PRELIMINARY DESIGN REPORT NO.2

WILEY BRIDGE

CLAIREVILLE CONSERVATION AREA

PROJECT NO 10009703

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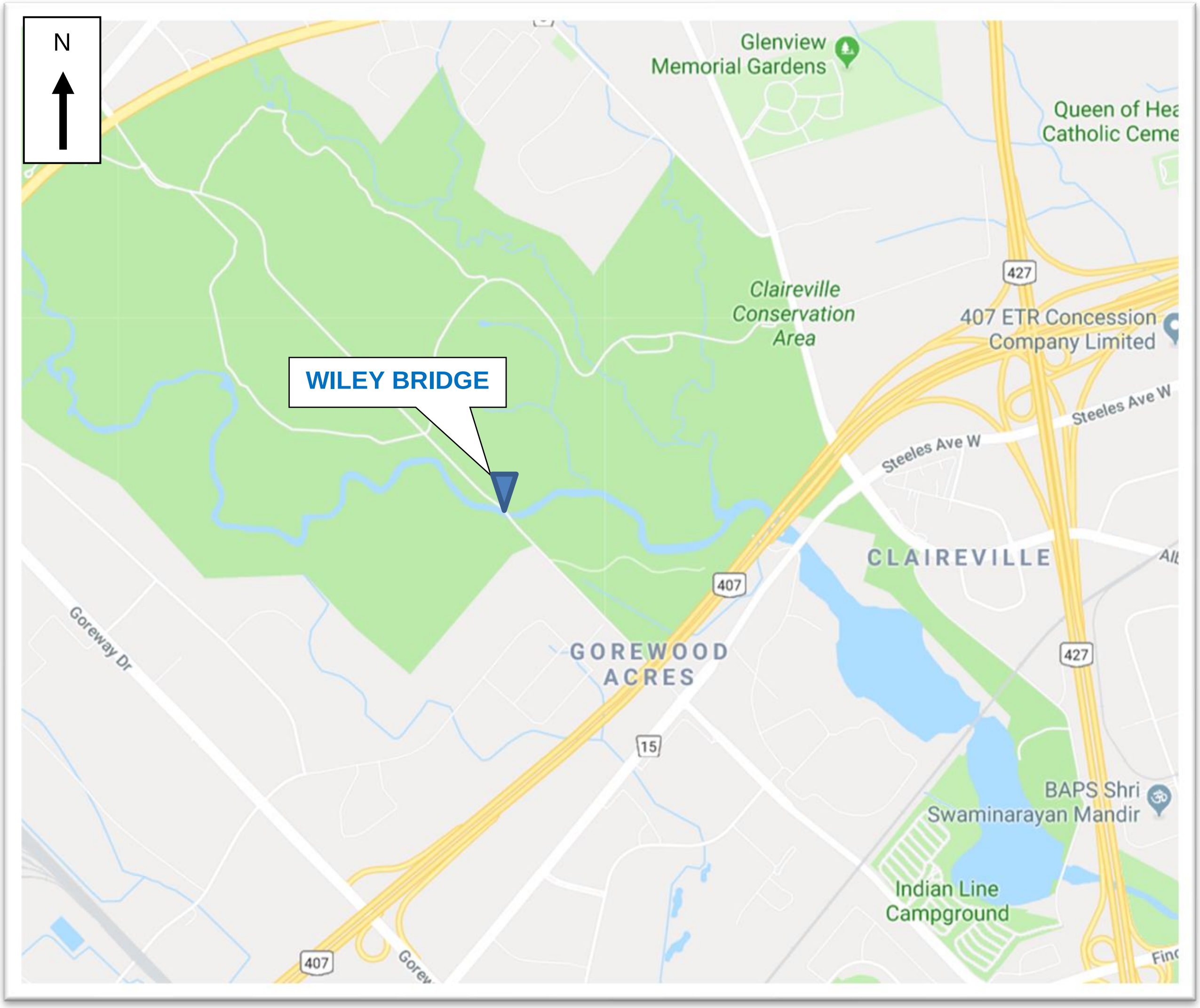
KEY PLAN



Wiley Bridge
Claireville Conservations Area
8180 Highway 50 | Brampton, Ontario

KEY PLAN
Scale: Not to Scale

1.0 INTRODUCTION

AMTEC Engineering Ltd (herein referred to as “AMTEC”) was retained by The Toronto and Region Conservation Authority (herein referred to as “TRCA”) to carry out a structural condition assessment and dimensional survey of the Wiley Bridge located at the Claireville Conservation Area in Brampton, Ontario. In addition, AMTEC has evaluated and provided alternatives for the renewal and replacement of the structure. For the purpose of this report, the bridge is considered orientated in the north-south direction.

The Wiley Bridge is a single span Concrete Bowstring Arch structure that crosses the West Humber River at the along the pedestrian trail at the Claireville Conservation Area in Brampton, Ontario. The bridge was constructed in the 1930’s by Langton and Bartho of Toronto and comprises of a single 26.83 m span supported by conventional concrete abutments. The structure comprises of two (2) reinforced concrete arch ribs, ten (10) vertical concrete hangers at each side (20 total), fourteen (14) concrete floor beams spanning the transverse direction, three (3) concrete sway braces, a reinforced concrete deck with curbs, and a post and railing barrier along each side of the bridge. There are also four (4) reinforced concrete retaining walls at the corners retaining the embankment fill.

The Wiley Bridge originally operated and accommodated a single lane of vehicular and pedestrian traffic, as part of the road network in the Clairville area. It is our understanding that the land for the current park was acquired in 1957, with the Bridge already in place. The bridge has not been used as an active highway bridge since that time.

The Wiley Bridge is of significant cultural and historical value and as of January 16, 2014, was designated as a heritage property under Part IV, Section 29 of the Ontario Heritage Act. The heritage impact assessment will inform development of the proposed interventions to ensure that the structure is appropriately conserved in relation to the designation by-law.

No existing structural drawings were provided to AMTEC; as such, a structural evaluation of the bridge was unable to be completed. However, a ten (10) tonne maximum vehicle load posting has been recommended as per Reference No. 2. AMTEC would like to note that no load posting signage was installed at the time of the site visit.

This report summarizes the findings of the condition survey and provides recommendations for renewal and replacement based on the site observations, economy, and consideration to its existing culvert heritage value.

2.0 REFERENCES

1. Wiley Bridge Condition Report, prepared by Brown and Co.; dated February 13, 2018.

2. Wiley Bridge Concrete Arch Bridge Visual Inspection Report, prepared by Brown and Co:, dated October 13, 2008.
3. Heritage Report, prepared by Brampton Heritage Board; dated June 19, 2012.
4. 2013 OSIM Report, prepared by Keystone Bridge Management Corp; dated: July 25, 2013.
5. “Notice of Passing of Designation By-Laws” (*Ontario Heritage Act*) letter, prepared by the City of Brampton; dated: January 16, 2014.
6. Heritage Impact Assessment Report prepared by Archaeological Services Inc (ASI); dated: July 2019.
7. CAN/CSA S6-19, “Canadian Highway Bridge Design Code” (CHBDC).

3.0 STRUCTURAL CONDITION SURVEY

The structural condition survey comprised of a close-up visual inspection and delamination of all accessible components (i.e. bridge deck top, barrier, lower arch components, curb, etc) and a visual inspection of the remaining components (i.e. deck soffit, abutments, upper arch components, etc). No specialized equipment was utilized for the condition survey. The findings of the inspection are presented in the following sections. Refer to Appendix B for the Condition Survey Mapping Sketches of Structure.

3.1 Bridge Deck

3.1.1 Concrete Deck Top

The bridge deck is considered to be in fair condition with local scaling, cracking, vegetation growth along the curbs, and ponding noted throughout. The deck of the bridge is partially covered in a gravel material, which does not appear to have been part of the parent concrete (see Photographs 11 and 42).

Locally scaling and scaling was noted in the deck surface throughout (see Photograph 43).

Debris / mud accumulation and local ponding was noted along the east and west curbs for the full span (see Photographs 12, 46, and 47).

Concrete cracking with efflorescence staining was noted in a few locations along the west fascia (see Photographs 26 and 31).

The bridge deck surface does not appear to be level, which may be contributing to the local ponding and poor drainage over the bridge.

Local vegetation growth was noted along the east and west curbs, particularly near the approaches (see Photographs 11 and 12).

3.1.2 Deck Soffit

The deck soffit was visually inspected and is considered to be in poor to fair condition with areas of spalled concrete, delaminated concrete, cracking, efflorescence staining, and wet staining.

Suspected concrete delamination was noted visually in five (5) of the deck soffit bays (see Photographs 22, 26, 29, and 33). These areas could not be hammer sounded due to limited access.

Spalled concrete with corroded steel reinforcement was noted in various locations throughout (see Photograph 30).

Localized concrete cracking with efflorescence staining were also noted throughout (see Photographs 29 and 33).

Wet staining was noted in the deck soffit in every bay (see Photographs 22, 29 and 33).

3.2 Arch Components

3.2.1 Frost Action or Potential ASR in Arch Components

As noted in the subsections below, *frost action* or *potential alkali silica reaction (ASR*) was noted in the arch components, mainly along the east and west arch ribs at the approach ends and locally at the midspan. Refer to the subsections below for specific site location(s) and photograph reference(s).

Frost action is caused by moisture freezing and can occur as cracks, stone splinters and swelling of the material. When water freezes, the volume of water increases by approximately 9%. If the degree of saturation exceeds about 91%, ice formation with consequent increase in volume of about 9% may produce rupture in one (1) or two (2) freeze-thaw cycles. If the increase of internal pressure exceeds the tensile strength of the concrete, micro-cracks occur. Visible frost damage occurs after an accumulation of micro cracks as a result of several freeze-thaw-cycles. Such situations are rare however they typically occur with young concretes that still have very large voids and are still nearly saturated, or they may occur in continuously soaked concretes of poor quality.

In Ontario, there exists several sources of aggregates that react adversely with the alkalis in cement to produce a highly expansive gel. Currently, these sources of reactive aggregates are generally avoided, but they do exist in many existing structures (i.e. structures built before the 1940s) and still may occur in newer structures. *ASR* is the most common form of alkali-aggregate reaction (AAR) in concrete. ASR can cause serious expansion and cracking in concrete, resulting in structural problems and sometimes necessitating demolition (in severe cases). ASR is caused by a reaction between the hydroxyl ions in the alkaline cement pore solution in the concrete and reactive forms of silica in the aggregate (eg: chert, quartzite, opal, strained quartz crystals). A gel is produced, which increases in volume by taking up water and so exerts an expansive pressure, resulting in failure of the concrete.

Once ASR / AAR starts, there are no remedial measures to stop or reverse the process of deterioration. Although there are no widely applicable methods of eliminating the deterioration of alkali-aggregate reaction, the rate of expansion may be reduced by taking steps to maintain the concrete in a condition that is as dry as possible. Low viscosity epoxies and High Molecular Weight Methacrylate (HMWM), when applied as a surface-sealer, may sometimes slow the rate of deterioration by lowering the moisture content of the concrete.

The best technique for the identification of ASR / AAR is the examination of concrete in thin section, using a petrographic microscope. Alternatively, polished sections of concrete can be examined by scanning electron microscopy (SEM); this has the advantage that the gel can be analysed using X-ray microanalysis in order to confirm the identification beyond any doubt. Section 3.2.2.1 provides the findings of the petrographic analysis of a concrete core sample which was extracted from the arch rib.

3.2.2 Arch Rib

The arch ribs were found to be in poor (arch rib ends) to fair (midsection) condition with honeycombing, wide cracking, cracking with efflorescence staining, spalled concrete, concrete delamination, concrete disintegration, and graffiti damage. Frost action or potential alkali silica reaction (ASR) was noted on both the east and west arch ribs, particularly at the ends and at the midspan.

Honeycombing was noted along the arch rib near the north and south approaches along the top of the arch.

The inside face of the east arch rib was noted have concrete cracking with efflorescence staining near the midspan and north approach (see Photographs 55 and 57). Two (2) wide horizontal cracks were noted near the midspan, at the upper arch. Concrete cracking with efflorescence staining was noted along the inside face of the east arch rib near the sway bracing (see Photograph 55).

Spalled concrete with exposed aggregate along the outside face of the west arch rib, near the south approach (see Photograph 18). Spalled concrete, concrete delamination and frost action (or potential ASR) was noted along the top and inside face of the west arch rib (end), near the south approach (see Photograph 15).

Concrete delamination, concrete cracking with efflorescence staining, and frost action (or potential ASR) was noted along the inside face of the east arch rib, near the north approach (see Photograph 41). Similar deterioration was also noted along the outside face of the east arch rib, near the north approach (see Photograph 41).

Concrete disintegration, honeycombing, and frost action (or potential ASR) was also noted in top of east arch rib, near north approach (see Photograph 44).

Graffiti damage was noted on the inside face of the west arch rib, near the north and south approaches (see Photographs 40 and 53).

3.2.2.1 Petrographic Analysis

A petrographic analysis was carried out to investigate whether or not the concrete in the arch ribs are AAR infected. Appendix D contains the Petrographic Analysis Report, which tested the concrete core sample extracted from the northeast corner of the arch.

The presence of AAR was confirmed in the concrete core sample as highlighted in the blue regions shown in the Figure 1. AAR occur when aggregates in concrete react with the alkali hydroxides in concrete producing a hygroscopic gel which (in the presence of moisture), absorbs water and leads to expansion and cracking in concrete overtime. Unfortunately, once AAR starts, there are no remedial measures to stop or reverse the process of deterioration.

