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Appendix M

Preliminary Structural Design Report

Preliminary Structural Design Report

Municipal Class Environmental Assessment (Schedule C Study)

Highway 401 New Road Crossing (Notion Road to Squires Beach Road)

Prepared by:

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Date:

September 2019

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September 30, 2019

Durham Live
1802 Bayly St.
Pickering, ON L1W 4C3
c/o Don Given
Malone Given Parsons Ltd.
140 Renfrew Drive, Suite 201
Markham, ON L3R 6B3

Dear Mr. Given:

Project No: **60584644**
Regarding: **Preliminary Structural Design Report**
Highway 401 New Road Crossing (Notion Road to Squires Beach Road)

As per the Terms of Reference for the above noted assignment, AECOM has prepared the Preliminary Structural Design Report for the new bridge structure crossing over Highway 401 and Metrolinx and CN tracks. The new bridge is an integral part of the new road crossing connecting Notion Road to the north with Squires Beach Road to the south, over Highway 401 and the Metrolinx and CN railways.

Enclosed with this letter, please find the Preliminary Structural Design Report for the proposed new bridge structure for your review and comments.

Sincerely,

AECOM Canada Ltd.

Dan Conte, P.Eng.
Senior Bridge Engineer
dan.conte@aecom.com

Encl. Preliminary Structural Design Report, Highway 401 New Road Crossing (Notion Road to Squires Beach Road)
cc: Kevin Philips, P.Eng. (AECOM Project Manager); Dragan Ilic, P.Eng. (AECOM Bridge Department Head)

Distribution List

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Revision Log

Revision #	Revised By	Date	Issue / Revision Description
1	Thomas Kowalczyk	May 10, 2019	Draft Submission
2	Thomas Kowalczyk	September 30, 2019	Final Submission

AECOM Signatures

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1. Introduction

AECOM has been retained by Durham Live to undertake a Municipal Class Environmental Assessment (Schedule C Study) which includes the conceptual design of a new road crossing over Highway 401 and the Metrolinx and CN railways, to connect Notion Road to the north with Squires Beach Road to the south, in the City of Pickering, Ontario.

The purpose of the present study is to develop and evaluate alternatives and present the conceptual preliminary design for the recommended preferred alternative, for the new bridge structure at this proposed crossing.

This Preliminary Structural Design Report discusses the proposed new bridge structure at the above location.

2. Location

The new bridge will be located along the realigned and extended Notion Road/Squires Beach Road. Notion Road will be realigned to the west starting from Pickering Parkway. Squires Beach Road will also be realigned to the west starting from Kellino Street. The new roadway and bridge will carry four (4) lanes of traffic over Highway 401 (including considerations of future widening of Highway 401 to a core-collector system) and over the CN Rail and Metrolinx rail lines south of Highway 401.

A key plan showing the location of the proposed road crossing is included in **Appendix A**.

3. Design Criteria

Highway 401 through the area is classified as UFD 120 (Urban Freeway Divided) with a design speed of 120 km/h and posted speed of 100 km/h.

Notion Road and Squires Beach Road are classified as ULU (Urban Local Undivided) with a design speed of 60 km/h and a posted speed of 50 km/h.

3.1 Alignment

The new structure will be in a north-south orientation. Approaching the proposed crossing with Highway 401 from the north the existing Notion Road will be realigned slightly to the west. The road and bridge will cross over Highway 401 and the CN and Metrolinx rail tracks. At the south end of the crossing, the extended Notion Road will connect to Squires Beach Road, which will also be slightly realigned to the west starting from the Kellino St. intersection.

The centerline of Notion Road/Squires Beach Road on the structure will intersect the centerline of Highway 401 at a skew angle of 11°42’38”.

The centerline of Notion Road/Squires Beach Road will be on a crest vertical curve and will intersect the centerline of Highway 401 at Station 10+000.

3.2 Cross-Section

The proposed cross-section of the structure from west to east is as follows:

- 50 mm fascia;
- 250 mm TL-4 parapet wall with combination traffic /bicycle railing;
- 2000 mm sidewalk;

- 1000 mm side clearance;
- 2 – 3500 mm traffic lanes;
- 2000 mm raised median;
- 2 – 3500 mm traffic lanes;
- 1000 mm side clearance;
- 4000 mm multi-use path;
- 250 mm TL-4 parapet wall with combination traffic/ bicycle railing;
- 50 mm fascia,

The total deck width is 24.600 m measured between fasciae, and the roadway width is 18.000 m measured between curb faces.

3.3 Clearances

3.3.1 Highway 401

In accordance with the Roadside Safety Manual, the required horizontal clear zone under the bridge for Highway 401 is 10.0 m from the edge of the travel lane and 7.0 m from the edge of the speed change lane. The following clear zone is provided at the north abutment:

- Interim: 24.60 m from the speed change lane
- Ultimate: 11.40 m from the travel lane

The required clear zone at Pier # 2, located south of Highway 401 and north of the Metrolinx tracks, is 7.0 m from the edge of the speed change lane. The following clear zone is provided:

- Interim: 23.85 m
- Ultimate: 7.78 m from the speed change lane

As per MTO Geometric Design Standards for Ontario Highways, the minimum vertical clearance over Highway 401 for a girder bridge is 5.00 m. For this structure, the following minimum vertical clearances over Highway 401 are provided:

- Interim: 5.8 m
- Ultimate: 5.5 m (located over the WB Collector)

3.3.2 CN Rail and Metrolinx Tracks

A minimum horizontal clearance of 7.62 m measured from the centerline of the rail track to the front face of the abutment/pier is required for structures over railway tracks. This requirement is provided if no adjacent maintenance road is required and if no protection wall is provided for the pier/abutment. For this structure, the following approximate horizontal clearances are provided:

- 9.50 m between Pier # 2 and the centreline of the north Metrolinx track
- 18.89 m between Pier # 3 and the centreline of the south Metrolinx track
- 8.86 m between Pier # 3 and the centreline of northernmost CN Rail track
- 21.17 m between the centreline of the southernmost CN track and south abutment

For non-electrified tracks, such as the CN Rail tracks, a minimum vertical clearance of 7.01 m, measured from the top of the rails to the underside of the structure is required as per CN Rail standards. For this structure, a minimum vertical clearance of approximately 7.1 m will be provided over the CN Rail tracks.

To accommodate future electrification, a minimum vertical clearance of 7.584 m is required over the Metrolinx tracks, in accordance with Metrolinx specifications. For this structure, a minimum vertical clearance of approximately 8.1 m will be provided over the Metrolinx tracks.

3.4 Profile Data

The vertical profile of Notion Road/Squires Beach Road is located on vertical curves and tangents with the following details:

1. 5.00% grade ascending to the south along the north portion of the structure, to Sta (9+977.73), for a

   Length: 27.73 m from the north abutment, and

2. Vertical crest curve for the remainder of the structure, with:

   BVC: STA. 09+977.73; Elevation: 96.03
   PVI: STA. 10+082.22; Elevation: 101.25
   EVC: STA. 10+186.70; Elevation: 96.55
   K = 22.00, L = 208.97

Along the profile control line, the north abutment is at Sta. 9+950.00 and the south abutment is at Sta. 10+127.00.

