significant Wetlands (PSWs) on south side • **No impact** to Areas of Natural and Scientific Interest (ANSI) or Environmentally Sensitive Area (ESA) within the study area segment • **No impact** to Greenbelt Plan Area
Protect Vegetation	• **Moderate** impact to vegetation due to construction of widening with larger footprint and excavation; adjacent vegetation communities consist of a golf course on the north side and cultural meadows on the south side • **No impact** to trees with 50dbh or higher • **No impact to rare, threatened, or endangered species**	• **Moderate** impacts to vegetation due to construction of widening; adjacent vegetation communities consist of a golf course on the north side and cultural meadows on the south side • **No impact** to trees with 50dbh or higher • **No impact to rare, threatened, or endangered species**
Protect Wildlife	• **Minimal impact** to vegetative communities yielding wildlife habitat, as they are generally sparse on both sides of the study corridor at this section due to existing land-use. • Minimal impact to Eastern Towhee found in cultural meadows on the south side	
Protect Aquatic Habitat	• **No anticipated impact** to aquatic habitat	
Improve Air Quality	• **Improved air quality** through elimination of at-grade crossing which eliminates vehicle queuing caused by increased GO Train service and additional train crossings. Additional capacity to address congestions and more efficient transit service and provisions of continuous active transportation facilities that will encourage people to divert from cars	
Protect Surface Water and Ground Water	• **Significant impact** with increased roadway width and hard surface area; stormwater quantity will increase, and quality mitigation must be implemented • Land identified in the study area fall within the Significant Groundwater Recharge Area (SGRA) under the Clean Water Act, 2006. **Moderate impact** to shallow groundwater system due to potential increase in contaminants (for ex. road salt) resulting from increased roadway width. Stormwater quality mitigation required. • **Significant excavation-based impacts** to groundwater are anticipated • **Dewatering** will be required to lower the groundwater table at least 1.0 m below the excavation base, with the majority of the dewatering quantities arising from	• **Moderate impact** with increased roadway width and hard surface area; stormwater quantity will increase, and quality mitigation must be implemented. Corridor will be urbanized • Land identified in the study area fall within the Significant Groundwater Recharge Area (SGRA) under the Clean Water Act, 2006. **Moderate impact** to shallow groundwater system due to potential increase in contaminants (for ex. road salt) resulting from increased roadway width. Stormwater quality mitigation required. • **No excavation-based impacts** to groundwater are anticipated as excavation is expected to remain above the groundwater level

CRITERIA	ALTERNATIVE 2 (2A and 2B): UNDERPASS - Kirby Road under Rail	ALTERNATIVE 3: OVERPASS - Kirby Road over Rail
	the sand layer. If lowering of the groundwater table is not permitted, installation of a permanent shoring and groundwater control system (such as a contiguous caisson wall enclosure) will be required to retain both soil and groundwater during and after construction. • **Category 3 Permit to Take Water anticipated** to be required for construction and to support long-term improvements • If permanent drainage of groundwater is permitted by external agencies, dewatering soils can be achieved by either: gravity drainage if topography and discharge location feasible; or pumping station. • If permanent drainage is not permitted, then requires watertight "bathtub" structure that is designed to resist uplift.	• No construction dewatering to lower the groundwater level is expected to be required. • **Permanent dewatering is not required** • **Permit to take water not anticipated** to be required for construction or to support long-term improvements • Unwatering to remove seepage entering the excavation would be less than 400,000 litres per day and thus **registration on the Environmental Activity and Sector Registry (EASR)** would be required.
Minimize Effects of Climate Change	• **Lower reliance** on automobiles through increased non-auto mode share can reduce vehicle emissions and reduce effects on climate change • **Decreased congestion** resulting from elimination of vehicle queuing caused by gate closures at the rail crossing can decrease vehicle emissions and negative associated effects on climate change	
Minimize Flooding and Erosion and Protect Slope Stability	• Deep cut slopes inclined at 2H:1V with a 2 m wide mid-height berm are expected to be stable provided permanent groundwater control is provided to dewater the sand layer.	• High fill embankment slopes inclined at 2H:1V with a 2 m wide mid-height berm are expected to be stable. Settlement of the foundation soils under the fill loads to be reviewed if this option is carried forward. .
Summary of Natural Environment	**Less Preferred**	**Preferred**
OVERALL SUMMARY		
	This option provides continuous active transportation facilities, additional vehicle, and mitigates vehicle queuing caused by increased GO Train service. Pedestrian and cyclists also travel along a raised platform to minimize travelling distance and are grade separated from the rail crossing.	This option provides continuous active transportation facilities, additional vehicle lanes, and mitigates vehicle queuing caused by increased GO Train service. Pedestrian and cyclists travel along a steep incline (~7%) west of the tracks resulting in increased travel distance.
	Recommended	