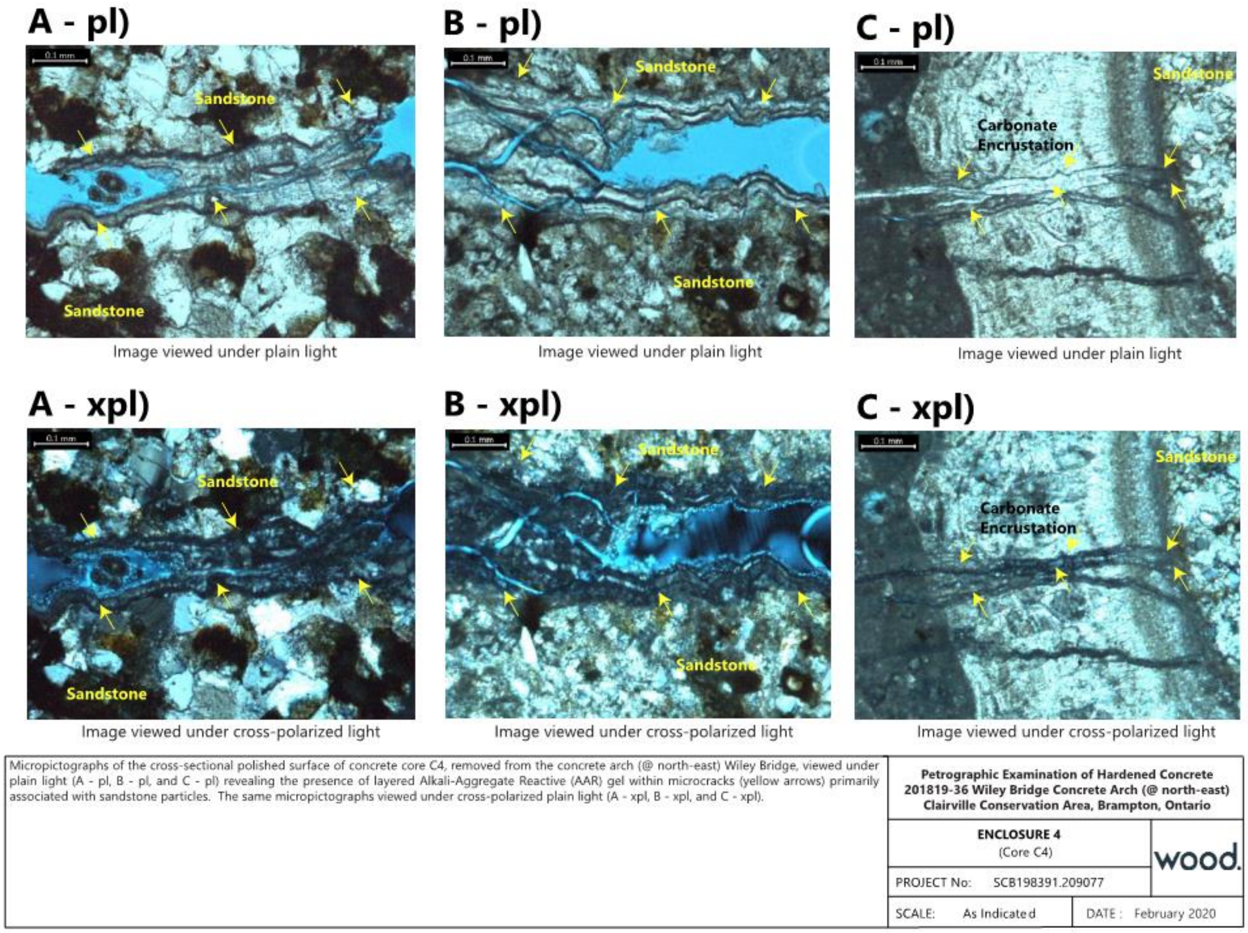


Figure 1 – Micropictographs of Cross-Sectional Polished Surface of Concrete Core (by Wood Environmental & Infrastructure Solutions, a division of Wood Canada Limited)

3.2.3 Hangers

The hangers are reinforced concrete vertical members which connect the bridge deck and floor beams to the top chord of the arch.

In general, the hangers are considered to be in fair to good condition, with localized cracking, concrete delamination, and concrete spalling. Wide horizontal cracks were noted at some of the hanger locations at the handrail level (see Photograph 58). Wide vertical cracking was noted in the second (2nd) west hanger near the north approach (see Photograph 59).

3.2.4 Floor Beam

There are fourteen (14) reinforced concrete floor beams which are aligned with the skew of the bridge, spanning from hanger to hanger. In general, the floor beams are in poor to fair condition with spalled concrete with exposed corroded reinforcement, concrete delamination, and concrete cracking with efflorescence staining.

Spalled concrete noted in east fascia was noted in a few floor beam locations (see Photograph 17).

Spalled concrete and concrete cracking with efflorescence staining was noted in the west end of the floor beam in approximately five (5) locations (see Photograph 28).

The north and south faces of the floor beams exhibit localized spalled concrete with exposed corroded reinforcement throughout (see Photographs 27 and 30).

3.2.5 Sway Bracing

Three (3) concrete sway braces are present, spanning from the top of the east to west arch rib, which are generally used to provide lateral stability to the structure (see Photograph 54). The sway braces were noted to be in good condition.

Exposed corroded steel reinforcement was noted in the one (1) of the sway bracing members near the east arch rib (see Photograph 56).

3.3 Other Components

3.3.1 Post and Railing Barrier

The post and railing barrier consists of seven (7) precast concrete pickets under a cast-in-place reinforced concrete handrail spanning between the arch hangers. Overall, the posts were found to be in poor to fair condition and the handrails in poor condition. Based on our experience, we do not anticipate any steel reinforcement in the posts (pickets).

Sections of the railings were noted to be severely delaminated and / or spalled, with some sections of the railing completely missing in a few locations (see Photographs 48, 49, 50, and 51). Concrete delamination was noted along the east handrail in eight (8) bays.

The height of the existing post and railing barrier was measured to be 1.28 mm (+/-) from the top of the deck to the top of the handrail. The railing heights are not consistent with current requirements for bicycle guardrails. In accordance with Clause 5.9.2 of Ontario Traffic Manual (OTM) Book 18 and Table 12.8 of the Canadian Highway Bridge Design Code (CHBDC S6-14), a minimum 1.37 m high barrier fence or parapet wall / railing combination should be provided on a bridge or culvert where a designated bike route is identified (i.e. a bicycle barrier).

3.3.2 Retaining Wall

Four (4) reinforced concrete retaining walls exist at the approach corners. The retaining walls were found to be in fair condition with localized concrete cracking, concrete disintegration honeycombing, and spalled concrete with exposed corroded steel reinforcement.

At the southeast and northwest retaining walls, an existing tree, at each location, was noted to be in direct contact with the back face of the wall (see Photographs 9 and 39, respectively). At both locations, the trees appear to be supported by the retaining wall, potentially exerting a force on the retaining wall. At the location of the tree in contact with the northwest retaining wall, a continuous wide vertical and horizonal cracks were noted. At the location of the tree in contact with the southeast retaining wall, three (3) wide horizontal cracks were noted in the retaining wall.

Honeycombing, concrete cracking with efflorescence staining, wide diagonal crack near abutment, wide horizontal cracks were noted in the southeast retaining wall (see Photograph 37).

Severe concrete disintegration, horizontal cracking, concrete delamination, and honeycombing with exposed aggregate, and exposed / damaged corroded reinforcement was noted in the southwest retaining wall (see Photographs 20, 21, and 32).

Concrete scaling, severe honey combing, concrete cracking with efflorescence staining, and a wide vertical and horizontal cracking spanning the full width of the northwest retaining wall was noted (see Photograph 35).

Spalled concrete, concrete cracking, scaling, and honeycombing along the waterline was noted in the northeast retaining wall (see Photograph 36).

3.3.3 Embankment

The embankments at the four (4) approaches were found to be in fair to good condition with localized of signs of erosion at the northeast and southwest embankments.

Medium erosion and material loss were noted in the northeast embankment along the retaining wall (see Photograph 10). An erosion hole was noted in the in the southwest embankment, adjacent to the retaining wall (see Photograph 19).

3.3.4 Curb on Deck

Concrete curbs were noted along the east and west sides of the bridge, adjacent to the post and railing barrier (see Photograph 47). The curbs were found to be generally in fair to good condition with honeycombing and abrasion damage.

Honeycombing was noted along the inside face of the east curb over three (3) bays near the midspan. Abrasion damage was noted along the inside face of the east curb (see Photograph 45).

3.3.5 Approaches

The north and south approaches consist of a gravel roadway to the structure (see Photographs 1 and 3). The approaches were found to be in fair condition with localized rutting along the edges and an uneven surface.

No record and drawings were provided, and no concrete cores(s) were carried out to confirm whether or not an approach slab is present.

3.3.6 Watercourse

The watercourse was found to be in good condition with no significant obstructions east and west of the structure at the time of the site visit (see Photographs 5 and 6). The watercourse was noted to be flowing in the west-to-east direction. Local tree failure was noted along the southwest embankment, slightly encroaching into the watercourse (see Photographs 24 and 61).

4.0 REHABILITATION / RENEWAL ALTERNATIVES

Recommendations for rehabilitation / renewal are considered to address the issues observed from the structural condition assessment. The following seven (7) alternatives were considered based on the findings of the structural condition survey:

- Alternative No. 1 – Do Nothing;
- Alternative No. 2 – Minimum Rehabilitation;
- Alternative No. 3 – Major Rehabilitation;
- Alternative No. 4 – Removal of Existing Bridge and Construct a New Prefabricated Pratt Truss Bridge;
- Alternative No. 5 – Removal of Existing Bridge and Construct a New Prefabricated Bowstring Arch Bridge;
- Alternative No. 6 – Removal of Existing Bridge and Construct a New Concrete Bowstring Arch Bridge; and
- Alternative No. 7 – Removal of Existing Bridge and Construct a Slab-on-Girder Bridge,

4.1 Alternative No. 1 – Do Nothing

This alternative, which postpones capital expenditure further into the future, is *not* recommended in view of the fact that the Wiley Bridge retains heritage value and postponement of work will enable the deterioration to continue and may potentially extend into other parts of the structure.

Furthermore, AMTEC's condition survey has identified that the existing post and railing barrier extends approximately 1.28 m from the top of the deck to the top of the handrail. Clause 5.9.2 of Ontario Traffic Manual (OTM) Book 18 and Table 12.8 of the Canadian Highway Bridge Design Code (CHBDC S6-14) states that a minimum 1.37 m high barrier fence or parapet wall / railing combination should be provided on a bridge or culvert where a designated bike route is identified (i.e. a bicycle barrier). The existing barrier system does not confirm to this requirement and the no signage instructing cyclists to 'dismount' from their bicycle when crossing the bridge is currently posted.

Due to the extent of concrete deterioration in the deck, in our opinion there is a potential hazard for user's below (i.e. on a canoe) or on the structure for falling concrete, trips, falls, etc.

Based on the above, this alterative is not recommended and is not carried forward for further discussion.

4.2 Alternative No. 2 – Minimum Rehabilitation

This alternative is based on undertaking the minimum necessary repairs to the bridge only. It would postpone major capital expenditure for an estimated 15-20 years at which time the structure may require another rehabilitation (or replacement) program. The work includes:

- Locally repair all spalled / delaminated concrete on the arch components (arch rib, hangers, sway braces), bridge deck (concrete deck slab and soffit), retaining walls, and concrete curb;
- Arch rib ends shall be repaired at all three (3) faces (inside face, outside face, and top of arch);
- Patch repair (or potential concrete re-facing) of the floor beams to all three (3) faces;
- Apply crack injection to the actively leaking cracks in the deck soffit;
- Locally repair the erosion in the embankments by backfilling and / or re-grading;
- Remove the two (2) trees which are currently being supported by the northwest and southeast retaining walls (to be carried out internally by TRCA staff and as such, has not been included in the engineers estimate as part of a construction contract);
- Surface sealing the arch components with a 'Metro Grey' protective coating in an attempt to enhance long-term preservation of the concrete;
- Provide rock protection (rip rap) at the four (4) embankments;

- Concrete refacing in southwest retaining wall;
- Removal, salvage, and reinstate armour stones to facilitate the concrete refacing at the southwest retaining wall;
- Modify / extend the deck drains along the structure;
- Regrading / reconstruction of the north and south approaches;
- Remove and replace the existing top railing of the barrier to ensure that the post and railing barrier conforms to the minimum 1.37 m height requirement per Table 12.8 of CHBDC and Clause 5.9.2 of OTM Book 18; and
- Provide ten (10) tonne load post signage at each bridge approach (per Reference No.7 recommendation).

Refer to Section 5.1 for the estimated capital cost for the rehabilitation works noted above.

4.3 Alternative No. 3 – Major Rehabilitation

This alternative involves scarifying the top 25 mm of existing concrete deck and constructing a new 60 mm thick normal concrete overlay (30 MPa) on the existing bridge deck to improve drainage along the structure and provide adequate concrete cover to the steel reinforcement, in addition to the points listed within "Alternative No. 2 – Minimum Rehabilitation". This alternative would postpone major capital expenditure for an estimated 25-30 years at which time the structure may require another rehabilitation (or replacement) program.

Refer to Section 5.1 for the estimated capital cost for the rehabilitation works noted above.

4.4 Alternative No. 4 – Removal of Existing Bridge and Construct a New Prefabricated Pratt Truss Bridge

This alternative is based on the removal of the existing bridge and replacement with a prefabricated steel pratt truss pedestrian bridge. For the purposes of this report, the new bridge is considered to be supported by new concrete abutments founded on helical piers, as shown in Figures 2 and 3.

The construction process for this alternative would include the following:

- Install temporary traffic control to fully close access along the pedestrian trail over the bridge;
- Install protection system(s);
- Remove the existing structure and approaches;
- Excavate and prepare the foundation subgrade;
- Install helical piers;
- Construct cast-in-place concrete abutments and retaining walls at the four (4) embankment corners;
- Install bridge bearings and prefabricated truss bridge;

➢ Backfill the structure;
➢ Construct granular pads at the approaches;
➢ Locally regrade embankments / approaches;
➢ Provide rip rap along embankments; and
➢ Remove temporary traffic control and re-open pedestrian trail.

The service life of a new structure, with good maintenance practices, is anticipated to be 75 years per Clause 1.4.2.3 of CHBDC (Reference No.7).

AMTEC notes that consultation with Brampton Heritage Board would be required to confirm the viability of this alternative. Replacement and removal of the existing bridge would require full heritage recording and documentation of the existing bridge, carried out by a qualified heritage consultant.