The profile control of Highway 401 is located within the limits of a crest vertical curve with the following geometrics:

B.V.C: STA. 30+773.71; Elevation: 88.01
P.V.I: STA. 30+873.90; Elevation: 88.31
E.V.C: STA. 30.974.09; Elevation: 87.61
K = 200.00, L=200.38

Elevations are given to the top of pavement.

4. Foundation Engineering

A geotechnical site investigation was carried out by Thurber Engineering Ltd. in December 2018/January 2019. A total of six boreholes were drilled within the approaches and structure limits. Two (2) boreholes were drilled north of Highway 401, one (1) was drilled near the existing centreline of Highway 401, one (1) was drilled near the south edge of Highway 401, and two (2) were drilled south of Highway 401 along the existing Squires Beach Road. No borehole was drilled near Pier # 3, which is located between the Metrolinx and CN Rail tracks. Information for this location is therefore missing and will need to be obtained during detailed design.

A Preliminary Foundation Investigation and Design Report was prepared and submitted by Thurber Engineering Ltd. to Palmer Environmental Consulting Group Inc. on September 13, 2019. This report presents the results of the subsurface investigation and recommendations for the foundation design of the new structure.

From the existing ground surface, the subsurface stratigraphy encountered in the boreholes generally consists of either pavement structure or other fill overlying a very soft to stiff silty clay deposit, which in turned overlies a very

stiff to hard cohesive till deposit. The overburden soils are underlain by shale bedrock at most borehole locations, found at elevations ranging from 78.1 m to 70.2 m, corresponding to depths of 9.6 m to 17.1 m. The silty clay deposit was absent in the southernmost borehole drilled near the existing intersection of Squires Beach Road and Kellino Street, and the bedrock surface was not encountered in the two (2) boreholes drilled north of Highway 401. Groundwater levels in the monitoring wells ranged in elevation from 82.9 m to 83.8 m, approximately 3 m to 4 m below the existing ground surface.

Based on the subsurface conditions at the site, the following foundation types were considered:

- Spread footings on native soils;
- Augured caissons (drilled shafts); and
- Driven steel H-piles.

4.1 Spread Footings

Spread footings on native soils or engineering fill are not recommended due to the relatively low bearing resistance available from the silty clay deposit and the risk of large footing settlement. Constructing the footings on the underlying very stiff to hard clay till or very dense sand at depths of 7.2 m to 11.9 m is not practical.

4.2 Augured Caissons (Drilled Shafts)

A foundation consisting of augured caissons socketed into shale bedrock is considered feasible from a geotechnical perspective. For preliminary design purposes, it is recommended to socket the caissons at least 3 m into sound shale bedrock due to the generally poor quality of the upper layers of shale encountered in the boreholes. As the shale bedrock becomes harder/more sound with increased depth and contains hard limestone interbeds, the presence of hard layers may slow auger advance or require use of coring equipment during socketing of the caissons. The caisson drilling equipment must be capable of advancing through possible obstructions and hard layers, such as cobbles, boulders and rock slabs in the till. The use of drilling mud and/or a temporary steel liner sealing into the bedrock will be required to support the sidewalls of the caisson excavation in the cohesionless soils below the groundwater level and the soft silty clay.

The axial geotechnical resistances at ULS recommended for the preliminary design of caissons socketed at least 3.0 m into the shale bedrock are presented in the table below:

Caisson Diameter (mm)	Factored Axial Geotechnical Resistance at ULS (kN)
1200	4500
1500	6350

The factored serviceability geotechnical resistance for 25 mm of settlement will be higher than the factored ultimate geotechnical axial resistance reported; hence SLS resistance does not apply in this case.

4.3 Steel H-Piles

A foundation consisting of steel H-piles driven to bedrock or practical refusal in the hard glacial till is another feasible option for the foundation design of the proposed structure. This option would require the construction of pile caps, necessitating some localized excavation. It is assumed that the new pile caps will be “perched” within the approach embankments at the abutment locations. The pile tips shall be reinforced as per OPSD 3000.100 when driving them

through the hard glacial till containing cobbles and boulders. For piles driven and seated into bedrock (where angle of pile to bedrock is less than 60°) Oslo Point rock points per OPSD 3000.201 shall be specified.

For preliminary design purposes, the recommended axial and vertical factored geotechnical ULS resistance is 1400 kN per pile, and the recommended axial and vertical factored geotechnical SLS resistance is 1200 kN per pile. These resistance values are based on the assumption that the piles will be driven to refusal in the hard till deposit, since the piles may meet refusal in this layer before reaching the bedrock.

Estimated pile tip elevations and pile lengths at the support locations of the proposed structure are summarized in the table below, with Pier # 3 excluded since borehole data was not collected at this location:

Support Location	Highest Pile Tip Elevation (m)	Anticipated Pile Length Below Existing Ground (m)
North Abutment	71.0	16.2
Pier # 1*	70.0	17.3
Pier # 2*	73.5	13.5
South Abutment	77.5	9.7

*Pier numbers correspond to numbering on the preliminary GA drawing.

4.4 Summary of Foundation Recommendations

Spread footings are not recommended due to the low bearing resistance of the available soil at a shallower depth and the possibility of large settlements. Excavation to construct the footings deep enough to reach the stiff to hard till layer is not considered feasible.

Augured caissons and driven steel H-piles are both technically feasible. In consideration of the subsurface conditions at this site with cobbles and boulders and dense till, Thurber Engineering recommended a foundation system consisting of driven steel H-piles for the bridge foundations.

5. Structure Design Alternatives

Based on the cross-section of the proposed highway widening, profiles and required clearances, the resulting total distance between the centerline of the abutments is approximately 177 m, measured on skew along the centerline of Notion Road/Squires Beach Road. This distance is practically too long for a single span structure; therefore, a multi-span bridge is envisioned for the new structure. Although an integral abutment design would be preferred, the bridge is too long to permit the use of integral abutments. Semi-integral abutments were also discarded on this basis. Therefore, the bridge design will incorporate conventional abutments with expansions joints.

A two-span arrangement would consist of a 102 m span and a 75 m span. Due to the necessity of accommodating both the current and future configurations of Highway 401, the span lengths cannot be balanced, unless significant length is added to the shorter span. These span lengths are practically too long for precast concrete girders. Feasible structural options for these span lengths include steel box girders and post-tensioned concrete rectangular voided slabs. For uniform depth superstructures these long spans will result in uneconomical and deep sections, estimated from between 3.8 m to 4 m, and result in more costly heavier substructures, high-grade raise, and additional costs for shipping, construction and erection complications with such large and heavy bridge elements. These impacts and design inefficiencies can be somewhat reduced by designing a variable depth superstructure; however, the design efficiency improvements will be offset by increased costs of fabrication and construction of variable depth sections. Additional grade raise may also be required to provide the required vertical clearance at the

deeper haunch sections near the piers. Therefore, a two-span arrangement is considered not practical, nor cost-effective or suitable at this site and is discarded.