Table 5: Evaluation of Alternatives - Structure Types

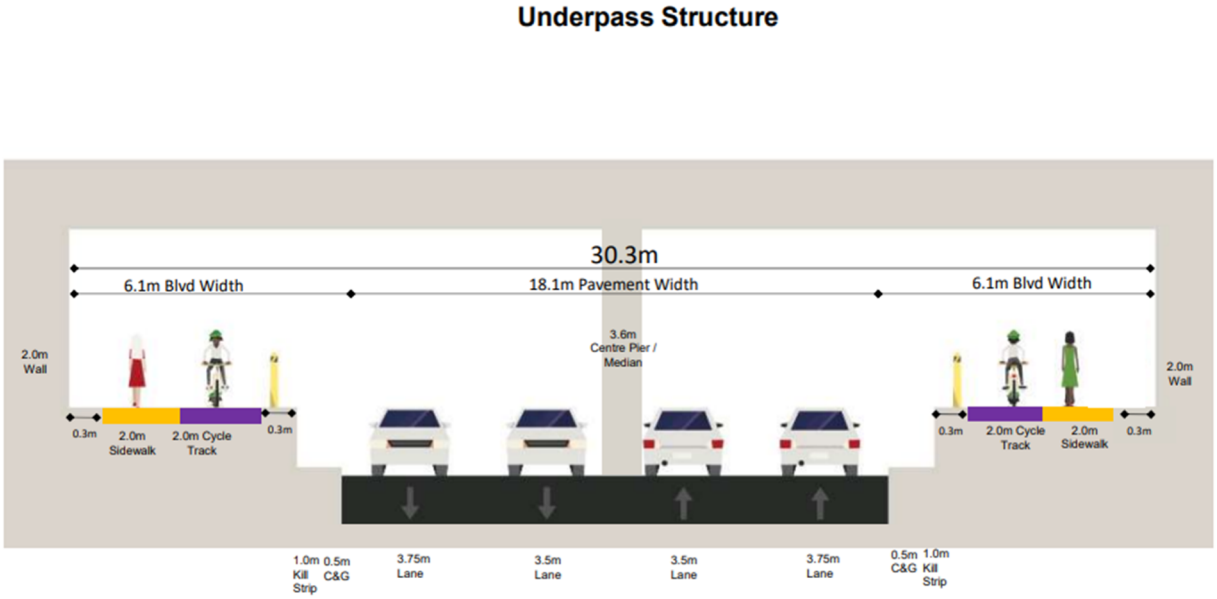
Barrie Go Rail Underpass	Option 2A - Underpass with Retaining walls along Kirby Road	Option 2B - Underpass without Retaining wall along Kirby Rd	Option 3 - Overpass
Functionality & Roadside Safety	Moderate impact to pedestrian environment due to increased travel distance for pedestrians traveling along moderate incline.	Moderate impact to pedestrian environment due to increased travel distance for pedestrians traveling along moderate incline.	Significant impact to pedestrian access along this section of the corridor due to steep grades.
Total Structural Cost	**$63,990,000**	**$21,540,235**	**$21,313,468**
Design + CA Cost	$7,960,000	$2,809,596	$2,780,018
Contingency Cost	$12,930,000	$4,322,455	$4,276,950
Construction Cost	$43,100,00	$14,408,184	$14,256,500
Utilities	Moderate utility conflicts and impacts based on existing utilities.	Moderate utility conflicts and impacts based on existing utilities.	Minor to moderate utility conflicts based on existing utilities compared to Underpass option.
Constructability	Considerably higher risk associated with significantly more complex construction methods. 2 span steel deck plate girder bridge with more detailed construction methods will be needed. Shoring walls and retaining walls addressing ground water along Kirby Road will be required.	Considerably higher risk associated with significantly more complex construction methods. 2 span steel girder bridge with more detailed construction methods will be needed. Shoring walls addressing ground water along Kirby Road will be required. However this option is not a watertight design and will require a permanent pumping station for groundwater. This option requires additional land for the embankment slope along Kirby Road.	Common construction materials and techniques. Due to longer spans required to span the railway, we may need prestressed girders.
Construction Duration	Anticipated to be a 3-to-4-year construction	Anticipated to be a 3-to-4-year construction	Anticipated to be a 1.5-to-2-year

Barrie Go Rail Underpass	Option 2A - Underpass with Retaining walls along Kirby Road	Option 2B - Underpass without Retaining wall along Kirby Rd	Option 3 - Overpass
	period. Construction of various components of the bridge are assumed to be constructed separately and not at the same time. Construction duration may be reduced if some components are built at the same time	period. Construction of various components of the bridge are assumed to be constructed separately and not at the same time. Construction duration may be reduced if some components are built at the same time	construction period. Construction of various components of the bridge are assumed to be constructed separately and not at the same time. Construction duration may be reduced if some components are built at the same time
Durability/ Maintenance	Maintenance requirements exceed conventional measures due to relatively complex construction and to address potential drainage issues resulting from storm events such as 100 years storm events.	Maintenance requirements exceed conventional measures due to relatively complex construction and to address potential drainage issues resulting from storm events such as 100 years storm events.	Conventional maintenance requirements.
Potential Traffic Noise & Aesthetic Considerations	Positive; Visually less intrusive option	Positive; Visually less intrusive option	Negative; Visually an intrusive option.
Existing Barrie Go Railway Line	Existing Barrie Go Rail Line will need to be redirected during construction.	Existing Barrie Go Rail Line will need to be redirected during construction.	Existing Barrie Go Rail Line does not need to be redirected during construction. Construction can be carried around the rail crossing and girders can be dropped in.
TECHNICALLY PREFERRED ALTERNATIVE	**Recommended option.**	Not recommended.	Not recommended

Recommended Structure

Based on the comparison of alternatives, **Alternative 2A: Underpass (Road Under Rail) with Retaining Walls along Kirby Road** is the recommended structure at the Barrie GO Rail crossing. The proposed cross-section for the Kirby Road Underpass will be urbanized and consist of two (2) lanes (3.5m through lane and 3.75m curb lane) of traffic in each direction. To accommodate the left turn lane at the Keele Street intersection the traffic lanes at the rail crossing will be divided by a raised centre median. A 2.0m one-directional cycle track immediately adjacent to a 2.0m sidewalk are proposed on each side of Kirby Road. In addition width has been allocated for clearance and pedestrian / cyclist railings as required. A schematic of the underpass typical section is provided in **Figure 5**.

Figure 5: Underpass Typical Section



The horizontal alignment of Kirby Road remains unchanged after the construction.

The vertical profile of the proposed underpass for Kirby Road will have a sag vertical curve that connects the descending grades. The elevation at the low point of the sag curve is approximately 284.3 and the splined curve has a slope of -7.00% and +7.00%.

The underpass excavation is anticipated to extend through the sand layer and into the clay till. Based on the borehole logs these layers will likely behave as an unconfined aquifer. A watertight structure is required to control the groundwater level; otherwise permanent drainage of the groundwater is required. The recommended structure type has been designed to be water tight and therefore a pumping station for ground water is not anticipated.

The underpass will result in the disruption of surface flow at this location, as the roadway profile will be lowered. Under proposed conditions, the runoff generated from a portion of drainage area will flow towards the low point in the profile below the GO Rail crossing. Based on the available information of the existing catchment outlet location, it may be feasible to drain the

surface runoff generated within the underpass area by connecting it to Don River culvert, located approximately 1 km west of the underpass, using a long stretch of storm sewer. This approach may be more cost effective compared to constructing a pumping station to provide drainage during both minor and major storm events for surface water. Further investigation and design details, including required water quality and quantity control measures, will need to be completed in the Detailed Design of the underpass.

The following outlines the design requirements of the recommended structure:

Design Code
The design of the depressed corridor will be undertaken in accordance with the CAN/CSA-S6-19 Canadian Highway Bridge Design Code (CHBDC), Ministry of Transportation of Ontario's "Structural Manual", and all other current directives and standards.

The design of the railway bridge will be undertaken in accordance with the latest edition of American Railway Engineering and Maintenance of Way Association (AREMA) Manual for Railway Engineering and Metrolinx General Guidelines for Design of Railway Bridges and Structures.

Access to the Site and Staging
The site is readily accessible from Kirby Road. A traffic and construction staging plan will need to be developed during Detailed Design in consultation with the City of Vaughan, Metrolinx and York Region.

Property
Property acquisition is anticipated on the North and South side of Kirby Road within the project limits to accommodate a wider cross-section. Extent of the property acquisition will be determined during Detailed Design.

Utilities
The proposed Barrie GO Rail Corridor Underpass on Kirby Road has a significant impact to the existing underground utilities. Relocation of utility lines maybe required.