AMTEC notes that the following additional studies would be required to proceed with this alternative:

➢ Environmental assessment;
➢ Geotechnical investigation;
➢ Environmental studies;
➢ Hydraulic investigation;
➢ Topographic survey; and
➢ Fluvial geomorphological review of the watercourse is recommended for the proposed culvert location, orientation, span and erosion protection.

We anticipate that the construction duration for this alternative would be approximately four (4) to five (5) months.

Refer to Section 5.1 for the estimated capital cost for the rehabilitation works noted above.

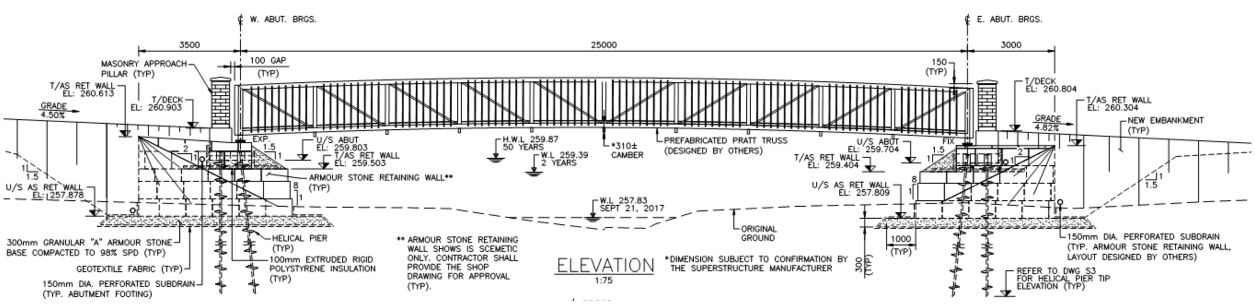


Figure 2 – Representative Elevation of Prefabricated Steel Pratt Truss Bridge Founded on Helical Piers

Figure 3 – Representative Photograph of Prefabricated Steel Pratt Truss Bridge

4.5 Alternative No. 5 – Removal of Existing Bridge and Construct a New Prefabricated Bowstring Arch Bridge

This alternative is based on the removal of the existing bridge and replacement with a prefabricated steel bowstring arch pedestrian bridge. For the purposes of this report, the new bridge is considered to be supported by new concrete abutments founded on helical piers.

The intent would be to replace the structure with a sympathetically designed structure which maintains the bowstring arch component of the original bridge, as exemplified in Figures 4 and 5.

The construction process for this alternative would include the following:

- Install temporary traffic control to fully close access along the pedestrian trail over the bridge;
- Install protection system(s);
- Remove the existing structure and approaches;
- Excavate and prepare the foundation subgrade;
- Install helical piers;
- Construct cast-in-place concrete abutments and retaining walls at the four (4) embankment corners;
- Install bridge bearings and prefabricated bowstring arch bridge;
- Backfill the structure;
- Construct granular pads at the approaches;
- Locally regrade embankments / approaches;
- Provide rip rap along embankments; and
- Remove temporary traffic control and re-open pedestrian trail.

The service life of a new structure, with good maintenance practices, is anticipated to be 75 years per Clause 1.4.2.3 of CHBDC (Reference No.7).

AMTEC notes that consultation with Brampton Heritage Board would be required to confirm the viability of this alternative. Replacement and removal of the existing bridge would require full heritage recording and documentation of the existing bridge, carried out by a qualified heritage consultant.

AMTEC notes that the following additional studies would be required to proceed with this alternative:

- Environmental assessment;
- Geotechnical investigation;
- Environmental studies;
- Hydraulic investigation;
- Topographic survey; and
- Fluvial geomorphological review of the watercourse is recommended for the proposed culvert location, orientation, span and erosion protection.

We anticipate that the construction duration for this alternative would be approximately four (4) to five (5) months.

Refer to Section 5.1 for the estimated capital cost for the rehabilitation works noted above.

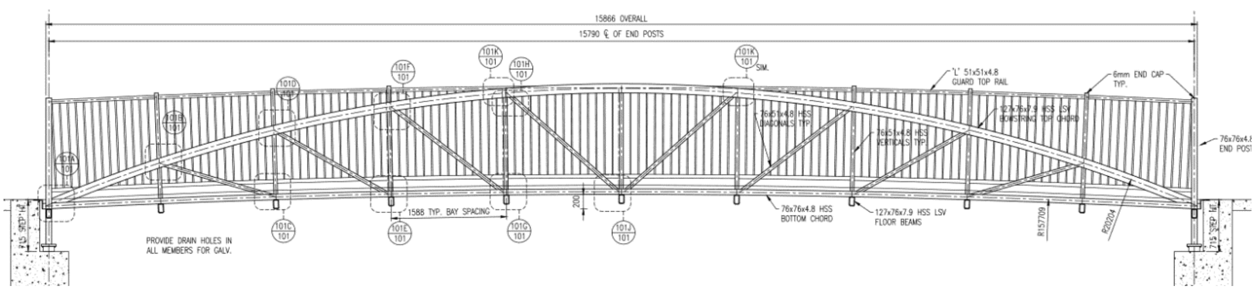


Figure 4 – Representative Elevation of Prefabricated Steel Bowstring Arch Bridge

Figure 5 – Representative Photograph of Prefabricated Bowstring Arch Bridge

4.6 Alternative No. 6 – Removal of Existing Bridge and Construct a New Concrete Bowstring Arch Bridge

This alternative considers the removal of the existing bridge and replacement with a new concrete bowstring arch bridge.

Concrete bowstring arch bridges are not common in modern construction, as the evolution of the arch bridge has shifted to 'through arch bridge' structures. A 'through arch bridge' generally comprises of lighter materials, such as steel or prestressed concrete, where the base of an arch structure is below the deck and the arch rises above the deck. Thus, the deck is within the arch, and cables or beams that are in tension suspend the central part of the deck from the arch.

It is well known that arch bridges present constructability challenges, which is mainly attributed to the fact that entire structure is not an arch until the closure is completed. Construction duration is also greatly increased due to the time required to build the structure, due to the specialized methods of construction. Arch bridges also require additional maintenance requirements over the lifespan of the structure in comparison to other bridge types.

As such, this alternative is not considered for further discussion, due to the construction challenges associated with a new concrete bowstring arch bridge, modern construction methods, construction duration, and economy.

4.7 Alternative No. 7 – Removal of Existing Bridge and Construct a Slab-on-Girder Bridge

This alternative is based on the removal of the existing bridge and replacement with a new concrete slab-on-girder bridge. The girders may be precast prestressed concrete box girders or steel I-girders. An environmental assessment would be required to confirm the viability of this alternative.

For the approximately 30 m span, the concrete box girders could consist of four (4) B900 deep box girders butted up against each other, for pedestrian and maintenance vehicle access only. Each of these girders consists of a hollow 1220 mm wide by 900 mm deep concrete box. On top of the box girders would be the installation of a 150 mm thick concrete distribution slab and 90 mm asphalt and waterproofing. Barriers would then be constructed on both sides of the bridge. The box girders could span between the existing abutments, or alternatively, new abutments could be constructed.

For the steel I-girders, the new 225 mm concrete deck could be supported by three (3) W840x176 steel girders. A 90 mm asphalt and waterproofing system would be installed on top of the concrete deck, and 1.37 m high concrete parapet walls would be constructed on both sides of the bridge. The steel girders could span between the existing abutments, or alternatively, new abutments could be constructed.

However, in accordance with the Ontario Heritage Bridge Guidelines (Reference No.1), this option is not carried forward as the replication of the appearance of the existing heritage bridge in new bridge design, cannot be achieved with a slab-on-girder superstructure. Nor is this design considered to be compatible with the existing heritage structure. As such, this alterative is not carried forward for further consideration.

5.0 FINANCIAL ANALYSIS

The objective of the financial analysis is to identify the most economical renewal option for the Wiley Bridge. Details of the analyses can be found in Appendix C.

5.1 Summary of Capital Costs

Cost estimates for the proposed renewal / rehabilitation alternatives are presented in Table 1. The engineer's estimate was calculated based on estimated unit cost prices and quantities to date. The following shall be considered when reviewing the estimates:

- Estimates are based on the current level of evaluation and design completed by AMTEC to date;
- Estimated construction costs account for traffic control costs;
- Allowances for construction contingencies (15%) are included in the estimates;
- Engineering allowances / fees are not included;
- Estimates do not account for any unforeseen conditions;
- Estimates are rounded to the nearest $1000; and

- Prices are based on current 2021 dollars.

Table 1 – Summary of Estimated Construction Capital Cost for Rehabilitation Alternatives

Alternative	Estimated Construction Cost	Construction Contingency Allowance (15%)	Total Capital Cost
2	$ 407,000	$ 61,000	$ 468,000
3	$ 436,000	$ 65,000	$ 501,000
4	$ 442,000	$ 66,000	$ 508,000
5	$ 482,000	$ 72,000	$ 554,000

5.2 Life Cycle Cost Analysis

The objective of the life cycle cost analysis is to identify the most economical of the renewal / rehabilitation alternatives over a fifty (50) year period. The following summarizes the assumptions used for each of the options:

- Discount rate = 6%; Sensitivity analysis discount rate = 5%, 7%;
- Life cycle period was based on fifty (50) years;
- Estimates do not account for routine maintenance and unforeseen conditions;
- Allowances for construction contingencies (15%) are included in the estimates;
- Engineering allowances / fees are not included;
- Estimates are rounded to the nearest $1000;
- Design life of components such as concrete deck overlay, asphalt wearing surface and so on, are in accordance with clause C2.3.1 of CHBDC Commentary; and
- Prices are based on current 2021 dollars.

A sensitivity analysis was undertaken to determine how changes in the discount rate impact the present values for each alternative in the analysis. Two (2) scenarios are considered; scenario 1 and scenario 2 consider discount rates that are 1% higher and 1% lower than the base rate, respectively. Potential impacts identified through the sensitivity analysis are illustrated below.

Table 2 – Summary of 50 Year Life Cycle Cost Analysis Comparison

Alternative	Total Capital Cost	Present Value DR = 6%	Sensitivity Analysis	
			7.0%	5.0%
2	$ 468,000	$ 637,000	$ 618,000	$ 654,000
3	$ 501,000	$ 619,000	$ 602,000	$ 637,000
4	$ 508,000	$ 503,000	$ 506,000	$ 497,000
5	$ 554,000	$ 549,000	$ 552,000	$ 543,000

6.0 RECOMMENDATIONS

6.1 Rehabilitation Recommendations

Based on the findings of the condition survey and consideration of the financial analyses, Alternative No. 5, ""Removal of Existing Bridge and Construct a New Prefabricated Bowstring Arch Bridge", is considered the preferred alternative. The service life of a new structure, with good maintenance practices, is anticipated to be 75 years.

The presence of AAR was confirmed in the concrete core samples extracted from the arch ribs. As noted in Section 3.2.1, once AAR starts, there are no remedial measures to stop or reverse the process of deterioration. As such, Alternatives 2 and 3 are not considered to be worthwhile options going forward due to the age (90+ years) and condition of the structure. Replacement (or another rehabilitation) program is anticipated in 15-20 years for Alternative 2, and 25-30 years for Alternative 3. Both Alternatives 2 and 3 provide the least favourable LCCA results over a 50-year period in comparison to both replacement options.

The LCCA infers that Alternative 5 is favourable in comparison to Alternative 2 over a 50-year period, as Alternative 5 offers a 14.8%, 11.3%, and 18.5% lower percentage difference between these options at discount rates of 5%, 6%, and 7%, respectively. Alternative 5 also presents a favourable (lower) percentage difference in comparison to Alternative 3 over a 50-year period with 11.1%, 8.7%, and 15.9% differences between these options at discount rates of 5%, 6%, and 7%, respectively. In our opinion, it would be ill-advised to invest additional funds into a structure which is over 90+ years old, in its current condition, and AAR has been confirmed.

We acknowledge that Alternative 5 is not the most economical replacement alternative in comparison to Alternative 4. However, we consider Alternative No.5 to be acceptable, as it provides a fair compromise between economy and maintaining a design which is sympathetic to the existing concrete bowstring arch structure.

The estimate capital construction cost, including a 15% contingency allowance, would be approximately $554,000. The estimate was based on the assumption that the bridge will be shut down during replacement. Construction notification signage will need to be placed around the Claireville Conservation Area to notify users.

Due to the noted state of deterioration, we recommend this work to be carried out within the next twelve (12) months.

We trust that the above is satisfactory for your purposes. Please call the undersigned if you wish to discuss the contents of this report.

Yours truly,

AMTEC Engineering Ltd

Agostino Monteleone, P.Eng., M.A.Sc.
Senior Bridge / Structural Engineer

APPENDIX A – SITE PHOTOGRAPHS

(1)

South approach (looking south).

(2)

South elevation (looking north).

(3)

North approach (looking north).

(4)

North elevation (looking south).

(5)

Looking west (upstream).

(6)

Looking east (downstream).

(7)

West elevation.

(8)

East elevation.

(9)

Southeast retaining wall. Note the severe honeycombing, cracking with efflorescence staining, wide diagonal crack near abutment, and wide horizontal crack. Note the trees in contact with the retaining wall.

(10)

Northeast embankment. Note the severe erosion.

(11)

Deck wearing surface (looking north). Note the debris accumulation along the curbs.

(12)

Deck wearing surface (looking south). Note the debris accumulation along the curbs.

(13)

Potential Alkali Silica Reaction (ASR) in outside face of east arch rib (end), near south approach.

(14)

Concrete disintegration, honeycombing and potential ASR in top of east arch rib near south approach.

(15)

Spalled concrete and potential ASR along top and inside face of west arch rib (end) near south approach.

(16)

Concrete cracking with efflorescence staining, and potential ASR in east truss (looking south).

(17)

Spalled concrete in east end of floor beam.

(18)

Spalled concrete with exposed aggregate along the outside face of the west arch rib, near the south approach.

(19) 

Erosion hole in the southwest embankment, adjacent to the retaining wall.