A three-span arrangement was also considered. It is possible to create a more balanced span arrangement with 50 m end spans and a 77 m interior span. Nevertheless, this interior span length is only feasible with steel box girders or post-tensioned concrete rectangular voided slabs, and will result in superstructure depths of approximately 2.9 m to 3.1 m. As for the two-span alternative, the depth of superstructure can be mitigated with design of a variable depth superstructure; however, the design efficiency improvements will be offset by increased costs of fabrication and construction of variable depth superstructures. Additional grade raise will be required to provide the required clearances at the deeper haunch sections near the piers. Also, a three-span alternative reduces the horizontal clearances on the west side of the Metrolinx tracks, which may restrict future expansion of the tracks to the south. Therefore, a three-span arrangement is also considered not suitable at this site and is discarded.

With a four-span arrangement, the location of the piers is dependant on the existing lane arrangement and future expansion of Highway 401, and the locations and potential expansion of the existing Metrolinx and CN Rail tracks. Under these conditions, the piers are placed at the following locations: at the median of the existing (and future) centreline of Highway 401, between the future south edge of the Highway 401 EB collector and the Metrolinx tracks, and between the Metrolinx and CN Rail tracks. To accommodate both the current configuration of Highway 401 and future core-collector system, as well as meeting the minimum horizontal requirements for Highway 401 and the Metrolinx and CN Rail tracks, a balanced span arrangement is not possible. Under these constraints, a four-span arrangement with span lengths of 50 m - 52 m - 40 m and 35 m, from north to south was considered. The longest 52 m span can be achieved with NU girders, steel I girders, steel box girders and PT concrete voided slabs.

The following alternatives were considered as viable and practical designs for the new structure, and were compared based on considerations of structure depth, construction cost, design and construction complexity, long term durability and aesthetics:

Alternative 1	Four span (50 m, 52 m, 35 m, 40 m) Steel Box Girders
Alternative 2	Four span (50 m, 52 m, 35 m, 40 m) Post-tensioned Concrete Voided Slab
Alternative 3	Four span (50 m, 52 m, 35 m, 40 m) NU Girders
Alternative 4	Four span (50 m, 52 m, 35 m, 40 m) Steel Plate Girders

5.1 Alternative 1: Steel Box Girders

Steel box girders provide for a lighter superstructure, with sections that are relatively easy to transport and erect. No falsework is necessary for construction, except for temporary support towers which may be required at the field splice locations. This design is aesthetically pleasing with a shallower superstructure, and contrast in materials.

The proposed cross-section consists of four (4) steel box girders with an approximate depth of 2.0 m, spaced at 6.15 m c/c, and composite with a 225 mm concrete deck slab and 90 mm asphalt and waterproofing system. The depth of the superstructure measured from top of asphalt to the soffit of girders will be approximately 2.39 m, assuming a 75 mm-deep haunch.

Taking deck crossfall into account, this alternative results in the following approximate minimum vertical clearances to the underside of the steel box girders:

- Highway 401: 5.8 m (Interim), 5.5 m (Ultimate)
- Metrolinx Rail Line: 8.1 m
- CN Rail Line: 7.1 m

Based on a parametric analysis for structure type and deck area, the construction cost for this alternative, including 15% contingency is estimated at $4,200/m^2 of deck area, for an estimated cost of $18.3M.

5.2 Alternative 2: Post-Tensioned Rectangular Voided Slab

Post-tensioned concrete decks are typically shallow, durable and aesthetically pleasing superstructures. On the other hand, construction of a post-tensioned concrete structure requires extensive falsework and formwork and longer duration of construction for placement of reinforcing and cast-in-place concrete, and additional time and complexities in longitudinal and transverse post tensioning operations. Also, there are fewer contractors who are experienced with this type of construction.

The cross-section for the superstructure could consist of a single or multi-spine post-tensioned concrete slab(s) with rectangular voids, and with an approximate depth of 2.29 m measured from top of asphalt to the soffit considering a 90 mm asphalt and waterproofing system on the deck. Taking deck cross fall into account, this alternative results in the following approximate minimum vertical clearances to the soffit of the superstructure:

- Highway 401: 5.9 m (Interim), 5.6 m (Ultimate)
- Metrolinx Rail Line: 8.2 m
- CN Rail Line: 7.2 m

Vertical clearance is reduced during the construction of a post-tensioned concrete deck due to the requirements for falsework. Over Highway 401, a minimum temporary vertical clearance of 4.5 m is required during construction in accordance with MTO geometric design guidelines. The estimated depth of falsework to span the existing EB or WB lanes of Highway 401 is estimated at approximately 1.25 m, reducing vertical clearance during construction to 4.65 m. As per Transport Canada standards, the minimum allowable vertical clearance during construction over railway lines is 6.706 m. With an estimated 900 mm depth of falsework to span two (2) Metrolinx tracks, the minimum vertical clearance reduces to 7.3 m. With an estimated 1.20 m depth of falsework to span three (3) CN tracks, the minimum vertical clearance over the CN tracks reduces to 6.0 m, requiring a grade raise of at least 0.706 m.

Based on a parametric analysis for structure type and deck area, the construction cost for this alternative, including 15% contingency is estimated at $5,000/m^2 of deck area, for an estimated cost of $21.8M.

5.3 Alternative 3: NU Precast Pre-Stressed Concrete Girders

NU precast prestressed concrete girders usually involve relatively straightforward design, fabrication, and erection, with no need for falsework during construction. NU girders are typically cost-effective and have a short lead time for fabrication, estimated at between 9 and 17 weeks.

The cross-section of this alternative consists of eleven (11) NU 2400 girders spaced at 2.25 m c/c, composite with a 225 mm concrete deck slab and 90 mm asphalt and waterproofing system. The depth of the superstructure measured from top of asphalt to the soffit of girders will be approximately 2.790 m, assuming a 75 mm haunch depth.

Taking deck cross fall into account, this alternative results in the following approximate minimum vertical clearances to the underside of the girders:

- Highway 401: 5.4 m (Interim), 5.1 m (Ultimate)
- Metrolinx Rail Line: 7.7 m
- CN Rail Line: 6.7 m

Based on a parametric analysis for structure type and deck area, the construction cost for this alternative, including 15% contingency is estimated at $3,600/m^2 of deck area, for an estimated cost of $15.7M.