Drainage
The proposed Underpass on Kirby Road has a sag vertical curve, with the road crossing under the railway. A surface drainage system must be installed along the road along the depressed corridor.

Concrete
All cast-in-place concrete will be class C-1 concrete as per CSA A23.I. Min. 28 days concrete compressive strength in railway bridges:

- Precast prestressed elements fc' = 50 MPa; and
- Conventional reinforced concrete elements, fc' = 35 MPa

Structural Steel
All fracture critical members including main girders, web flanges, floor beams, stringers and bearing stiffeners shall be according to CSA G40.21 Grade 350WT, Category 5. Other non-

fracture critical members including connecting angles, rolled section, end bearing stiffeners, diaphragms and all secondary members shall be CAN3-G40.21 Grade 350A. The bearing plates shall be CAN3-G40.21 Grade 300W.

The type of structural steel and non-ferrous bearing components in the proposed railway bridge shall be in accordance with Metrolinx Guidelines, Part 2A, Chapter 15.

Reinforcing Steel
Stainless steel reinforcement will be used in areas of the components where their surfaces are within the splash zone, including the front face of the retaining wall, front face of the abutment wall, and the centre pier.

For all other components, black steel (Grade 400W) will be used as specified in Section 12 of the MTO Structural Manual and the MTO Bridge Office Memorandum dated November 22, 2010 “Reinforcing Steel”.

Rebar welding is not allowed on any components in railway bridges and structures.

Additional description of the recommended structure is provided in the preceding section. Refer to **Appendix A** for the General Arrangement Drawing of the Barrie Go Rail Underpass. The plan and profile design of the proposed Underpass is provided under separate cover in the Preliminary Design plates.

4 Wildlife Corridor Crossing

Existing Conditions

As documented in the Natural Heritage Report completed for the EA study, in addition to the minor ecological linkage at the West Don River Tributary Crossing, there are two potential locations for wildlife passage linkages in the corridor. One potential wildlife passage linkage is located where the Maple Spur Channel ESA and Maple Uplands and Kettles Life Science ANSI crosses Kirby Road between Keele Street and Foothills Road. There is no cross-road culvert that currently exists at this potential linkage. However, the presence of natural lands on either side of the road, which are narrowed between adjacent agricultural and urban land uses (on the north and south sides of Kirby Road, respectively) may have the effect of funneling and directing wildlife movements across the road in this location. This potential linkage may provide a crossing location for small-, medium-, and large-sized wildlife. A second potential location for a crossing for up to large-sized wildlife location occurs to the immediate west of Dufferin Street, where Significant Woodland associated with the ESA and ANSI occurs on both sides of the road.

Wildlife road-crossing data for Kirby Road within the study area was not available for the completion of this study. It is recommended that the section of road that falls within the ESA/ANSI crossings (between west of Radha Road and Dufferin Street) be further investigated in consultation with the TRCA and City to determine if there is suitable rationale to incorporate measures that would mitigate wildlife road crossing impacts and/or reduce hazards of motorist-wildlife collisions. For example, this may include consideration for deer crossing signs or other measures if existing data suggests that deer crossings are more concentrated at this location, or if deer-vehicle collisions have occurred there. It may also include the installation of one or two terrestrial eco-passages as part of the ROW Detailed Design if there is evidence that wildlife, particularly deer, do or may cross the road at this location. Based on the proposed road elevations at the east end of the study area, west of Dufferin Street, a large mammal (deer) wildlife eco-passage can be accommodated at this location.

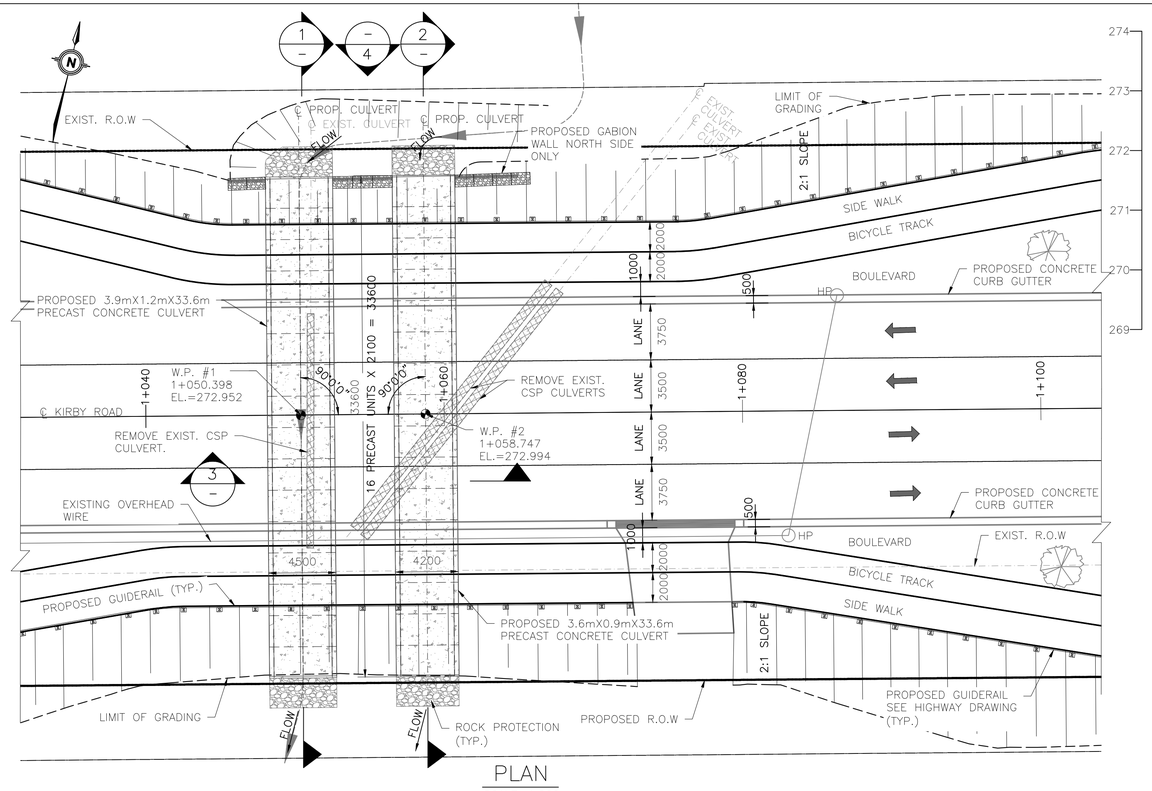
Recommendations

Increased motorist use of the road will lead to increased potential for conflicts with crossing wildlife. Due to the lack of highly-defined vegetated corridors (e.g., permanent watercourse channels) that cross Kirby Road within the western end of the study area, wildlife crossings may occur across a broad front within the study area lands, particularly where agricultural fields or fragmented vegetated features exist on both sides of the road. However, as described in the Natural Heritage Assessment Report, potential wildlife linkages occur where the municipally-mapped ESA/ANSI lands cross Kirby Road between Keele and Dufferin Streets. Consideration should be made at the Detailed Design stage for the need for measures that would mitigate wildlife road mortality as well as hazards to motorists, including but not limited to the use of wildlife eco-passages and deer crossing signage.