(20) 

Severe concrete disintegration, concrete delamination, and exposed / damaged corroded reinforcement in southwest retaining wall.

(21) 

Concrete cracking and honeycombing with exposed aggregate in southwest retaining wall.

(22) 

Wet staining and concrete delamination in deck soffit adjacent to south abutment.

(23)

Spalled concrete in west fascia of truss floor beam (3rd floor beam from south abutment). Note the adjacent cracked concrete with efflorescence staining.

(24)

Local tree failure encroaching waterway near southwest embankment.

(25)

West fascia (looking north). Note the concrete cracking with efflorescence staining (potential ASR).

(26)

West fascia and deck soffit. Note the concrete cracking with efflorescence staining (potential ASR).

(27)

Spalled concrete with exposed corroded reinforcement in floor beam. Note the efflorescence staining (potential ASR).

(28)

Spalled concrete in west fascia of truss floor beam (6th floor beam from south abutment). Note the adjacent cracked concrete with efflorescence staining.

(29)

Concrete delamination and wet staining in deck soffit (5th bay from south abutment).

(30)

Spalled concrete with exposed corroded reinforcement in floor beam. Note the delaminates concrete in the deck soffit.

(31)

West fascia (6th bay from south abutment). Note the honeycombing and concrete cracking with efflorescence staining.

(32)

Southwest retaining wall. Note the horizontal crack, exposed / failed corroded reinforcement, and concrete disintegration.

(33)

Wet staining and concrete delamination in deck soffit (7th bay from south abutment).

(34)

North abutment.

(35)

Northwest retaining wall. Note the wide horizontal crack and the tree in contact with the wall.

(36)

Northeast retaining wall.

(37)

Honeycombing in top of southeast retaining wall.

(38)

East fascia (looking north).

(39)

Northwest embankment. Note the tree in contact with the retaining wall.

(40)

Graffiti damage noted on the inside face of the west arch rib, near the north approach.

(41)

Concrete delamination and concrete cracking with efflorescence staining (potential ASR) along inside face of east arch rib, near the north approach.

(42)

Concrete delamination and concrete cracking with efflorescence staining (potential ASR) along the outside face of the east arch rib, near the north approach.

(43)

Exposed aggregate and scaling in bridge deck.

(44)

Concrete disintegration, honeycombing and potential ASR in top of east arch rib, near north approach.

(45)

East curb (looking south). Note the abrasion damage along the upper corner.

(46)

Debris accumulation along east shoulder.

(47)

West curb and parapet wall. Note the debris accumulation along the shoulder.

(48)

Section loss, spalled concrete and exposed / failed corroded reinforcement in west parapet rail (upper rail).

(49)

Section loss, spalled concrete and exposed corroded reinforcement in east parapet rail (upper rail).

(50)

Section loss, spalled concrete and exposed corroded reinforcement in east parapet rail (upper rail).

(51)

Complete section loss in upper rail of east parapet wall (near south approach). Note the exposed corroded reinforcement.

(52)

Concrete delamination and cracking with efflorescence staining along the inside face of east arch rib, near the south approach.

(53) 

Graffiti damage at inside face of west arch rib, near the south approach.

(54) 

Sway bracing (general).

(55)

Concrete cracking with efflorescence staining along the inside face of east arch rib near the sway bracing.

(56)

Exposed corroded reinforcement in sway bracing near the east arch rib.

(57)

Concrete cracking with efflorescence staining (potential ASR) at inside face of east arch rib near the north sway bracing.

(58)

Wide cracking in easy vertical member near parapet wall (typical for west verticals).

(59)

Wide vertical cracking in west hanger (second from north approach).

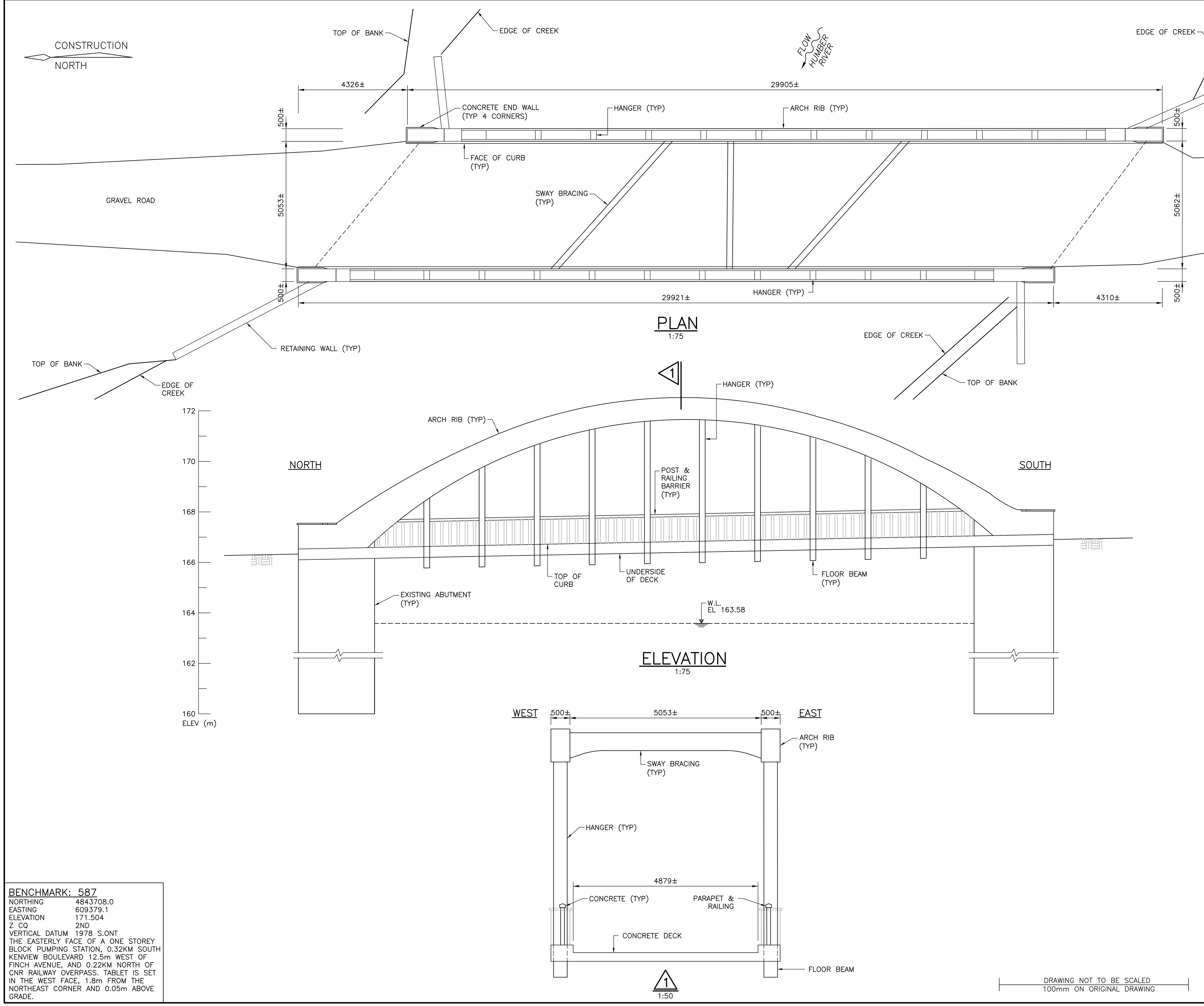
(60)

Concrete delamination and disintegration at the inside face of east arch rib, near the north approach.

(61)

Failed trees in watercourse along south shoreline (upstream / west of bridge).

APPENDIX B – CONDITION SURVEY MAPPING



NOTE:

1. ALL DIMENSIONS ARE IN MILLIMETRES AND ALL ELEVATIONS ARE IN METRES UNLESS OTHERWISE NOTED.

BENCHMARK: 587

NORTHING	4843708.0
EASTING	609379.1
ELEVATION	171.504
Z CQ	2ND
VERTICAL DATUM	1978 S.ONT

THE EASTERLY FACE OF A ONE STOREY BLOCK PUMPING STATION, 0.32KM SOUTH KENVIEW BOULEVARD 12.5m WEST OF FINCH AVENUE, AND 0.22KM NORTH OF CNR RAILWAY OVERPASS. TABLET IS SET IN THE WEST FACE, 1.8m FROM THE NORTHEAST CORNER AND 0.05m ABOVE GRADE.

CAD FILE LOCATION AND NAME: E:\OneDrive\1Projects\2018-2019\201819-36 Wiley Bridge Rehab\10 PDR & Insp Rpt\10.1 CAD - Condition Survey\201819-36 Wiley Bridge.dwg
MODIFIED: 8/15/2019 4:03:04 AM BY: USER
DATE PLOTTED: 8/15/2019 4:04:40 AM BY: USER

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AM	WA	DB

PROJECT TITLE

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DRAWING TITLE

GENERAL ARRANGEMENT

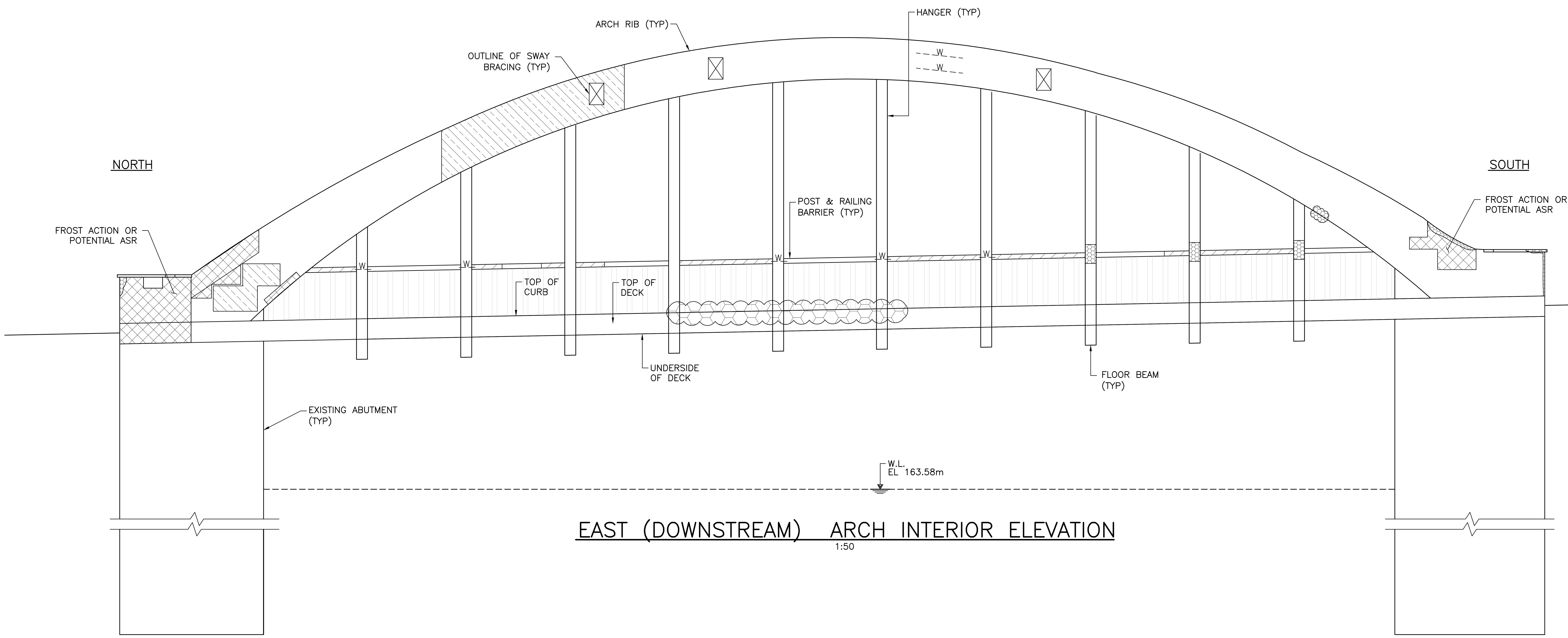
DRAWING NO.	FILE NO.
S1	201819-36 Wiley Bridge.dwg

DATE	SCALE	REV.
APR 15, 2019	AS SHOWN	–

CONSTRUCTION NORTH

LEGEND:

- DENOTES DELAMINATION
- DENOTES HONEYCOMBING CRACKING
- DENOTES SPALLED CONCRETE W/ EXPOSED CORRODED REINFORCEMENT
- DENOTES CONCRETE CRACKING WITH EFFLORESCENCE STAINING
- W DENOTES WIDE WIDTH CONCRETE DELAMINATION



EAST (DOWNSTREAM) ARCH INTERIOR ELEVATION

1:50

NOTE:

1. ALL DIMENSIONS ARE IN MILLIMETRES AND ALL ELEVATIONS ARE IN METRES UNLESS OTHERWISE NOTED.

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DRAWING TITLE

EAST (DOWNSTREAM) ARCH INTERIOR ELEVATION

DRAWING NO.	FILE NO.	
S2	201819-36 Wiley Bridge.dwg	
DATE	**SCALE**	**REV.**
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MODIFIED: 8/12/2019 7:00:35 PM BY: WORKING
DATE PLOTTED: 8/12/2019 7:08:00 PM BY: WORKING

CONSTRUCTION NORTH

LEGEND:

DENOTES DELAMINATION

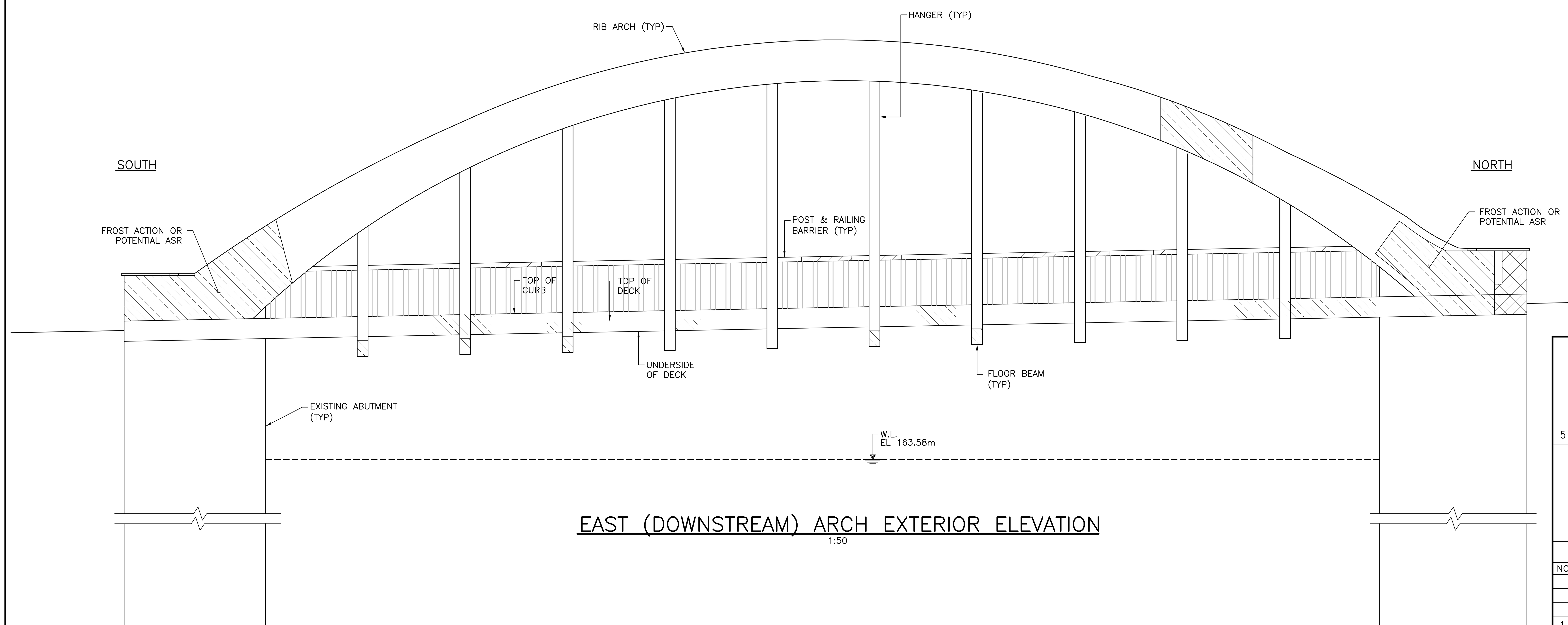
DENOTES HONEYCOMBING CRACKING

DENOTES SPALLED CONCRETE W/ EXPOSED CORRODED REINFORCEMENT

DENOTES CONCRETE CRACKING WITH EFFLORESCENCE STAINING

VEGETATION/MOSS GROWTH

DENOTES WIDE WIDTH CONCRETE DELAMINATION



EAST (DOWNSTREAM) ARCH EXTERIOR ELEVATION

1:50

NOTE:

1. ALL DIMENSIONS ARE IN MILLIMETRES AND ALL ELEVATIONS ARE IN METRES UNLESS OTHERWISE NOTED.

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DRAWING TITLE

EAST (DOWNSTREAM) ARCH EXTERIOR ELEVATION

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DATE APR 15, 2019 | SCALE AS SHOWN | REV. –

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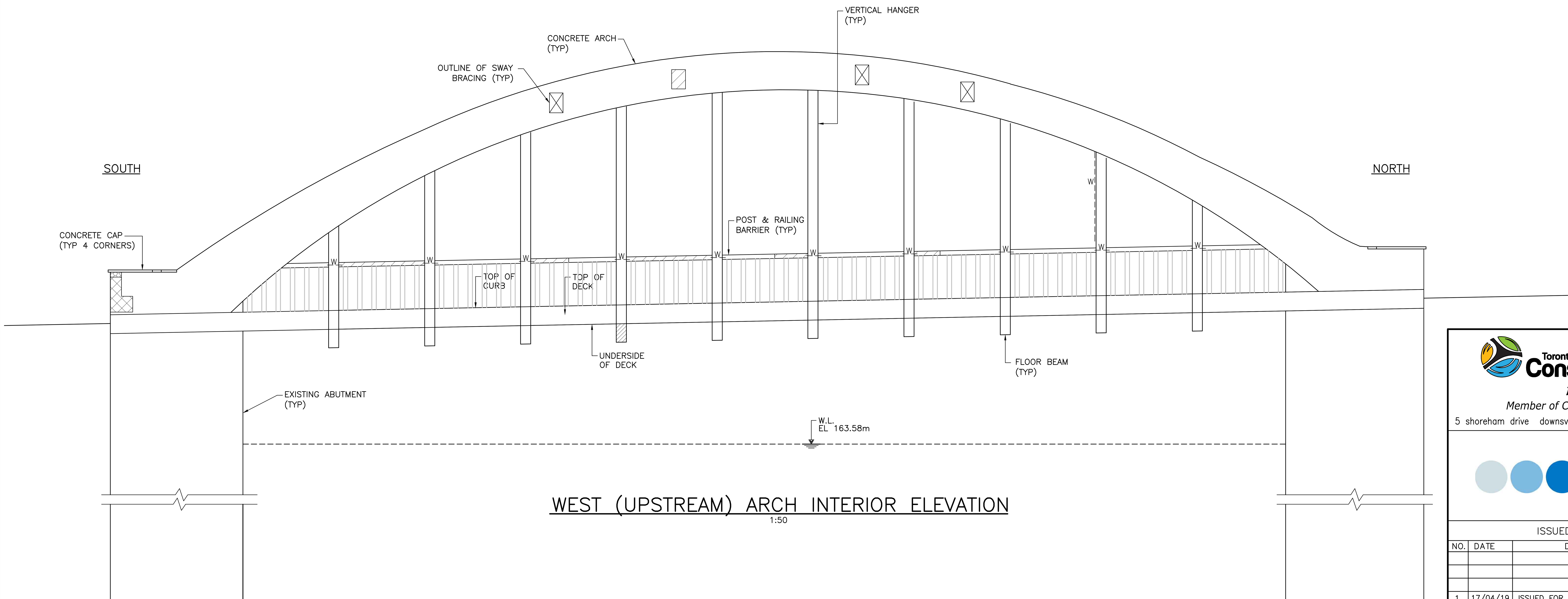
CONSTRUCTION NORTH

LEGEND:

- DENOTES DELAMINATION
- DENOTES HONEYCOMBING CRACKING
- DENOTES SPALLED CONCRETE W/ EXPOSED CORRODED REINFORCEMENT
- DENOTES CONCRETE CRACKING WITH EFFLORESCENCE STAINING
- W DENOTES WIDE WIDTH CONCRETE DELAMINATION



WEST (UPSTREAM) ARCH INTERIOR ELEVATION

1:50

NOTE:

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AM	WA	DB

PROJECT TITLE

REPAIRS TO WILEY BRIDGE AT CLAIREVILLE CONSERVATION AREA CONTRACT # 10009703

DRAWING TITLE

WEST (UPSTREAM) ARCH INTERIOR ELEVATION

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APR 15, 2019	AS SHOWN	–	

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DATE PLOTTED: 8/15/2019 4:05:11 AM BY: USER

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LEGEND:

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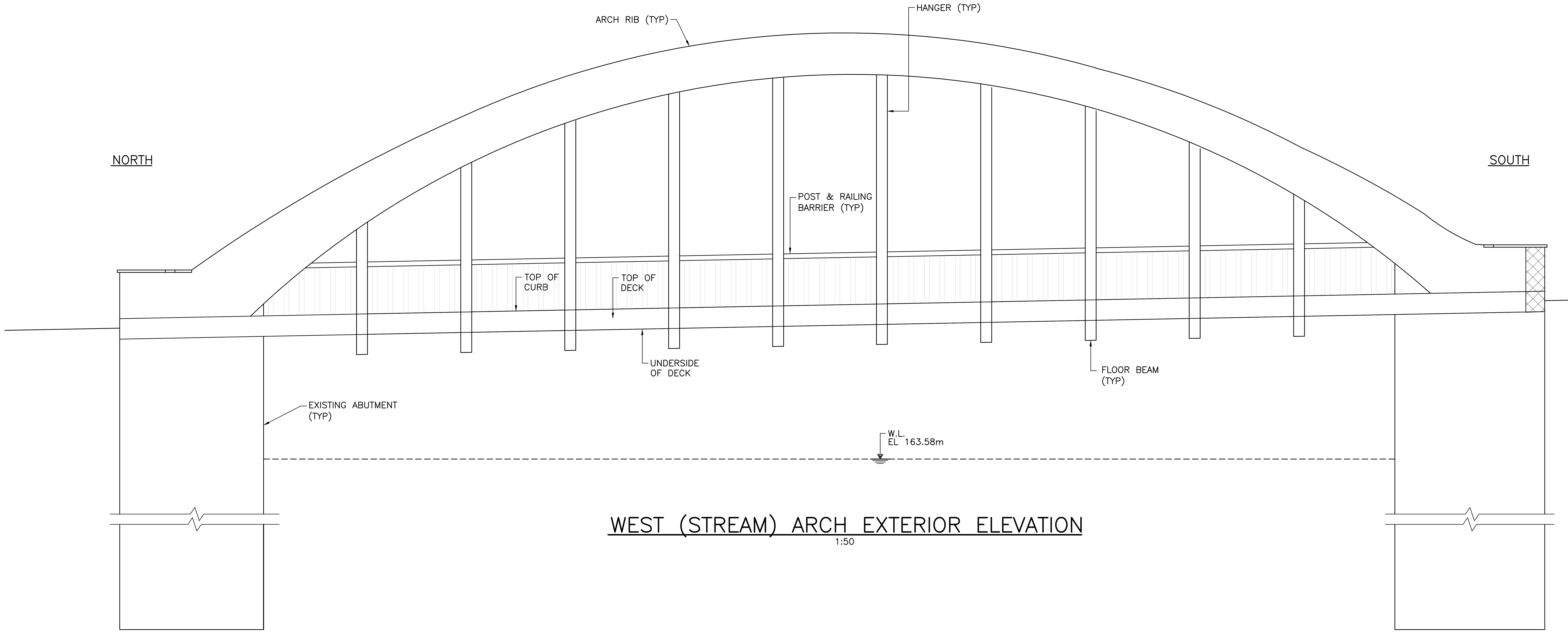
DENOTES HONEYCOMBING CRACKING

DENOTES SPALLED CONCRETE W/ EXPOSED CORRODED REINFORCEMENT

DENOTES CONCRETE CRACKING WITH EFFLORESCENCE STAINING

W DENOTES WIDE WIDTH CONCRETE DELAMINATION



WEST (STREAM) ARCH EXTERIOR ELEVATION

1:50

NOTE:

1. ALL DIMENSIONS ARE IN MILLIMETRES AND ALL ELEVATIONS ARE IN METRES UNLESS OTHERWISE NOTED.

DRAWING NOT TO BE SCALED
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DRAWING TITLE

WEST (STREAM) ARCH EXTERIOR ELEVATION

DRAWING NO.	FILE NO.
S5	201819-36 Wiley Bridge.dwg

DATE	SCALE	REV.
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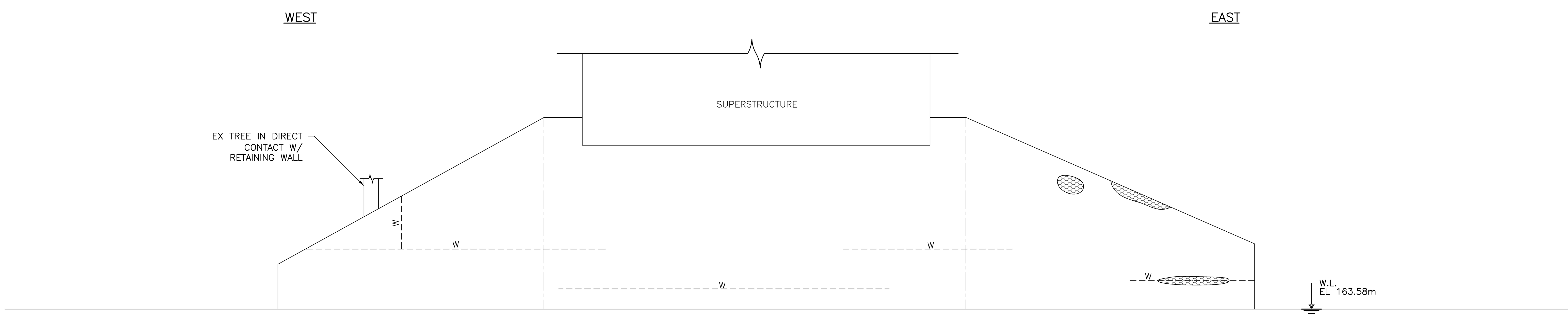
LEGEND:

DENOTES HONEYCOMBING CRACKING

W — DENOTES WIDE WIDTH CONCRETE DELAMINATION



NORTH SUBSTRUCTURE ELEVATION

1:50

NOTE:

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AM	WA	DB

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DRAWING TITLE

NORTH SUBSTRUCTURE ELEVATION

DRAWING NO.	FILE NO.
S6	201819–36 Wiley Bridge.dwg

DATE	SCALE	REV.
APR 15, 2019	AS SHOWN	–

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DATE PLOTTED: 8/12/2019 7:08:33 PM BY: WORKING

LEGEND:

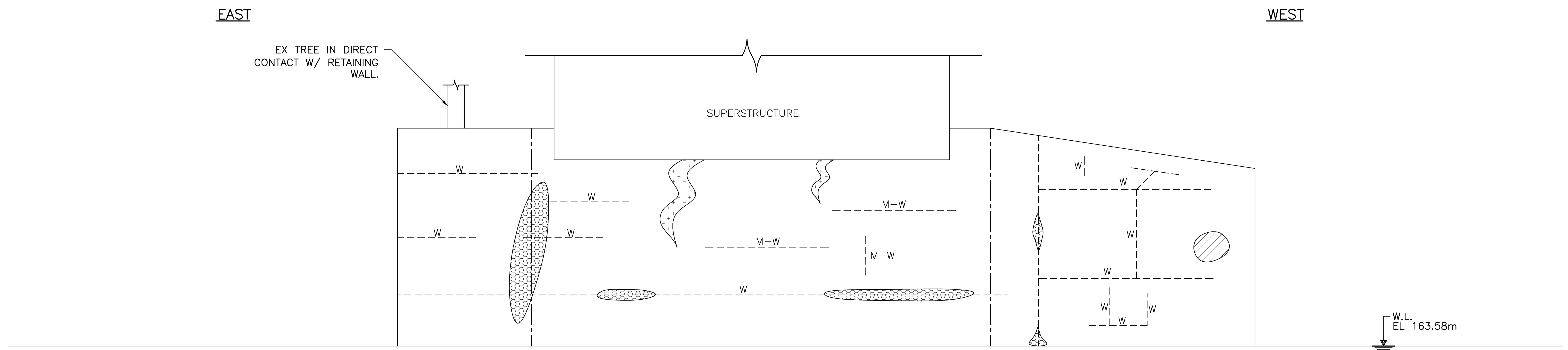
DENOTES CONCRETE DISINTEGRATION

DENOTES HONEYCOMBING CRACKING

DENOTES SPALLED CONCRETE W/ EXPOSED CORRODED REINFORCEMENT

DENOTES WATER STAINING

W DENOTES WIDE WIDTH CONCRETE DELAMINATION



SOUTH SUBSTRUCTURE ELEVATION
1:50

NOTE:

1. ALL DIMENSIONS ARE IN MILLIMETRES AND ALL ELEVATIONS ARE IN METRES UNLESS OTHERWISE NOTED.

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DRAWING TITLE

SOUTH SUBSTRUCTURE ELEVATION

DRAWING NO.	FILE NO.	
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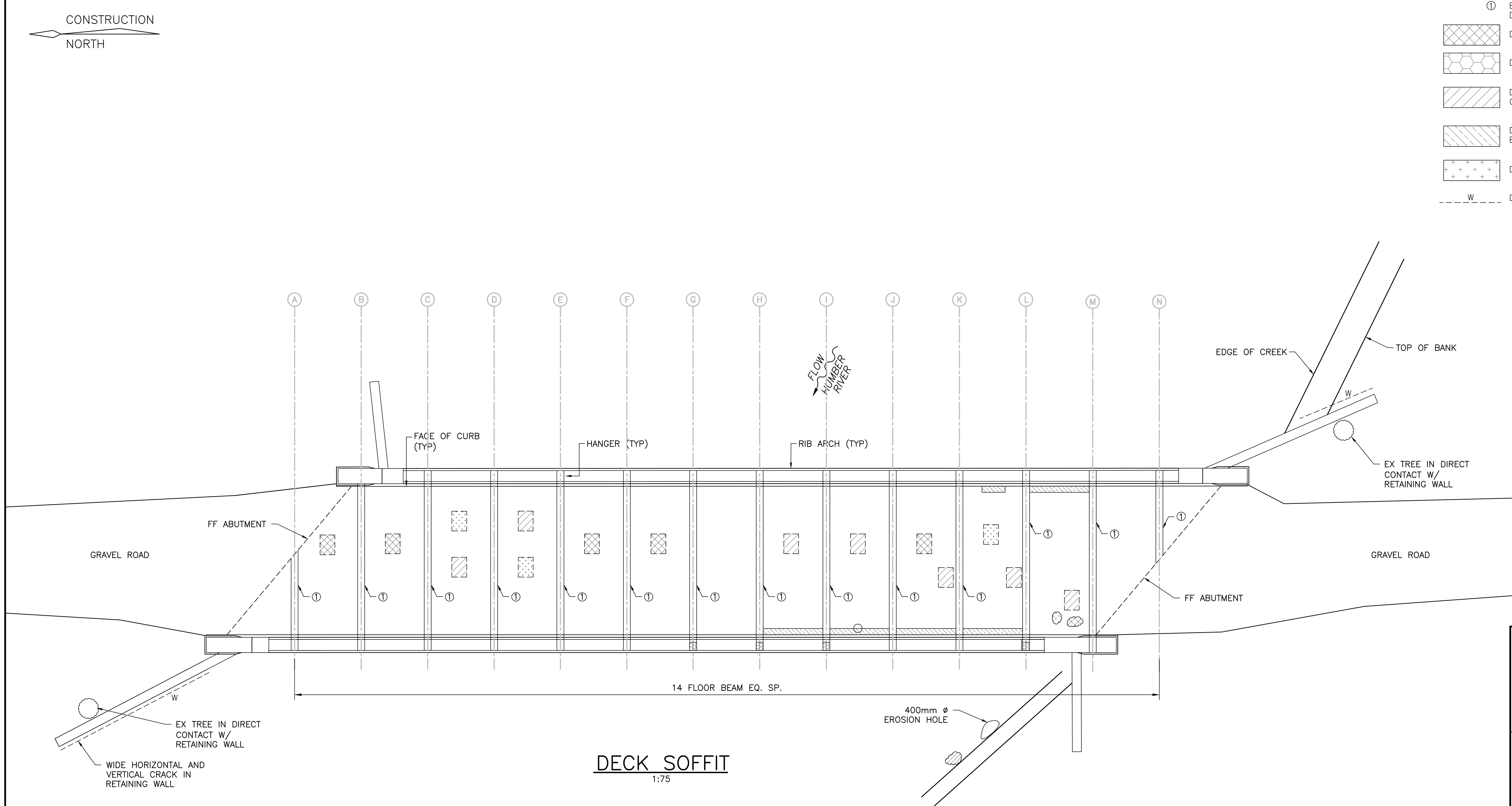
DATE	SCALE	REV.
APR 15, 2019	AS SHOWN	–



DECK SOFFIT
1:75

LEGEND:

① CONCRETE CRACKING, SPALLED CONCRETE W/ EXPOSED CORRODED REINFORCEMENT DELAMINATED CONCRETE THROUGHOUT.

DENOTES DELAMINATION

DENOTES HONEYCOMBING CRACKING

DENOTES SPALLED CONCRETE W/ EXPOSED CORRODED REINFORCEMENT

DENOTES CONCRETE CRACKING WITH EFFLORESCENCE STAINING

DENOTES WET/WATER STAIN

W — DENOTES WIDE WIDTH CONCRETE DELAMINATION

NOTE:

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DRAWING TITLE

DECK SOFFIT

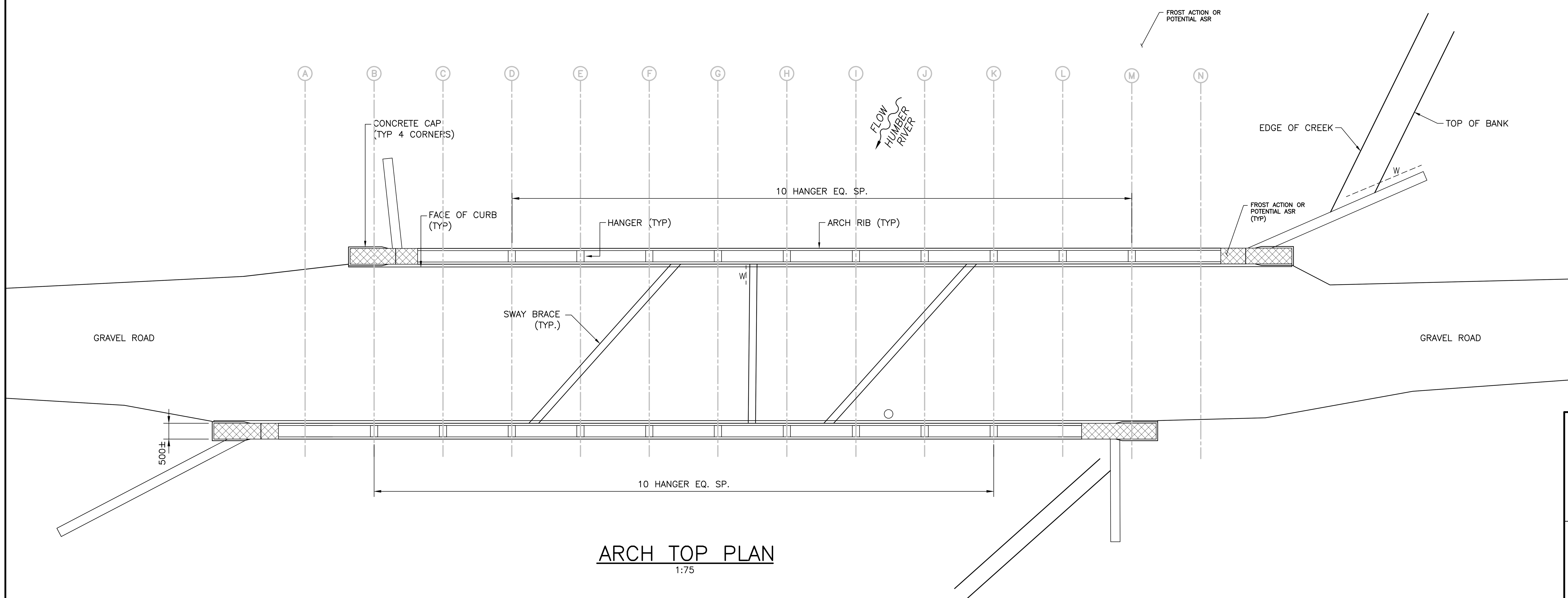
DRAWING NO.	FILE NO.
S8	201819-36 Wiley Bridge.dwg

DATE	SCALE	REV.
APR 15, 2019	AS SHOWN	–

CAD FILE LOCATION AND NAME: E:\OneDrive\1Projects\2018-2019\201819-36 Wiley Bridge Rehab\10 PDR & Insp Rpt\10.1 CAD - Condition Survey\201819-36 Wiley Bridge.dwg
MODIFIED: 8/15/2019 4:03:04 AM BY: USER
DATE PLOTTED: 8/15/2019 4:05:26 AM BY: USER

CONSTRUCTION
NORTH

LEGEND:
W — DENOTES WIDE WIDTH CONCRETE DELAMINATION



ARCH TOP PLAN
1:75

NOTE:

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AM	WA	DB

PROJECT TITLE

REPAIRS TO WILEY BRIDGE AT CLAIREVILLE CONSERVATION AREA CONTRACT # 10009703

DRAWING TITLE

ARCH TOP PLAN

DRAWING NO.	FILE NO.
S9	201819-36 Wiley Bridge.dwg

DATE	SCALE	REV.
APR 15, 2019	AS SHOWN	–

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MODIFIED: 8/15/2019 4:03:04 AM BY: USER
DATE PLOTTED: 8/15/2019 4:05:38 AM BY: USER

APPENDIX C – FINANCIAL ANALYSIS

WILEY BRIDGE

ALTERNATIVE 2 - MINIMUM REHABILITATION WITH SURFACE SEALING

PRELIMINARY ENGINEER'S ESTIMATE

May 2021

Item		Description	Unit	Estimated Quantity	Unit Price	Total Per Item
1	SP	Construction Sign	EACH	2	$ 600.00	$ 1,200.00
2	SP	Construction Survey and Layout	LS	1	$ 3,000.00	$ 3,000.00
3	SP	Field Office	LS	1	$ 3,000.00	$ 3,000.00
4	SP	Bonds and Insurance	LS	1	$ 3,500.00	$ 3,500.00
5	SP	Utility locates	LS	1	$ 750.00	$ 750.00
6	SP	Mobilization / Demobilization	LS	1	$ 10,000.00	$ 10,000.00
7	SP	Temporary Chain Link Fence (Installation, Removal)	M	95	$ 60.00	$ 5,700.00
8	OPSS.MUNI 404 and 539, SP	Protection System	LS	1	$ 35,000.00	$ 35,000.00
9	OPSS.MUNI 511	Rip Rap (R10)	M2	35	$ 110.00	$ 3,850.00
10	OPSS.MUNI 511 and 1860	Geotextiles	M2	80	$ 15.00	$ 1,200.00
11	802, 804, SP	Topsoil, Seed, and Mulch	M2	150	$ 25.00	$ 3,750.00
12	OPSS.MUNI 801	Heavy Duty Silt Fence Barriers	M	100	$ 20.00	$ 2,000.00
13	OPSS.MUNI 904	Concrete in Parapet Wall	M3	2.1	$ 3,000.00	$ 6,300.00
14	OPSS.MUNI 904, SP	Dowels in Concrete	EACH	154	$ 40.00	$ 6,160.00
15	OPSS.MUNI 905, SP	Reinforcing Steel	LS	1	$ 3,500.00	$ 3,500.00
16	OPSS.MUNI 928, SP	Concrete Removal - Handrail	LS	1	$ 3,500.00	$ 3,500.00
17	OPSS.MUNI 928	Concrete Removal - Partial Depth, Type A	M2	5	$ 700.00	$ 3,500.00
18	OPSS.MUNI 928	Concrete Removal - Partial Depth, Type B	M2	62	$ 1,250.00	$ 77,500.00
19	OPSS.MUNI 928	Concrete Removal - Partial Depth, Type C	M2	46	$ 1,250.00	$ 57,500.00
20	OPSS.MUNI 930	Concrete Patches - Formed Surfaces	M2	108	$ 1,000.00	$ 108,000.00
21	OPSS.MUNI 930	Concrete Patches - Unformed Surfaces	M2	5	$ 600.00	$ 3,000.00
22	OPSS.MUNI 932	Crack Injection	M	12	$ 600.00	$ 7,200.00
23	SP	Deck Drain Extensions	EACH	26	$ 800.00	$ 20,800.00
24	SP	Armour Stone - Removal, Salvage, and Reinstate	LS	1	$ 2,000.00	$ 2,000.00
25	SP	Surface Sealing of Structural Concrete - Pigmented	LS	1	$ 35,000.00	$ 35,000.00
					Subtotal (Excluding HST)	$ 406,910.00
					Construction Contingency (15%)	$ 61,036.50
					Total including Contingency (Excluding HST)	$ 467,946.50