5.4 Alternative 4: Steel Plate Girders

An option utilizing steel plate girders was also considered. Similar to steel box girders, this alternative provides relative ease in transportation and erection, with no need for falsework during construction. Steel plate girders are typically more expensive and complicated to produce than precast concrete girders but are easier and less costly to fabricate than steel box girders. Steel plate girders are more likely to entrap salt and debris when used in highway underpass structures, leading to bottom flange deterioration.

The cross-section for this alternative would consist of seven (7) steel plate girders with an approximate depth of 2.2 m, spaced at 3.5 m c/c, composite with a 225 mm concrete deck slab and 90 mm asphalt and waterproofing system. The depth of the superstructure measured from top of asphalt to the soffit of girders will be approximately 2.590 m, assuming a 75 mm-deep haunch.

Taking deck cross fall into account, this alternative results in the following approximate minimum vertical clearances to the underside of the girder bottom flanges:

- Highway 401: 5.6 m (Interim), 5.3 m (Ultimate)
- Metrolinx Rail Line: 7.9 m
- CN Rail Line: 6.9 m

The use of steel plate girders over roadways with posted speeds exceeding 100 km/h, as for Highway 401, would require a minimum vertical clearance of 7.0 m per section 8.1.3 of the Structural Manual. The road and bridge profile would need to be raised by at least 1.7 m to permit the use of a steel plate girder structure at this site. The necessary grade raise and resulting increase in embankments, complications and measures to mitigate property issues is considered unacceptable; therefore, this alternative is discarded from further consideration.

6. Decision Analysis

In order to select the preferred new structure alternative, criteria were developed and weighted out of 100 points based on their significance or importance. The alternatives were scored on a scale of 1 to 5 for best satisfying those criteria. The evaluation criteria and their individual weights are as follows:

1. Construction Cost (30)
2. Superstructure Depth/Required Grade Raise (25)
3. Constructability (25)
4. Durability and Maintenance (15)
5. Aesthetics (5)

Construction cost is assigned a weight of 30 points. Costs are based on the unit cost per m^2 of deck area and vary based on the type of superstructure. The alternatives with the lower construction costs are given a higher score.

Superstructure depth/grade raise is assigned a weight of 25 points. Alternatives with shallower superstructure depths and lower grade difference are given a proportionally higher score. Shallower superstructures result in lower profile for the Notion Road/Squires Beach Road crossing, thereby minimizing road construction costs and difficulties with tying into nearby streets at the approaches to the structure. Although the post-tensioned concrete deck alternative results in the shallowest final superstructure depth, it requires considerable additional depth during construction due to falsework. The NU girder option requires the deepest superstructure. The steel box girder

alternative is preferred as it provides a relatively shallow superstructure and least grade difference and no temporary vertical clearance reduction during construction.

Constructability is assigned a weight of 25 points and alternatives are assessed based on ease and speed of construction, fabrication, delivery, and erection of structural components (e.g. girders), and overall simplicity of construction of the structure. Although precast concrete girders are typically the most favourable with regards to constructability, the NU girder sections needed for this structure are very deep, and constructability is complicated by the difficulty in transporting and erecting such large and heavy girders. Steel box girders require longer lead times, with more complexity in fabrication and design, but also provide lighter superstructures with ease in transportation and erection. Temporary bents may be required for a short time to support the girders at the field splice locations. Post-tensioned concrete decks involve the most complicated construction techniques and require the use of extensive formwork and falsework throughout most of the construction period.

Durability and maintenance is assigned a weight of 15 points. It is difficult to carry out inspections inside both steel box girders and voided post-tensioned concrete slabs. Steel box girders also require corrosion protective coating to be applied over a length of about 3 m from the girder ends in the vicinity of deck expansion joints at the abutments. The steel must be periodically cleaned and recoated over the service life of the structure. Steel box girders are well suited for highway crossings because they are not likely to entrap salt and debris on bottom flanges. Deterioration of the top surface of bottom flanges is a potential durability issue for NU girders. Also, NU girders may present issues when removing concrete over the relatively thin top flange during future deck replacement.

Aesthetics is assigned a weight of 5 points. With such a large and prominent bridge structure, alternatives that provide a more slender appearance, with a mixture of materials and colour contrast are considered more aesthetically pleasing and given a higher score. A post-tensioned concrete deck would provide the shallowest final superstructure, sloped sides giving an impression of shallower depth and continuity of lines. Steel box girders also provide an aesthetically pleasing superstructure, with contrast between materials in addition to sloped sides and a shallow superstructure.

Details on the comparison and evaluation of the alternatives are provided in **Appendix C.**

7. Recommended Alternative

Based on the results of the evaluation and decision matrix comparing the four alternatives, the recommended preferred alternative for the new Notion Road/Squires Beach Road Bridge is a four-span structure with a superstructure consisting of four (4) steel box girders with an approximate depth of 2.0 m and spaced at 6.15 m c/c. The deck will consist of a 225 mm-thick concrete deck slab with 90 mm of asphalt and waterproofing. The total width of the bridge deck will be 24.6 m and will accommodate four (4) lanes of Notion Road/Squires Beach Road traffic (two (2) lanes in each NB and SB directions) plus 1.0 m wide shoulders, a 2.0 m wide raised median, a 4.0 m multi-use path, and a 2.0 m sidewalk.

The substructure will consist of conventional reinforced concrete abutments with expansion joints, and reinforced concrete pier columns. Abutments and piers will be supported on steel H-piles driven to refusal. RSS retaining walls will be provided at all four corners of the structure. The south RSS walls will have a total length of 13 m, and the RSS wall at the north-west quadrant of the structure will have a length of 9 m. The RSS wall at the north-east quadrant will run along the full length of the approach embankment, to accommodate the nearby cemetery to the north-east.

8. Structure Aesthetical Considerations

Bridges are long-lasting, important landmarks and as such they should be designed to be aesthetically pleasing and blend with the surroundings and the natural environment. Additional consideration was given to the following aesthetic design principles during the Preliminary Design and should continue through detail design:

- Slenderness
- Appropriate proportion of mass
- Continuity of lines
- Simplicity and compatibility of materials
- Compatibility with environment and surroundings

Attention should be paid to the design of the piers, such as incorporating aesthetically pleasing shapes and embossment of the pier shaft or columns. The aesthetic appearance of the bridge can also be enhanced through the use of decorative railings and embossment on the concrete parapet walls, either inside or outside face or both, and on the abutment and wingwall/retaining wall surfaces.

9. Traffic and Construction Staging

The structure will be supported on piers placed within and adjacent to Highway 401, Metrolinx, and CN Rail rights-of-way. The abutments are located outside MTO ROW and the CN Rail corridor. Construction of the Pier # 1 foundation requires excavation and roadway protection at the Highway 401 median and may require localized staging including temporary shoulder and lane reductions. Construction of Pier #'s 2 and 3 should be possible without or with minimal disruption to Highway 401, CN or Metrolinx operations. Nonetheless, the construction of Pier #'s 2 and 3 within the CN Rail and Metrolinx corridors will need to be coordinated with each rail company. The approach embankments and roadways to the structure and can be constructed on the offset alignment with no impacts to Highway 401 and Metrolinx operations, and minimal impacts to CN Rail operations and local traffic on the existing municipal road network. For the sections that are matching the existing horizontal and vertical alignments, the widening of Notion Road and Squires Beach Road can be completed through narrowing and shifting of existing lanes within the existing platform in order to create a work zone to construct the widened platforms, while maintaining existing traffic lanes.