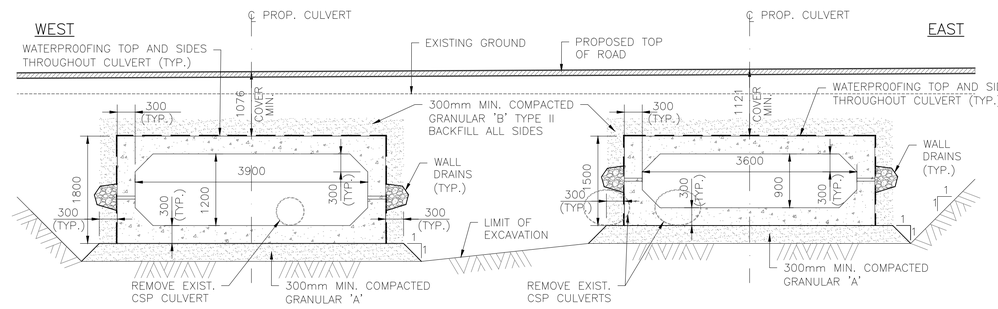
Depending on the nature of recommended measures to mitigate wildlife road crossing and ecological connectivity impacts, monitoring tasks tailored to those measures may be warranted as determined through consultation with agency staff. The monitoring measures are to be designed such that negative effects (e.g., as caused by ineffective mitigation) may be recognized through the data. To achieve this, baseline/pre-construction monitoring may be recommended where feasible against which to compare post-construction data. The need for and details of such monitoring measures are to be determined during the Detailed Design stage.

Appendix A: General Arrangement Drawings

METRIC



PLAN
SCALE: 1:200



SECTION 3
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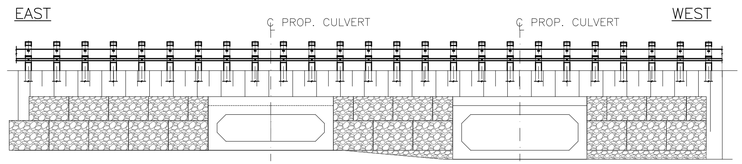

ELEVATION 4
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LIST OF ABBREVIATIONS

EL.	DENOTES ELEVATION
BLVD	DENOTES BOULEVARD
RND	DENOTES ROUND
S/W	DENOTES SIDE WALK
STA.	DENOTES STATION
WP	DENOTES WORKING POINT
MUP	DENOTES MULTI PURPOSE LANE
TYP.	DENOTES TYPICAL
INV.	DENOTES INVERT

LEGEND

- EXISTING GROUND
- RIP-RAP
- PRECAST CONCRETE
- ASPHALT
- GRANULAR "A" AND "B" BACKFILL
- REMOVAL

APPLICABLE STANDARD DRAWINGS

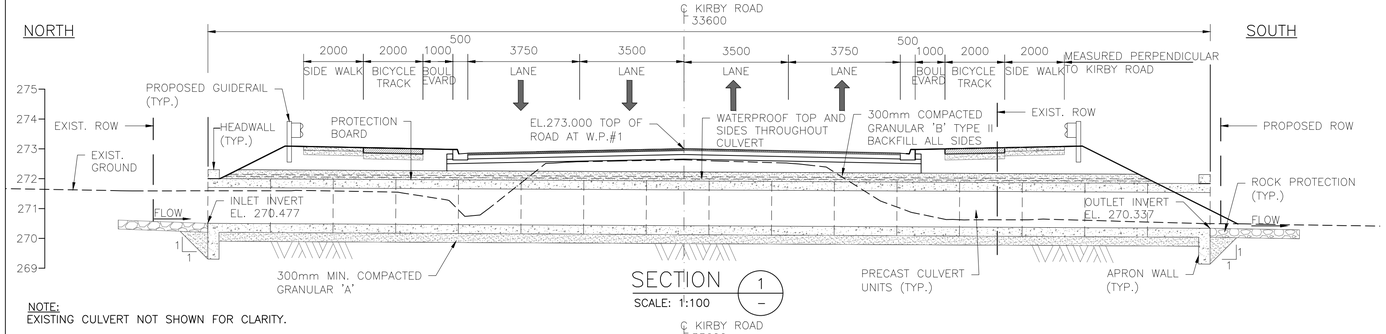
OPSD 3941.200	FIGURES IN CONCRETE SITE NUMBER AND DATE LAYOUT
OPSD 803.010	BACKFILL AND COVER FOR CONCRETE CULVERTS
OPSD 3190.100	WALL DRAIN
OPSD 3950.100	JOINTS CONCRETE EXPANSION AND CONSTRUCTION ON STRUCTURE

GENERAL NOTES PRECAST BOX CULVERT

1. CLASS OF CONCRETE:
   PRECAST CONCRETE:.....45 MPa
   CAST IN PLACE CONCRETE.....30 MPa
   UNLESS OTHERWISE NOTED.
2. CLEAR COVER TO REINFORCING STEEL SHALL BE 50 ± 15
3. PRECAST CONCRETE CULVERT SHALL BE CONSTRUCTED IN ACCORDANCE WITH OPSS 904, OPSS 422 AND OPSS 1821
4. REINFORCING STEEL:
   -REINFORCING STEEL SHALL BE GRADE 400W OR 500W UNLESS OTHERWISE SPECIFIED.
   -REINFORCING STEEL SHALL BE LAPPED IN TENSION ZONES.
   MINIMUM BENDING DIAMETERS. WHILE STIRRUPS AND TIES SHALL HAVE MINIMUM HOOK DIMENSIONS. ALL HOOKS SHALL BE IN ACCORDANCE WITH THE STRUCTURAL STANDARD DRAWINGS SS12-1 UNLESS INDICATED OTHERWISE.