WILEY BRIDGE

ALTERNATIVE 3 - MAJOR REHABILITATION WITH SURFACE SEALING

PRELIMINARY ENGINEER'S ESTIMATE

May 2021

Item		Description	Unit	Estimated Quantity	Unit Price	Total Per Item
1	SP	Construction Sign	EACH	2	$ 600.00	$ 1,200.00
2	SP	Construction Survey and Layout	LS	1	$ 3,000.00	$ 3,000.00
3	SP	Field Office	LS	1	$ 3,000.00	$ 3,000.00
4	SP	Bonds and Insurance	LS	1	$ 3,500.00	$ 3,500.00
5	SP	Utility locates	LS	1	$ 750.00	$ 750.00
6	SP	Mobilization / Demobilization	LS	1	$ 10,000.00	$ 10,000.00
7	SP	Temporary Chain Link Fence (Installation, Removal)	M	95	$ 60.00	$ 5,700.00
8	201, SP	Clearing and Grubbing	LS	1	$ 3,000.00	$ 3,000.00
9	OPSS MUNI 206, SP	Earth Excavation, Grading	M3	30	$ 75.00	$ 2,250.00
10	OPSS.MUNI 314, OPSS 902, OPSS.MUNI 1010, SP	Granular A	M3	20	$ 125.00	$ 2,500.00
11	OPSS.MUNI 404 and 539, SP	Protection System	LS	1	$ 35,000.00	$ 35,000.00
12	OPSS.MUNI 511	Rip Rap (R10)	M2	35	$ 110.00	$ 3,850.00
13	OPSS.MUNI 511 and 1860	Geotextiles	M2	80	$ 15.00	$ 1,200.00
14	802, 804, SP	Topsoil, Seed, and Mulch	M2	150	$ 25.00	$ 3,750.00
15	OPSS.MUNI 805, SP	Heavy Duty Silt Fence Barriers	M	100	$ 35.00	$ 3,500.00
16	OPSS.MUNI 904	Concrete in Parapet Wall	M3	2.1	$ 3,000.00	$ 6,300.00
17	OPSS.MUNI 904, SP	Dowels in Concrete	EACH	154	$ 40.00	$ 6,160.00
18	OPSS.MUNI 905, SP	Reinforcing Steel	LS	1	$ 3,500.00	$ 3,500.00
19	OPSS.MUNI 928, SP	Concrete Removal - Handrail	LS	1	$ 3,500.00	$ 3,500.00
20	OPSS.MUNI 928	Concrete Removal - Partial Depth, Type A	M2	5	$ 700.00	$ 3,500.00
21	OPSS.MUNI 928	Concrete Removal - Partial Depth, Type B	M2	62	$ 1,250.00	$ 77,500.00
22	OPSS.MUNI 928	Concrete Removal - Partial Depth, Type C	M2	46	$ 1,250.00	$ 57,500.00
23	OPSS.MUNI 928, SP	Scarifying	M2	140	$ 40.00	$ 5,600.00
24	OPSS.MUNI 929	Abrasive Blast Cleaning for Overlays	M2	140	$ 20.00	$ 2,800.00
25	OPSS.MUNI 930	Place Concrete Overlay	M3	9	$ 700.00	$ 6,300.00
26	OPSS.MUNI 930	Finish and Cure Concrete Overlay	M2	140	$ 35.00	$ 4,900.00
27	OPSS.MUNI 930	Concrete Patches - Formed Surfaces	M2	108	$ 1,000.00	$ 108,000.00
28	OPSS.MUNI 930	Concrete Patches - Unformed Surfaces	M2	5	$ 600.00	$ 3,000.00
29	OPSS.MUNI 932, SP	Crack Injection	M	12	$ 600.00	$ 7,200.00
30	SP	Surface Sealing of Structural Concrete - Pigmented	LS	1	$ 35,000.00	$ 35,000.00
31	SP	Deck Drain Extensions	EACH	26	$ 800.00	$ 20,800.00
32	SP	Armour Stone - Removal, Salvage, and Reinstate	LS	1	$ 2,000.00	$ 2,000.00
					Subtotal (Excluding HST)	$ 435,760.00
					Construction Contingency (15%)	$ 65,364.00
					Total including Contingency (Excluding HST)	$ 501,124.00

WILEY BRIDGE

ALTERNATIVE 4 - REMOVAL OF EXISTING BRIDGE AND CONSTRUCT A NEW PREFABRICATED PRATT TRUSS BRIDGE

PRELIMINARY ENGINEER'S ESTIMATE

May 2021

Item		Description	Unit	Estimated Quantity	Unit Price	Total Per Item
1	SP	Construction Sign	EACH	2	$ 600.00	$ 1,200.00
2	SP	Construction Survey and Layout	LS	1	$ 3,000.00	$ 3,000.00
3	SP	Field Office	LS	1	$ 3,000.00	$ 3,000.00
4	SP	Bonds and Insurance	LS	1	$ 3,500.00	$ 3,500.00
5	SP	Utility locates	LS	1	$ 750.00	$ 750.00
6	SP	Mobilization / Demobilization	LS	1	$ 10,000.00	$ 10,000.00
7	SP	Temporary Chain Link Fence (Installation, Removal)	M	95	$ 60.00	$ 5,700.00
8	201, SP	Clearing and Grubbing	LS	1	$ 3,000.00	$ 3,000.00
9	OPSS MUNI 206, SP	Earth Excavation, Grading	M3	30	$ 100.00	$ 3,000.00
10	OPSS MUNI 206, OPSS.MUNI 212, SP	Embankments	LS	1	$ 10,000.00	$ 10,000.00
11	OPSS.MUNI 314, OPSS 902, OPSS.MUNI 1010, SP	Granular A	M3	20	$ 125.00	$ 2,500.00
12	OPSS.MUNI 404 and 539, SP	Protection System	LS	1	$ 25,000.00	$ 25,000.00
13	OPSS.MUNI 510	Removal of Bridge	M2	185	$ 550.00	$ 101,750.00
14	OPSS.MUNI 510	Removal of Bridge Footings	LS	1	$ 15,000.00	$ 15,000.00
15	OPSS.MUNI 511	Rip Rap (R10)	M2	35	$ 110.00	$ 3,850.00
16	OPSS.MUNI 511 and 1860	Geotextiles	LS	1	$ 3,500.00	$ 3,500.00
17	802, 804, SP	Topsoil, Seed, and Mulch	M2	150	$ 25.00	$ 3,750.00
18	OPSS.MUNI 805, SP	Heavy Duty Silt Fence Barriers	M	100	$ 35.00	$ 3,500.00
19	OPSS 902	Earth Excavation for Structure	LS	1	$ 15,000.00	$ 15,000.00
20	OPSS 902, OPSS.MUNI 314, OPSS 1010	Granular Backfill to Structure	LS	1	$ 15,000.00	$ 15,000.00
21	OPSS 903, SP	Helical Piers	m	96	$ 200.00	$ 19,200.00
22	OPSS.MUNI 904	Concrete in Substructure	M3	15	$ 1,500.00	$ 22,500.00
23	OPSS 905, OPSS.MUNI 1440	Reinforcing Steel	LS	1	$ 5,000.00	$ 5,000.00
24	OPSS 906, OPSS 911, SP	Prefabricated Bridge, Supply, Transportation and Installation	LS	1	$ 120,000.00	$ 120,000.00
25	OPSS.MUNI 922, OPSS.MUNI 1202, SP	Bearing	Each	4	$ 700.00	$ 2,800.00
26	SP	Armour Stone Retaining Wall, Supply and Construct	LS	1	$ 30,000.00	$ 30,000.00
27	SP	Armour Stone Retaining Wall, Relocate and Construct	LS	1	$ 10,000.00	$ 10,000.00
					Subtotal (Excluding HST)	$ 441,500.00
					Construction Contingency (15%)	$ 66,225.00
					Total including Contingency (Excluding HST)	$ 507,725.00

WILEY BRIDGE

ALTERNATIVE 5 - REMOVAL OF EXISTING BRIDGE AND CONSTRUCT A NEW PREFABRICATED BOWSTRING ARCH BRIDGE

PRELIMINARY ENGINEER'S ESTIMATE

May 2021

Item		Description	Unit	Estimated Quantity	Unit Price	Total Per Item
1	SP	Construction Sign	EACH	2	$ 600.00	$ 1,200.00
2	SP	Construction Survey and Layout	LS	1	$ 3,000.00	$ 3,000.00
3	SP	Field Office	LS	1	$ 3,000.00	$ 3,000.00
4	SP	Bonds and Insurance	LS	1	$ 3,500.00	$ 3,500.00
5	SP	Utility locates	LS	1	$ 750.00	$ 750.00
6	SP	Mobilization / Demobilization	LS	1	$ 10,000.00	$ 10,000.00
7	SP	Temporary Chain Link Fence (Installation, Removal)	M	95	$ 60.00	$ 5,700.00
8	201, SP	Clearing and Grubbing	LS	1	$ 3,000.00	$ 3,000.00
9	OPSS MUNI 206, SP	Earth Excavation, Grading	M3	30	$ 100.00	$ 3,000.00
10	OPSS MUNI 206, OPSS.MUNI 212, SP	Embankments	LS	1	$ 10,000.00	$ 10,000.00
11	OPSS.MUNI 314, OPSS 902, OPSS.MUNI 1010, SP	Granular A	M3	20	$ 125.00	$ 2,500.00
12	OPSS.MUNI 404 and 539, SP	Protection System	LS	1	$ 25,000.00	$ 25,000.00
13	OPSS.MUNI 510	Removal of Bridge	M2	185	$ 550.00	$ 101,750.00
14	OPSS.MUNI 510	Removal of Bridge Footings	LS	1	$ 15,000.00	$ 15,000.00
15	OPSS.MUNI 511	Rip Rap (R10)	M2	35	$ 110.00	$ 3,850.00
16	OPSS.MUNI 511 and 1860	Geotextiles	LS	1	$ 3,500.00	$ 3,500.00
17	802, 804, SP	Topsoil, Seed, and Mulch	M2	150	$ 25.00	$ 3,750.00
18	OPSS.MUNI 805, SP	Heavy Duty Silt Fence Barriers	M	100	$ 35.00	$ 3,500.00
19	OPSS 902	Earth Excavation for Structure	LS	1	$ 15,000.00	$ 15,000.00
20	OPSS 902, OPSS.MUNI 314, OPSS 1010	Granular Backfill to Structure	LS	1	$ 15,000.00	$ 15,000.00
21	OPSS 903, SP	Helical Piers	m	96	$ 200.00	$ 19,200.00
22	OPSS.MUNI 904	Concrete in Substructure	M3	15	$ 1,500.00	$ 22,500.00
23	OPSS 905, OPSS.MUNI 1440	Reinforcing Steel	LS	1	$ 5,000.00	$ 5,000.00
24	OPSS 906, OPSS 911, SP	Prefabricated Bridge, Supply, Transportation and Installation	LS	1	$ 160,000.00	$ 160,000.00
25	OPSS.MUNI 922, OPSS.MUNI 1202, SP	Bearing	Each	4	$ 700.00	$ 2,800.00
26	SP	Armour Stone Retaining Wall, Supply and Construct	LS	1	$ 30,000.00	$ 30,000.00
27	SP	Armour Stone Retaining Wall, Relocate and Construct	LS	1	$ 10,000.00	$ 10,000.00
					Subtotal (Excluding HST)	$ 481,500.00
					Construction Contingency (15%)	$ 72,225.00
					Total including Contingency (Excluding HST)	$ 553,725.00

50 YEAR LIFE CYCLE COST ANALYSIS					
Wiley Bridge Alternative 2 Minimum Rehahabilitation					
YEAR	**ITEM**	**CAPITAL COST**	**Present Value**	**Sensitivity Analysis**	
			Discount Rate of 6.0%	**7.0%**	**5.0%**
0	Minimum Rehabilitation	$ 468,000	$ 468,000	$ 468,000	$ 468,000
5			$ -	$ -	$ -
15			$ -	$ -	$ -
20			$ -	$ -	$ -
25			$ -	$ -	$ -
30			$ -	$ -	$ -
35			$ -	$ -	$ -
40			$ -	$ -	$ -
45			$ -	$ -	$ -
50			$ -	$ -	$ -
TOTAL PV			$ 468,000	$ 468,000	$ 468,000
NEXT REPL. YEAR		17.5			
Replacement Cost		$550,000			
RES. VALUE	(based on Replacement Cost)		$168,527	$149,653	$186,218
TOTAL NET PRESENT VALUE			**$ 637,000**	**$ 618,000**	**$ 654,000**

50 YEAR LIFE CYCLE COST ANALYSIS

Wiley Bridge
Alternative 3
Major Rehahabilitation

YEAR	ITEM	CAPITAL COST	Present Value	Sensitivity Analysis	
			Discount Rate of 6.0%	7.0%	5.0%
0	Major Rehabilitation	$ 501,000	$ 501,000	$ 501,000	$ 501,000
5			$ -	$ -	$ -
15			$ -	$ -	$ -
20			$ -	$ -	$ -
25			$ -	$ -	$ -
30			$ -	$ -	$ -
35			$ -	$ -	$ -
40			$ -	$ -	$ -
45			$ -	$ -	$ -
50			$ -	$ -	$ -
TOTAL PV			$ 501,000	$ 501,000	$ 501,000
NEXT REPL. YEAR		22.5			
Replacement Cost		$550,000			
RES. VALUE	(based on Replacement Cost)		$118,387	$101,342	$135,524
TOTAL NET PRESENT VALUE			**$ 619,000**	**$ 602,000**	**$ 637,000**

50 YEAR LIFE CYCLE COST ANALYSIS					
Wiley Bridge **Alternative 4** **Replacement with Prefabricated Steel Pratt Truss Bridge**					
YEAR	**ITEM**	**CAPITAL COST**	**Present Value**	**Sensitivity Analysis**	
			Discount Rate of 6.0%	**7.0%**	**5.0%**
0	Replacement	$ 508,000	$ 508,000	$ 508,000	$ 508,000
5			$ -	$ -	$ -
15			$ -	$ -	$ -
20			$ -	$ -	$ -
25			$ -	$ -	$ -
30	Minor Rehabilitation	$ 100,000	$ 17,411	$ 13,137	$ 23,138
35			$ -	$ -	$ -
40			$ -	$ -	$ -
45			$ -	$ -	$ -
50			$ -	$ -	$ -
TOTAL PV			$ 525,411	$ 521,137	$ 531,138
NEXT REPL. YEAR		75			
Replacement Cost		$550,000			
RES. VALUE	(based on Replacement Cost)		($22,902)	($15,231)	($33,799)
TOTAL NET PRESENT VALUE			**$ 503,000**	**$ 506,000**	**$ 497,000**