Temporary short-term closures and disruptions to Highway 401, CN and Metrolinx operations will be required for the erection of girders over the Highway 401, Metrolinx and CN Rail tracks and onto the piers. Construction of a temporary support tower or other system to support the girders at the field splice locations could result in temporary shifting of Highway 401 traffic lanes. Temporary closures of one Metrolinx and CN Rail track may also be required during splicing of the girders at the field splice locations.

Details for traffic staging and temporary closures to be further developed during detailed design. Coordination will be maintained with MTO, Metrolinx and CN Rail during detailed design.

The alternative of detouring traffic and closing the road near the approach grades could be considered for Kellino Street/Squires Beach Road in order to facilitate construction. The feasibility of a detour should be considered only if staged construction and maintenance of existing traffic lanes are not possible. The need and details for any detours will be determined in detail design.

10. Construction Duration

The construction of the new bridge can be completed within 3 years.

11. Cost Estimates

The construction cost of the recommended alternative is estimated at $18,133,000 including 15% contingencies. The details of the cost estimate are presented in **Appendix D**.

12. Miscellaneous

12.1 Design Code

The design of this structure will be carried out in accordance with CHBDC CAN/CSA S6-14. Design details will be in accordance with MTO Structural Manual and current MTO directives and standards.

12.2 Utilities

Existing utilities within the study area include hydro poles with overhead wires, Bell lines, Enbridge Gas lines, fibre optic cables and potential watermains or sanitary sewers. The exact location and depth of underground utilities are currently unknown; however, communication with utility companies has resulted in the provision of preliminary information regarding utilities present within the study area. A Subsurface Utility Engineering (SUE) investigation will be completed during detailed design to confirm exact locations of underground utilities.

12.3 Access to Site

The site is readily accessible from Highway 401, Notion Road and Squires Beach Road during construction.

12.4 Transportation of Components

Steel box girders in lengths up to 38.5 m can be transported to the site via existing highways, and CN Rail lines.

12.5 Environmental Considerations

There are no environmental considerations that are specifically attributed to the construction of the new structure.

12.6 Backfill

The backfill material at the abutments will be free draining Granular ‘B’ Type II.

12.7 Parapet Walls and Railing

Parapet walls conforming to Test Level 4 (TL-4) are required to meet safety requirements. The parapet walls will be detailed in accordance with either Structural Standard Drawings SS110-82 (Parapet Wall for Combination Traffic/Bicycle Rail, TL-4 (Stainless Steel Rebar)), SS110-83 (Parapet Wall for Combination Traffic/Bicycle Rail, TL-4 (GFRP Rebar)) or SS110-84 (Parapet Wall for Combination Traffic/Bicycle Rail, TL-4 (GFRP Rebar with Anchor Head)). These parapet walls will have to be modified for use with a sidewalk. The railing on the parapet wall will be detailed in accordance with Structural Standard Drawing SS110-85 (Railing on Parapet for Combination Traffic/Bicycle Rail, TL-4).

The parapet wall over the RSS walls will be detailed as per Structural Standard Drawings SS110-65 or SS110-75.

12.8 Illumination

Illumination of the bridge will be in accordance with the overall project illumination requirements for the project area as per the standards and specifications of the City of Pickering.

12.9 Approach Slabs

The new approach slabs will be detailed as per Structural Standard Drawing SS116-1.

12.10 Slope Paving

Slope paving is required in front of both abutments and will be detailed as per Structural Standard Drawing SS116-10.

12.11 Provision for Access to Property at Southwest Quadrant of Structure

Construction of the south embankment will obstruct access to the entrance of the renewable storage at the southwest quadrant of the proposed structure. The option of providing access to this property through the south embankment by a tunnel will be considered during detailed design.

12.12 Construction Limitations

The constructability reviews to date confirm that the proposed alternative is constructible. Additional factors influencing constructability such as soil conditions, groundwater, utilities, and construction staging will be further explored during detailed design.

12.13 Durability Strategy

Coating system 2 shall be applied to the girder ends at the abutments in three (3) coats, to prevent deterioration due to salt-laden roadway runoff through leaking expansion joints. The colour of the top coat shall be 10045 brown. Periodic re-coating will also be required over the service life of the bridge.

Premium reinforcing bars such as stainless steel or GFRP reinforcement will be used in the parapet walls, sidewalks, fascia, soffit and areas of exposed concrete components subject to salt splash as specified in the Structural Manual. Stainless steel reinforcing bars will be used in the expansion joint end dams and splash zones of the piers.

Use of a waterproofing membrane and paving on the deck will minimize the ingress of moisture and chloride and provide long term durability of the bridge deck.

12.14 Reinforcing Steel and GFRP Reinforcement

Black and stainless reinforcing steel and GFRP reinforcement are readily available. All reinforcing steel and GFRP reinforcement will be detailed in accordance with the latest MTO Structural Manual.