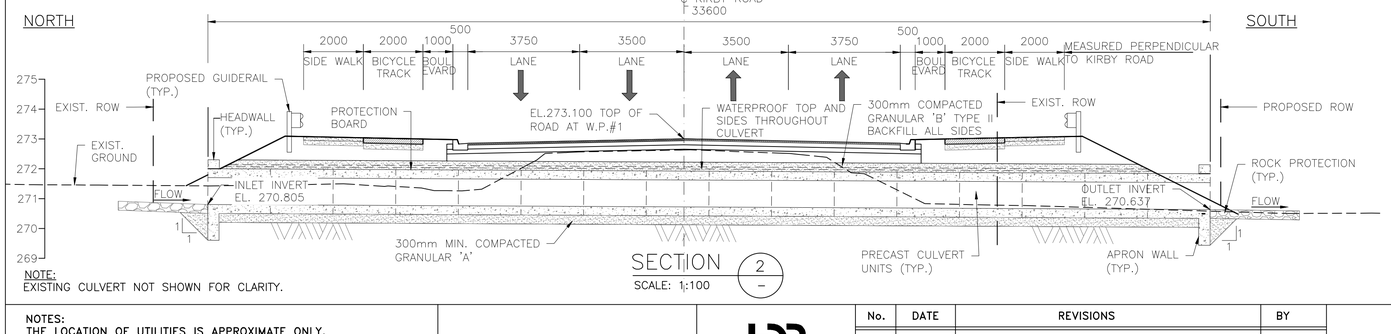
CONSTRUCTION NOTES

1. BACKFILL SHALL BE PLACED SIMULTANEOUSLY BEHIND BOTH SIDES OF CULVERT WALLS KEEPING THE HEIGHT OF THE BACKFILL APPROXIMATELY THE SAME. AT NO TIME SHALL THE DIFFERENCE IN ELEVATION BE GREATER THAN 400mm.
2. BACKFILL MATERIALS SHALL BE PLACE IN LOOSE LIFT THICKNESS NOT TO EXCEED 200mm LIFTS AND COMPACTED TO AT LEAST 98% OF ITS SPMDD
3. THIS DRAWING TO BE READ IN CONJUNCTION WITH HIGHWAY DRAWINGS.
4. BEARING CAPACITY FOR NEW CULVERT:
   SLS: 250 KPa
   ULS: 375 KPa
5. FOR CONSTRUCTION STAGING SEE HIGHWAY DRAWINGS
6. THE CONTRACTOR IS FULLY RESPONSIBLE FOR ADEQUATE PROTECTION OF ALL UTILITIES, SERVICES, STRUCTURES, ETC. DURING CONSTRUCTION OPERATIONS.



SECTION 1
SCALE: 1:100

NOTE:
EXISTING CULVERT NOT SHOWN FOR CLARITY.



SECTION 2
SCALE: 1:100

NOTE:
EXISTING CULVERT NOT SHOWN FOR CLARITY.

NOTES:
THE LOCATION OF UTILITIES IS APPROXIMATE ONLY. CONSULT THE RESPECTIVE MUNICIPAL AUTHORITIES AND UTILITY COMPANIES TO DETERMINE THE EXACT LOCATION OF THEIR UTILITIES. THE CONTRACTOR SHALL VERIFY THE LOCATION OF UTILITIES AND SHALL ADEQUATELY PROTECT AND SUPPORT THEM DURING CONSTRUCTION.

NOT FOR CONSTRUCTION

HDR
100 York Blvd., Suite 300,
Richmond Hill, ON, L4B 1J8
Phone (289) 695-4600
Fax (289) 695-4601

No.	DATE	REVISIONS	BY

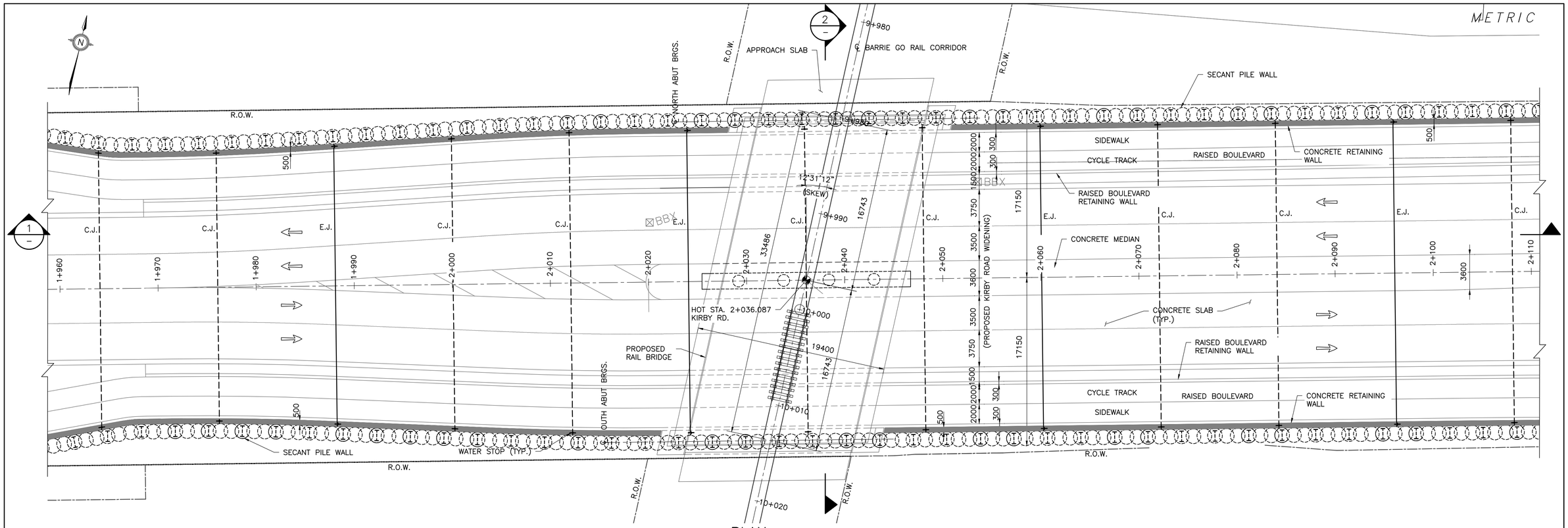
VAUGHAN
Infrastructure Delivery

DESIGN	S.S.
DRAWN	M.V.
CHECKED	M.B.

KIRBY ROAD WIDENING
WEST DON RIVER
TRIBUTARY CULVERT REPLACEMENT
GENERAL ARRANGEMENT I

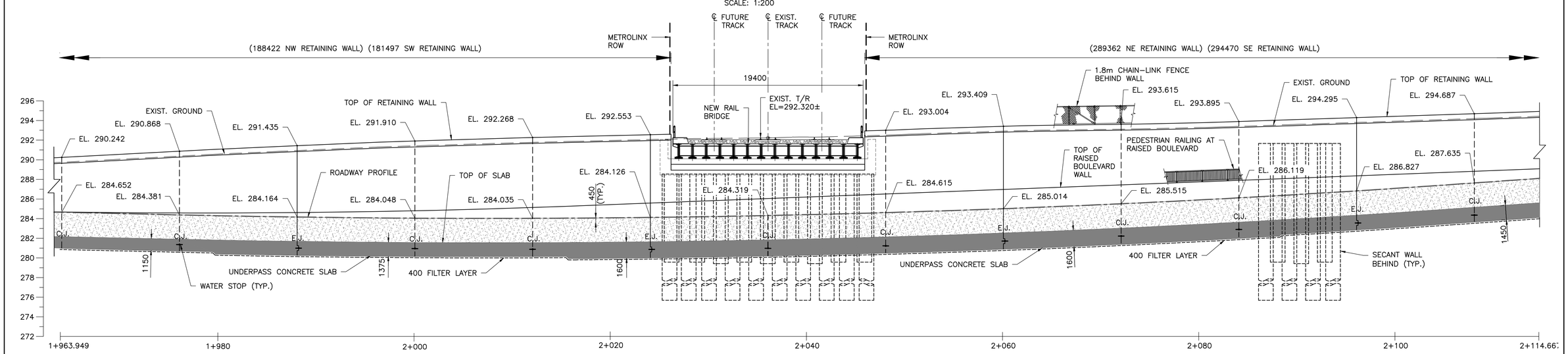
DWG. NO.	S01
CONT. NO.	10056259
SHEET NO.	-