12.15 Concrete

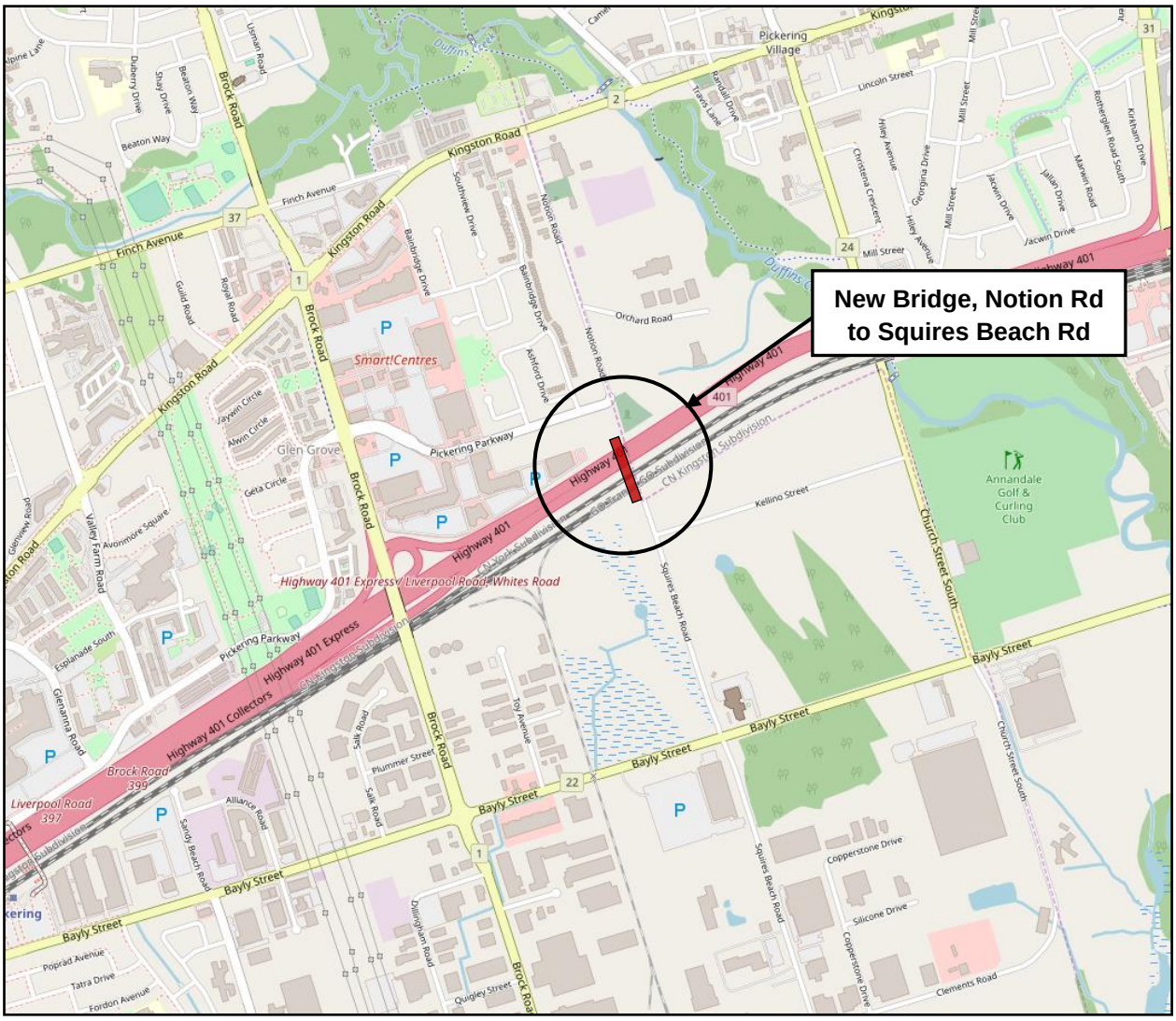
Normal 30 MPa concrete will be used for all the cast-in-place components of the bridge. Concrete is available near the site.

13. Summary

A new bridge structure is required to connect the new Notion Road/Squires Beach Road crossing over Highway 401, Metrolinx and CN Rail tracks in the City of Pickering, Ontario. The bridge deck will accommodate four (4) lanes of Notion Road/Squires Beach Road traffic (two (2) in each NB and SB directions) plus shoulders, a 2.0 m width raised median, a 4.0 m multi-use path, and a 2.0 m sidewalk.

Based on the evaluation of several alternatives, a steel box girder bridge with a cast-in-place deck slab is the recommended superstructure type for this bridge. Steel box girders offer a shallower superstructure than the other girder alternatives, with a favourable combination of durability and maintenance, constructability and aesthetic benefits. The new bridge is a four-span structure with a cross-section consisting of four (4) steel box girders with an approximate depth of 2.0 m and spaced at 6.15 m c/c. The deck will consist of a 225 mm thick concrete slab with 90 mm of asphalt and waterproofing. The substructure will consist of conventional abutments with expansion joints. Abutments and piers will be supported by steel H-piles driven to refusal. RSS retaining walls will be provided at all four corners of the structure.

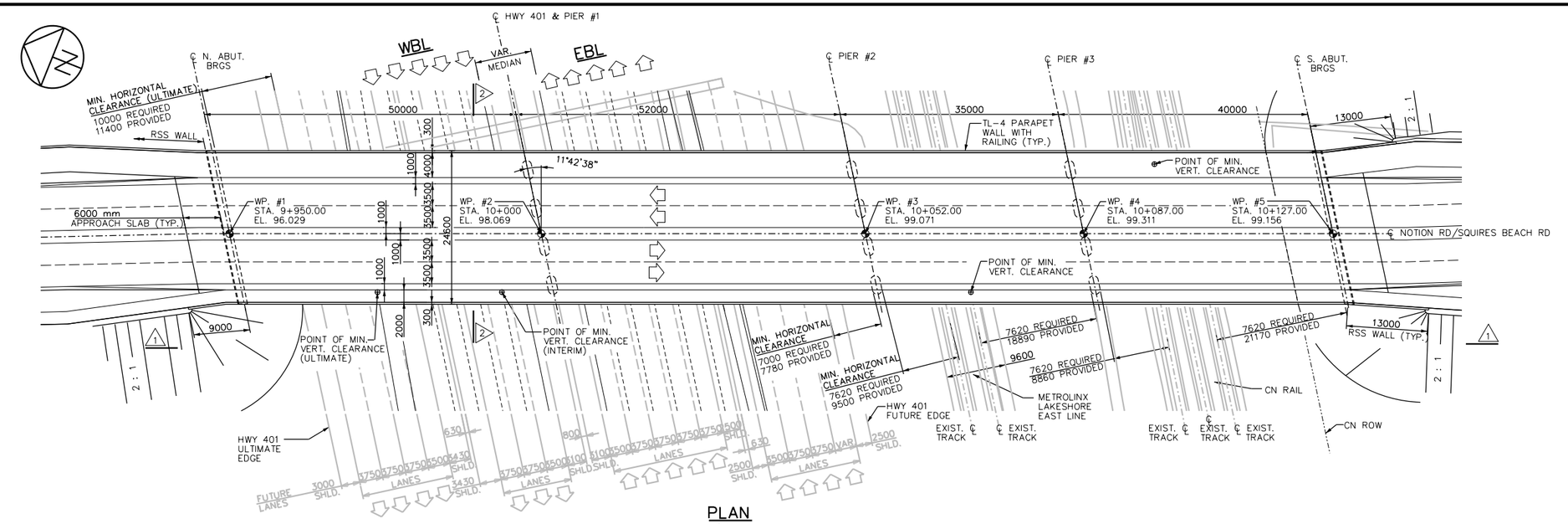
Appendix A – Bridge Location



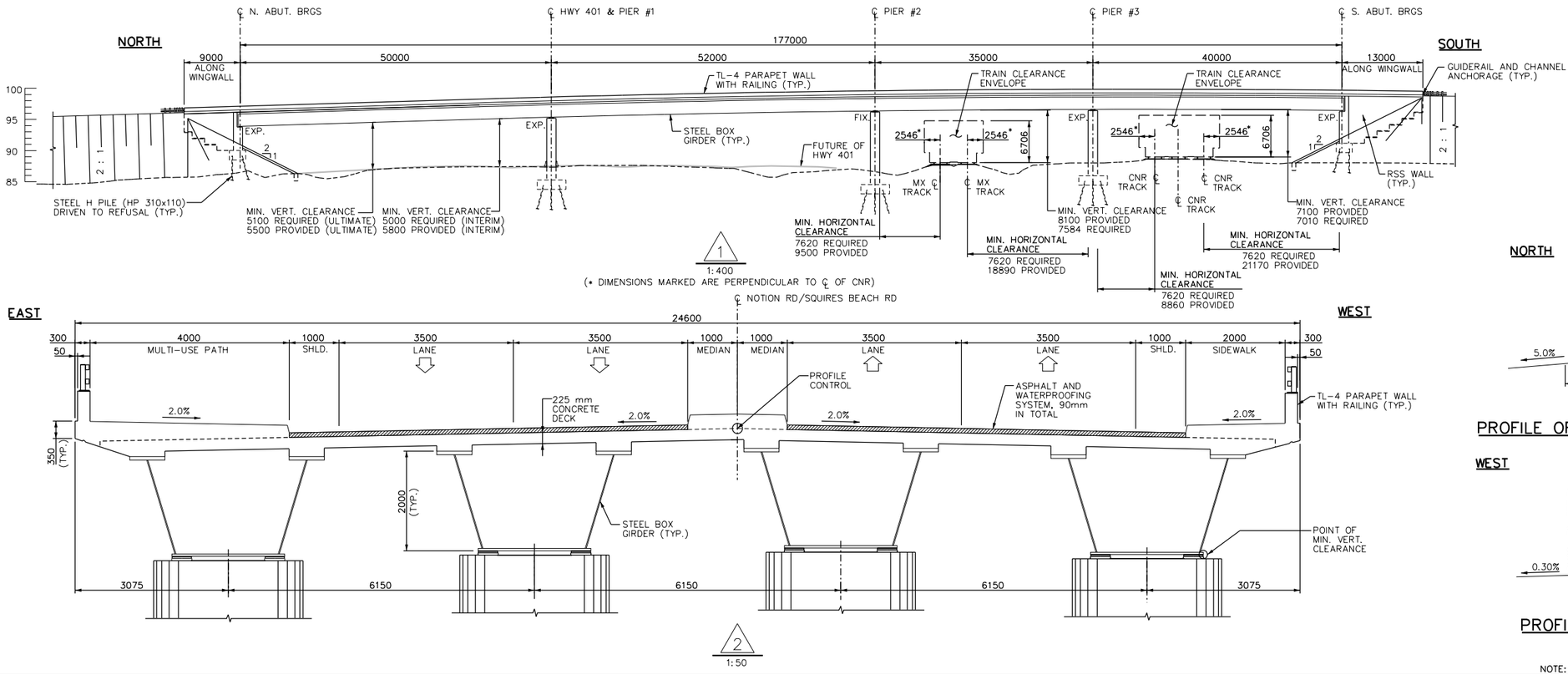
KEY PLAN

New Road Crossing of Highway 401, Notion Rd to Squires Beach Rd
City of Pickering, Ontario

Appendix B – Preliminary General Arrangement Drawing



PLAN
1:400



1
1:400
(* DIMENSIONS MARKED ARE PERPENDICULAR TO ℄ OF CNR)

2
1:50

GENERAL NOTES:

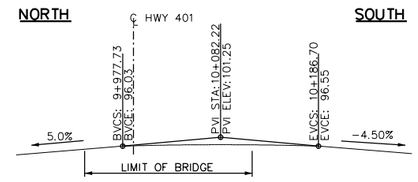
1. CLASS OF CONCRETE:
   DECK SLAB.....30 MPa
   REMAINDER.....30 MPa
   UNLESS NOTED OTHERWISE
2. CLEAR COVER TO REINFORCING STEEL:
   FOOTINGS.....100±25
   DECK – TOP.....70±20
   BOTTOM.....40±10
   REMAINDER.....70±20
   UNLESS NOTED OTHERWISE.
3. REINFORCING STEEL:
   – REINFORCING STEEL SHALL BE GRADE 400W UNLESS OTHERWISE SPECIFIED.
   – BAR MARKS WITH PREFIX 'S' DENOTE STAINLESS STEEL BARS.
   – STAINLESS REINFORCING STEEL BARS SHALL BE TYPE 316LN OR DUPLEX 2205 AND HAVE MINIMUM YIELD STRENGTH OF 500 MPa.
   – UNLESS SHOWN OTHERWISE TENSION LAP SPLICES SHALL BE CLASS B.
   – GLASS FIBRE REINFORCED POLYMER REINFORCING BARS SHALL BE GRADE III AS SPECIFIED IN THE CONTRACT DRAWINGS. THE NOMINAL DIAMETER, TENSILE MODULUS OF ELASTICITY AND GUARANTEED MINIMUM TENSILE STRENGTH SHALL BE AS SPECIFIED IN THE CONTRACT DOCUMENTS.
   BAR MARKS WITH THE PREFIX GIII DENOTE GRADE III GLASS FIBER REINFORCED POLYMER BARS.
   – BAR HOOKS SHALL HAVE STANDARD HOOK DIMENSIONS USING MINIMUM BEND DIAMETERS, WHILE STIRRUPS AND TIES SHALL HAVE MINIMUM HOOK DIMENSIONS. ALL HOOKS SHALL BE IN ACCORDANCE WITH THE STRUCTURAL STANDARD DRAWING SS12–1 UNLESS INDICATED OTHERWISE.

LIST OF ABBREVIATIONS

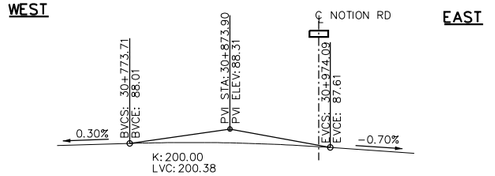
ABUT.	DENOTES ABUTMENT
BRGS.	DENOTES BEARINGS
MIN.	DENOTES MINIMUM
N.	DENOTES NORTH
N.T.S.	DENOTES NOT TO SCALE
S.	DENOTES SOUTH
SHLD	DENOTES SHOULDER
TYP.	DENOTES TYPICALDE
VAR.	NOTES VARIES
VERT.	DENOTES VERTICAL

APPLICABLE STANDARD DRAWINGS

OPSD 3101.150	WALLS ABUTMENT, BACKFILL MINIMUM GRANULAR REQUIREMENT
OPSD 3370.100	DECK, WATERPROOFING HOT APPLIED ASPHALT MEMBRANE WITH PROTECTION BOARD
OPSD 3370.101	DECK, WATERPROOFING HOT APPLIED ASPHALT MEMBRANE AT ACTIVE CRACKS GREATER THAN 2mm WIDE AND CONSTRUCTION JOINTS
OPSD 3390.100	DECK, DRIP CHANNEL
OPSD 3419.100	BARRIER AND RAILING, STEEL GUIDERAIL AND CHANNEL ANCHORAGE
MTOD 3941.210	FIGURES IN CONCRETE SITE NUMBER AND DATA LAYOUT
OPSD 3950.100	JOINTS–CONCRETE EXPANSION AND CONSTRUCTION ON CONCRETE



PROFILE OF ℄ NOTION RD/SQUIRES BEACH RD
N.T.S.