METRIC



PLAN

SCALE: 1:200



SECTION 1

SCALE: 1:200

NOTE:

NORTH RETAINING WALL ELEVATION SHOWN, SOUTH RETAINING WALL ELEVATION SIMILAR.

NOTES:
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Phone (289) 695-4600
Fax (289) 695-4601

No.	DATE	REVISIONS	BY

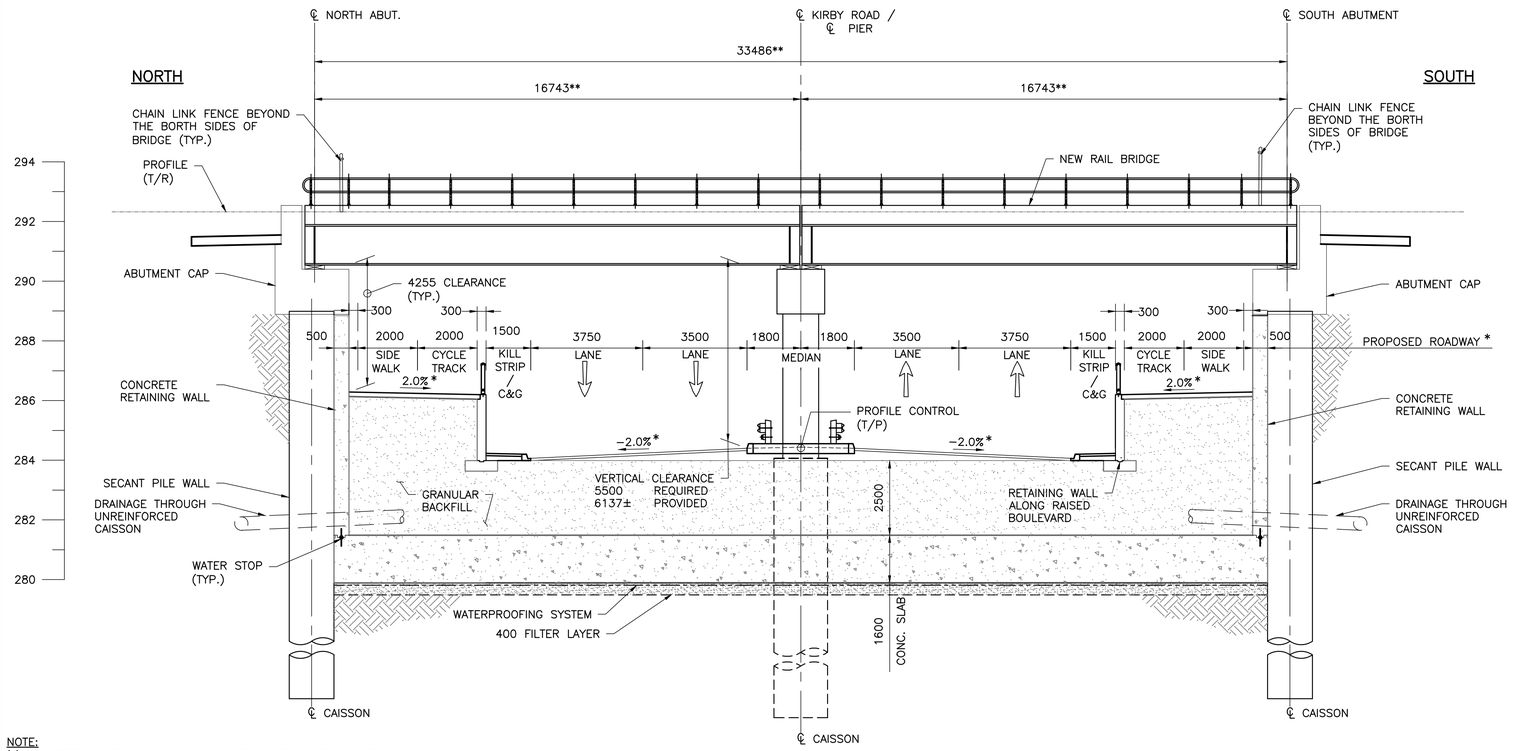
VAUGHAN
Infrastructure Delivery

DESIGN	S.S.
DRAWN	M.V.
CHECKED	M.B.