PROFILE OF ℄ EXISTING HWY 401
N.T.S.

NOTE: ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE NOTED.

UTILITIES VERIFIED

CABLE T.V.	200X XX XX
BELL CANADA	200X XX XX
ENBRIDGE GAS	200X XX XX

CONTRACTOR TO BE RESPONSIBLE FOR LOCATION OF ALL EXISTING U/G & OVERHEAD UTILITIES. VARIOUS UTILITIES REQUIRE ADVANCE NOTICE PRIOR TO DIGGING, FOR STAKE OUT. THE REGION ASSUMES NO RESPONSIBILITY FOR THE ACCURACY OF THE LOCATION OF EXISTING UTILITIES AS INDICATED ON THIS DRAWING.

PRELIMINARY
GENERAL ARRANGEMENT

NO.	DATE	NAME	REVISIONS

DRAWN:	O.Z.	DATE: 2019 09
DESIGN:	T.K.	DATE: 2019 09
CHECKED:	S.S.	DATE: 2019 09
APPROVED:	D.C.	DATE: 2019 09

AREA MUNICIPALITY

SURVEY DATA DATE	CONCESSION	REG. RD. NO.
200X XX XX	–	–

CITY OF PICKERING

NOTION ROAD/SQUIRES BEACH ROAD
FROM STA. 9+950 TO STA. 10+127

CONTRACT NO. D200X–XXX

DRAWING NO. 1

SHEET – OF –

CADD FILE NAME : T:\Projects\1-60584644 -DurhamLive Notion\900-Work\910-CAD\03-BRIDGES\20-SHEETS\Notion RD\Notion Road_Alt. A_ga.dgn

Appendix C – Alternatives Decision Matrix

Table 1: Evaluation Matrix of Alternatives

	Alternative 1	Alternative 2	Alternative 3
Structure Type	***Steel Box Girders***	***Post-Tensioned Concrete Slab***	***NU 2400 Prestressed Concrete Girders***
Approximate total Deck Area (m^2)	4,354	4,354	4,354
Construction Cost ($/$m^2$ of Deck Area)	**$4,200**	**$5,000**	**$3,600**
Span Lengths (m)	50; 52; 35; 40	50; 52; 35; 40	50; 52; 35; 40
Depth of Superstructure (mm)	2390	2290	2790

** Costs are rounded for comparison purposes and include 15% contingency*

Criteria	Weight		Alternative 1	Alternative 2	Alternative 3
Construction Cost	*30%*	**Score**	***3***	***1***	***5***
		Remarks	Moderate construction cost	Highest construction cost	Lowest construction cost
Depth of Superstructure/Grade Raise	*25%*	***Score***	***5***	***4***	***1***
		Remarks	Shallow superstructure - lowest profile/grade raise.	Superstructure depth is increased significantly during construction due to falsework.	Deepest superstructure – highest profile/grade raise.
Constructability	*25%*	**Score**	***3***	***1***	***4***
		Remarks	Least number of girders to fabricate; Light girders to transport and erect; Long lead time for fabrication of steel box girders.	Complexity of falsework and formwork. Lane reductions may be required to minimize depth of falsework and temporary bridging over Highway 401. Precast and cast in place not to be used over live traffic.	Most girders to fabricate, transport and erect; Largest and heaviest girder sections required; Shortest lead time for fabrication for concrete girders.
Durability and Maintenance	*15%*	**Score**	***4***	***5***	***4***
		Remarks	Girders require ongoing maintenance and re-coating; Difficult to inspect inside of box girders.	Difficult to inspect inside of PT voided slab.	Deterioration of top surface of bottom flanges.
Aesthetics	*5%*	**Score**	***4***	***5***	***2***
		Remarks	Contrast of materials; Shallow superstructure; Sloped sides giving a shallower superstructure depth impression.	Shallowest final superstructure; Sloped sides giving an impression of shallower depth; Continuity of lines.	Deepest superstructure; No contrast of materials.
Weighted Average Score	*100%*		***3.70***	***2.55***	***3.45***

Appendix D – Construction Cost Estimate

Table 1: Recommended Alternative Capital Cost Estimate

Item	Spec. Code	Item Description	Unit	Quantity	Unit Price	Total
1	0314-0190	Granular B Type II Backfill	t	3,000	$30	$90,000
2	0539-0040	Protection System	LS	100%	$500,000	$500,000
3	0599-5962 SP	Retaining Soil System, Wall	m^2	152.0	$1,200	$182,400
4	0599-5962 SP	Backfill for Retaining Soil System, Wall	t	4700.0	$30	$141,000
5	0902-0010	Earth Excavation for Structure	m^3	6,480	$25	$162,000
6	0903-0010	Supply Equipment for Driving Piles	LS	100%	$50,000	$50,000
7	0903-0054	H-Piles - HP 310x110	m	2,948	$500	$1,474,000
8	0903-0120	Driving Shoes	Each	211	$400	$84,400
9	0904-0085	Concrete in Substructure	m3	2,068	$1,500	$3,102,000
10	0904-0105	Concrete in Deck	m^3	1,524	$2,000	$3,048,000
11	0904-0125	Concrete in Parapet Walls	m^3	60	$2,500	$150,000
12	0904-0135	Concrete in Approach Slabs	m^3	74	$1,200	$88,800
13	0904-0135	Concrete in Slope Paving	m^3	171	$1,200	$205,200
14	0905-0010	Reinforcing Steel Bars	t	491.6	$2,800	$1,376,480
15	0905-0025	Stainless Reinforcing Steel Bars	t	4.7	$10,000	$47,000
16	0908-0030	Parapet Wall Railing	m	532.0	$200	$106,400
17	0906-0011	Fabrication of Structural Steel	t	632.4	$5,000	$3,162,000
18	0906-0020	Delivery of Structural Steel	t	632.4	$400	$252,960
19	0906-0030	Erection of Structural Steel	t	632.4	$1,000	$632,400
20	0911-0012	Coating New Structural Steel	m^2	104.0	$50	$5,200
21	0914-0011	Bridge Deck Waterproofing	m^2	2,848	$50	$142,400
22	0920-0010	Deck Joint Assemblies, Installation	m	50	$4,500	$225,000
23	0922-0010	Bearings	ea.	40	$1,000	$40,000
24	0928-0055	Access to Work Area, Work Platform and Scaffolding	LS	100%	$400,000	$400,000
25	0999-9150	Glass Fibre Reinforced Polymer (GFRP) Reinforcing Bars	m^3	2.0	$50,000	$100,000

Subtotal	$15,767,640
Contingencies (15%)	$2,365,146
Grand Total	**$18,133,000**