KIRBY ROAD WIDENING ENVIRONMENTAL ASSESSMENT BARRIE GO RAIL UNDERPASS GENERAL ARRANGEMENT I

DWG. NO.	S01
CONT. NO.	10056259
SHEET NO.	–

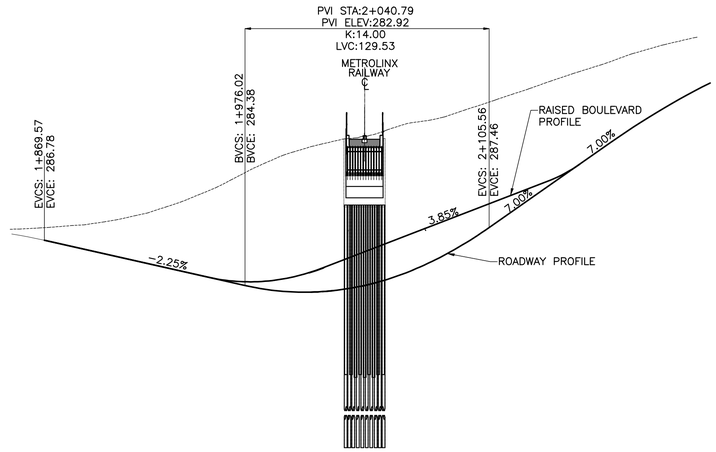
METRIC



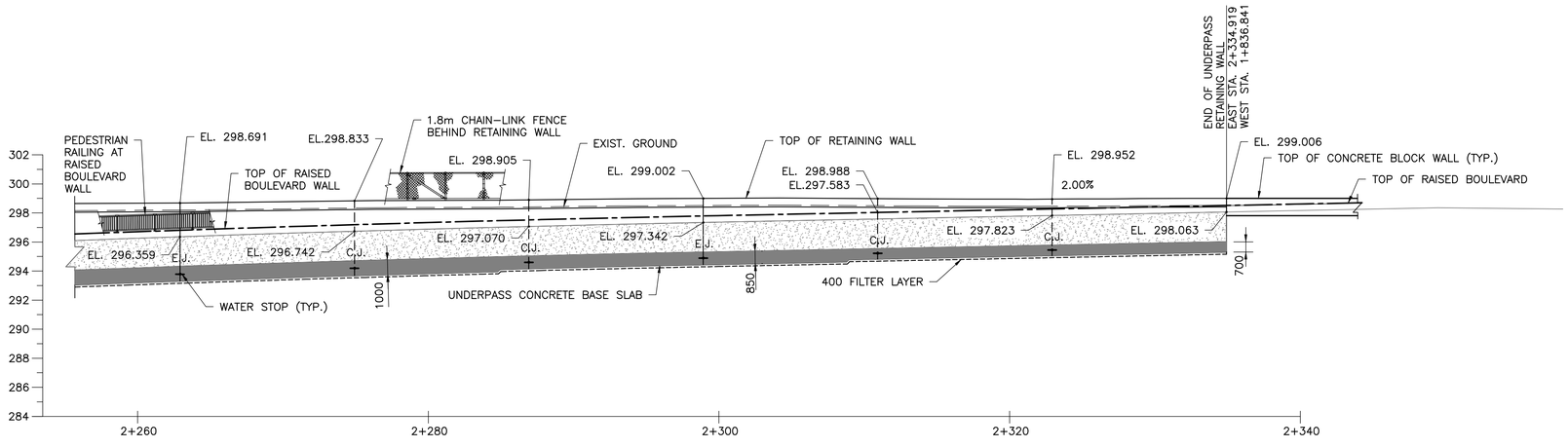
NOTE:
(*) DENOTES DIMENSIONS AND CROSS–FALL MEASURED PERPENDICULAR TO ℄ OF KIRBY ROAD

(**) DENOTES DIMENSIONS MEASURED SKEW TO ℄ OF KIRBY ROAD

SECTION 2
SCALE: 1:100



PROFILE ALONG ℄ KIRBY ROAD
N.T.S



EAST WALL END SECTION 1
SCALE: 1:200 S01

NOTE:
EAST WALL END SECTION SHOWN, WEST WALL END SECTION SIMILAR.

NOTES:
THE LOCATION OF UTILITIES IS APPROXIMATE ONLY. CONSULT THE RESPECTIVE MUNICIPAL AUTHORITIES AND UTILITY COMPANIES TO DETERMINE THE EXACT LOCATION OF THEIR UTILITIES. THE CONTRACTOR SHALL VERIFY THE LOCATION OF UTILITIES AND SHALL ADEQUATELY PROTECT AND SUPPORT THEM DURING CONSTRUCTION.

NOT FOR CONSTRUCTION

HDR
100 York Blvd., Suite 300,
Richmond Hill, ON, L4B 1J8
Phone (289) 695-4600
Fax (289) 695-4601

No.	DATE	REVISIONS	BY

VAUGHAN
Infrastructure Delivery

DESIGN	S.S.
DRAWN	M.V.
CHECKED	M.B.

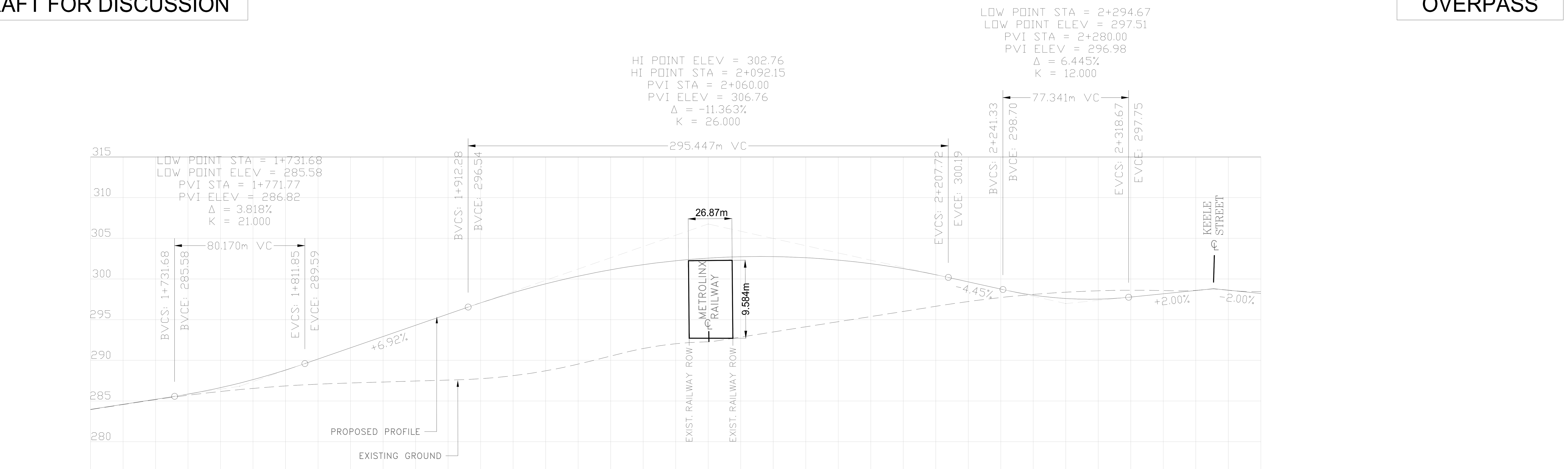
KIRBY ROAD WIDENING
ENVIRONMENTAL ASSESSMENT
BARRIE GO RAIL UNDERPASS
GENERAL ARRANGEMENT II

DWG. NO.	S02
CONT. NO.	10056259
SHEET NO.	–

Appendix B: Conceptual Overpass and Underpass Profiles

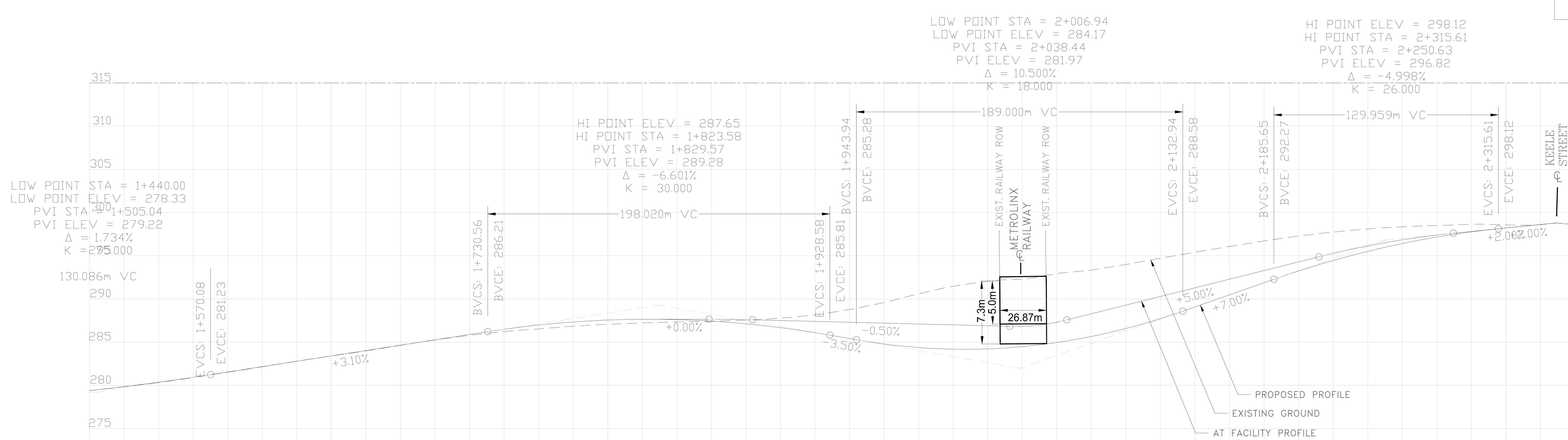
DRAFT FOR DISCUSSION

OVERPASS



CHAINAGE	Kirby Rd EX. Profile	Kirby Rd Prop. Profile - Overpass (7% Max)
1+680	283.95	283.97
1+700	284.56	284.59
1+720	285.17	285.21
1+740	285.71	285.85
1+760	286.17	286.64
1+780	286.55	287.63
1+800	286.85	288.80
1+820	287.07	290.16
1+840	287.22	291.54
1+860	287.33	292.92
1+880	287.45	294.31
1+900	287.57	295.69
1+920	287.74	297.06
1+940	288.11	298.31
1+960	288.71	299.40
1+980	289.53	300.34
2+000	290.52	301.13
2+020	291.45	301.76
2+040	292.04	302.24
2+060	292.28	302.56
2+080	292.86	302.73
2+100	293.49	302.75
2+120	294.12	302.61
2+140	294.75	302.32
2+160	295.38	301.88
2+180	296.01	301.28
2+200	296.64	300.52
2+220	297.23	299.65
2+240	297.72	298.76
2+260	298.10	298.01
2+280	298.38	297.60
2+300	298.55	297.52
2+320	298.62	297.78
2+340	298.58	298.18
2+360	298.60	298.58
2+380	298.61	298.62
2+400	298.45	298.22

UNDERPASS



CHAINAGE	Kirby Road Proposed Prof	Kirby Rd Existing Profile
1+500	279.39	279.40
1+520	279.85	279.83
1+540	280.36	280.32
1+560	280.93	280.90
1+580	281.54	281.52
1+600	282.16	282.15
1+620	282.78	282.80
1+640	283.40	283.40
1+660	284.02	283.99
1+680	284.64	284.63
1+700	285.26	285.25
1+720	285.88	285.78
1+740	286.49	286.23
1+760	286.98	286.53
1+780	287.33	286.85
1+800	287.56	287.06
1+820	287.65	287.22
1+840	287.61	287.35
1+860	287.43	287.42
1+880	287.12	287.55
1+900	286.68	287.78
1+920	286.10	288.17
1+940	285.41	288.78
1+960	284.79	289.58
1+980	284.37	290.60
2+000	284.19	291.46
2+020	284.22	292.03
2+040	284.48	292.28
2+060	284.96	292.93
2+080	285.66	293.35
2+100	286.58	294.00
2+120	287.72	294.71
2+140	289.08	295.40
2+160	290.48	296.07
2+180	291.88	296.71
2+200	293.24	297.28
2+220	294.45	297.74
2+240	295.51	298.10
2+260	296.41	298.34
2+280	297.17	298.51
2+300	297.76	298.64
2+320	298.21	298.58
2+340	298.61	298.60
2+360	298.58	298.59

KEY PLAN

CONTRACTOR'S NOTES:

1. ALL DIMENSIONS ARE IN METRES AND / OR MILLIMETRES UNLESS OTHERWISE INDICATED.
2. DRAWINGS ARE NOT TO BE SCALED.
3. THE CONTRACTOR SHALL VERIFY ALL DIMENSIONS IN THE FIELD AND SHALL REPORT ANY DISCREPANCIES TO THE ENGINEER IMMEDIATELY UPON FINDING.
4. THE EXACT LOCATION OF UTILITIES SHALL BE DETERMINED BY CONSULTING THE UTILITY COMPANIES CONCERNED. THE CONTRACTOR SHALL PROVE THE LOCATION OF UTILITIES AND SHALL BE RESPONSIBLE FOR ADEQUATE PROTECTION FROM DAMAGE.
5. BENCHMARKS FOR LAYOUT ARE TO BE OBTAINED FROM THE CITY OF VAUGHAN ENGINEERING DEPARTMENT.

NOTE:

EVERY REASONABLE EFFORT HAS BEEN MADE TO ENSURE THAT THE INFORMATION APPEARING ON THIS PLAN IS ACCURATE AND CURRENT. WE BELIEVE THE INFORMATION TO BE RELIABLE, HOWEVER, THE CITY OF VAUGHAN ASSUMES NO RESPONSIBILITY OR LIABILITY DUE TO ERRORS OR OMISSIONS.

NO.	DESCRIPTION	BY	DATE
8			
7			
6			
5			
4			
3			
2			
1			

UPDATES & REVISIONS

HDR

ENGINEER'S STAMP:

APPROVED AS TO FORM IN RELIANCE, UPON THE PROFESSIONAL SKILL AND ABILITY OF THE CONSULTING ENGINEERS AS TO DESIGN AND SPECIFICATIONS.

JACK GRAZIOSI, P.Eng., M.Eng.
DIRECTOR OF INFRASTRUCTURE DELIVERY

DATE

SCALE
HORIZONTAL: 0 15 75 150m
VERTICAL: 0 3 15 30m

KIRBY ROAD WIDENING
ENVIRONMENTAL ASSESSMENT

GRADE SEPARATION AT
METROLINX RAILWAY

VAUGHAN
Infrastructure Delivery

DESIGNED & DRAWN BY: ___	CHECKED BY: ___	TENDER No. T18-___
SURVEYED BY: ___	APPROVED BY: ___	
SCALE: HORIZONTAL: 1:500 VERTICAL: 1:100	PROJ. No. 18-______	DWG. No. _ of _

Printed: Oct. 26, 2020