50 YEAR LIFE CYCLE COST ANALYSIS

Wiley Bridge
Alternative 5
Replacement with Prefabricated Steel Bowstring Arch Bridge

YEAR	ITEM	CAPITAL COST	Present Value Discount Rate of 6.0%	Sensitivity Analysis 7.0%	Sensitivity Analysis 5.0%
0	Major Rehabilitation	$ 554,000	$ 554,000	$ 554,000	$ 554,000
5			$ -	$ -	$ -
15			$ -	$ -	$ -
20			$ -	$ -	$ -
25			$ -	$ -	$ -
30	Minor Rehabilitation	$ 100,000	$ 17,411	$ 13,137	$ 23,138
35			$ -	$ -	$ -
40			$ -	$ -	$ -
45			$ -	$ -	$ -
50			$ -	$ -	$ -
TOTAL PV			$ 571,411	$ 567,137	$ 577,138
NEXT REPL. YEAR		75			
Replacement Cost		$550,000			
RES. VALUE	(based on Replacement Cost)		($22,902)	($15,231)	($33,799)
TOTAL NET PRESENT VALUE			**$ 549,000**	**$ 552,000**	**$ 543,000**

APPENDIX D – PETROGRAPHIC ANALYSIS REPORT

Petrographic Examination of Hardened Concrete

201819-36 Wiley Bridge Concrete Arch (@ north-east)

Claireville Conservation Area, Brampton, Ontario

Project # SCB198391.20977

Prepared for:

Bridge Check Canada Ltd.
200 Viceroy Road, Unit 4, Vaughan, ON L4K 3N8

Attention: Mr. Savio DeSouza, P.Eng.

Prepared by:

Wood Environment & Infrastructure Solutions
3450 Harvester Road,
Suite 100
Burlington, Ontario, L7N 3W5
Canada
T: 905-335-2353

28 February 2020

1.0 Introduction

Wood Environment & Infrastructure Solutions, a division of Wood Canada Limited ("Wood") is pleased to present this report summarizing the results of our petrographic examination conducted on a single concrete core specimen obtained from a concrete arch (@ north-east) of the 201819-36 Wiley Bridge located in Claireville Conservation Area, Brampton, Ontario.

It is understood that this report is part of a larger concrete investigation following concerns of potential Alkali-Aggregate Reactivity (AAR) distress observed during a field assessment of a greater than 60 year old bridge.

2.0 Methodology

It is understood that sample selection, identification and coring operations were performed under the direction of a representative of Bridge Check Canada Ltd. (Bridge Check Canada). A single concrete core, identifed as core 4, was received at the Wood Burlington laboratory on 19 December 2019 and was understood to represent concrete from a concrete arch (@ north-east) of the 201819-36 Wiley Bridge

Upon receipt, the core was logged and photographed in its as-received condition recording parameters including the general condition of the concrete, identification of distress such as cracking, core dimensions, coarse aggregate lithologies, constituent proportions (sand, stone, cement paste, voids), and general features and/or signs of distress manifesting itself at the finished surface.

The core was logged and photographed prior to being cut parallel to its long axis to expose a cross-sectional surface that was polished to a high finish suitable for petrographic examination based on *ASTM C856, Standard Practice for Petrographic Examination of Hardened Concrete*.

Examination of a thin section prepared from the cross-sectional cut face of the core was used to provide detailed insight into the overall quality of the concrete, including the identification of the presence or absence of potential AAR. In addition, the freshly exposed cross-sectional surface of the core was tested with phenolphthalein indicator to determine if pervasive carbonation of the cementitious paste was present and if so, to what extent.

3.0 Results

Enclosures 1 to 3 provides a summary of core logging observations and the detailed petrographic findings conducted on the polished cross-sectional surface and thin section of core 4.

Petrographic examination conducted on core 4 confirmed the concrete is non-air entrained, the presence of a macro-crack pattern consistent with distress caused by cyclic freezing and thawing (Enclosure 3) and ASR damage features and distress (Enclosure 4). CSA document A864-00, *Guide to the Evaluation and Management of Concrete Structures Affected by Alkali-Aggregate Reaction* and US Department of Transportation FHA, *Report on the Diagnosis, Prognosis, and Mitigation of Alkali-Silica Reaction (ASR) in Transportation Structures* lists petrographic features commonly related to alkali-aggregate reaction:

- micro-cracks in and around aggregate particles and in the cement paste, with some of these cracks filled to various extents with secondary reaction products;
- reaction rims around aggregate particles;
- distribution of reaction products in voids or pores of the cement paste, or impregnating cement paste around reacted aggregate particles;
- cracks within the cement paste with and without reaction products;
- closed cracks as well as open or fine networks of cracks within coarse aggregates particles with and without reaction product; and,

4.0 Conclusion

Core logging and petrographic examination of core 4, removed from the concrete arch (@ north-east) of Wiley Bridge indicate that the distress reported by Bridge Check Canada has resulted from a combination of:

1) Cyclic freezing and thawing during its service life manifesting itself as a series of large, open cracks sub-parallel to the exterior surface of the concrete arch. This type of distress is typical of crack patterns associated to non-air entrained / poorly air entrained concrete as seen in core 4 when exposed to. The intensity of this crack pattern often overprints the fine distress features resulting from AAR near the surface;
2) Expansion cracking caused by AAR displaying gel that was occasionally observed lining or filling cracks and voids associated with sandstone aggregate.

5.0 Copyright and non-disclosure notice

6.0 Third-party disclaimer

Any disclosure of this report to a third party is subject to this disclaimer. The report was prepared by Wood at the instruction of, and for use by, our client named on the front of the report. It does not in any way constitute advice to any third party who is able to access it by any means. Wood excludes to the fullest extent lawfully permitted all liability whatsoever for any loss or damage howsoever arising from reliance on the contents of this report. We do not however exclude our liability (if any) for personal injury or death resulting from our negligence, for fraud or any other matter in relation to which we cannot legally exclude liability.

If you have any questions with regards to the test resuts of the concrete core, please do not hesitate to contact the undersigned at your convenience.

Yours truly,

Wood Environment & Infrastructure Solutions,

A Division of Wood Canada Limited

Reviewed by,

Martin Little, P.Geo.
Senior Geoscientist

John Balinski, P.Geo.
Senior Associate Materials Consultant

ml:JB

Enclosures: 4

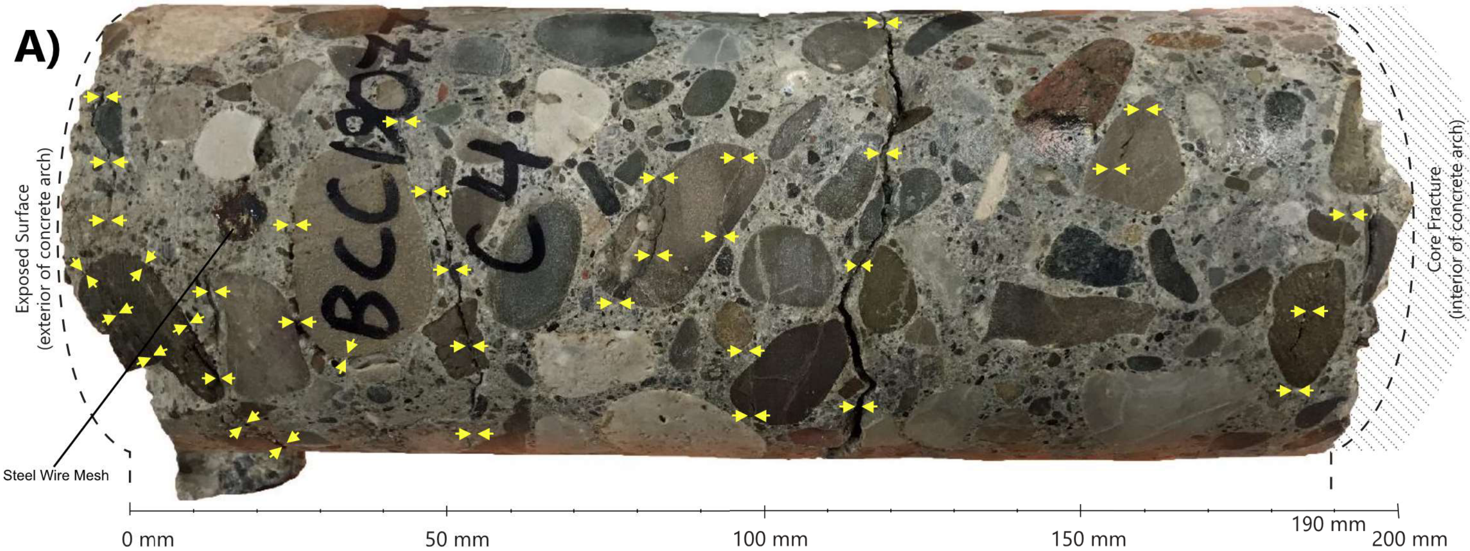
7.0 References

ASTM Standard C856, 2017, "Standard Practice for Petrographic Examination of Hardened Concrete", ASTM International, West Conshohocken, PA, 2014, www.astm.org.

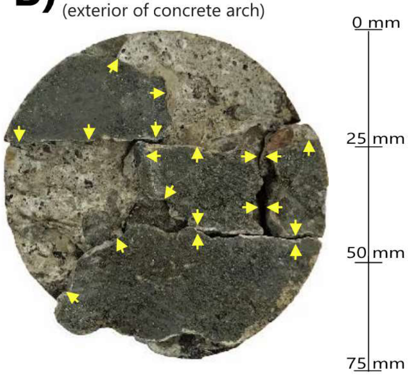
CSA A23.1-14/CSA A23.2-14, 2014 “Concrete Materials and Methods of Concrete Construction/Test Methods and Standard Practices for Concrete”, Canadian Standards Association.

ENCLOSURES

A)



B) Exposed Surface
(exterior of concrete arch)



C) Core Fracture
(interior of concrete arch)

Core Dimensions	
Length (mm) Min.	172
Length (mm) Max.	190
Diameter (mm)	70
Air Content	
Percentage (by volume of concrete)	<3
Percentage Voids (Lined / Filled)	40
Cement Paste	
Percentage (by volume of concrete)	30 to 35
Depth of Carbonation (mm) (by Phenolphthalein Indicator)	20

Fine Aggregate	
Material Type	Natural
Percentage (by volume of concrete)	40 to 45
Grading	Even
Coarse Aggregate	
Material Type	Gravel
Percentage (by volume of concrete)	30 to 35
Preferred Orientation	Not Observed
Grading	Well Graded
Distribution	Even

Photographs and core logging results of concrete core C4, removed from the concrete arch (@ north-east) Wiley Bridge, showing (A) tan evenly graded, well distributed, 20 mm gravel coarse aggregate estimated to contribute 30% to 35% of the concrete by volume. Approximately 30 mm below the exposed arch surface, 8M steel wire mesh was observed displaying signs of corrosion and oxidation staining in adjacent cementitious paste. A second, 8M steel wire mesh was observed perpendicular to the core axis 10 mm to 190 mm (fracture face) below the top surface. Fragments of the wire mesh were noted near the broken surface. *Several horizontal branching macrocracks (yellow arrows) which were observed 5 mm, 17 mm, 25 mm, 40 mm, 55 mm,* 62 mm, 80 mm, 110 mm, 140 mm, 152 mm, 160 mm, 170 mm, and 190 mm (core base). Remnants of a smooth planar exterior surface (B) consisted of broken fragments to a depth of approximately 20 mm. A white secondary mineralization (efflorescence) was present at the fracture interfaces. The core base (C) displayed a coring fracture through cementitious paste and aggregate particles that resulted in an irregular surface that exposed coarse and fine aggregate particle perimeters as well as many cross-sectional faces.

Petrographic Examination of Hardened Concrete
201819-36 Wiley Bridge Concrete Arch (@ north-east)
Clairville Conservation Area, Brampton, Ontario

ENCLOSURE 1 (Core C4)	wood.
PROJECT No: SCB198391.209077	
SCALE: As Indicated	DATE : February 2020

Wood Environment & Infrastructure Solutions
3450 Harvester Road, Suite 100
Burlington, Ontario, Canada
L7N 3W5

wood.

Petrographic Examination of Hardened Concrete - ASTM C856

ENCLOSURE 2

Job No	SCB198391.20977			Exam Date	13-Feb-2020
Lab No	C043-20			Analyzed by	Martin Little, P.Geo.
Sample No	Core 4	Received	19-Dec-19		

Location
Claireville Conservation Area, Brampton, Ontario

Details of Structure

Year of Construction	Prior to 1960's	Description of Structure	201819-36 Wiley Bridge
Description of Deterioration / Problem			Concrete Arch (@ north-east)
Surface Cracking - Potential AAR			

Total Concrete

Hit with Hammer	Dull - Near Macro crack	Unusually Wet / Dry Areas	Near Macro crack
Strength	Strong	Cement / Coarse Aggregate Bond	Strong
Breaks with Fingers	Particles Not Dislodged	Cement / Fine Aggregate Bond	Strong

Observations
Diameter: 70 mm
Length (Minimum): 172 mm
Length (Maximum): 190 mm

Exposed Surface:
Planar, slightly rough, fragmented (broken into multiple pieces) with loss of approximately 20% of concrete surface to a depth of 20 mm. Remaining concrete surface displayed efflorescence coating measured approximately 0.1 mm thick. Random patches of exposed fine agger agate particle perimeters were observed, partially obscured by efflorescence. Cementitious paste underlying efflorescence was strong, difficult to scratch or gouged with metal probe under moderate pressure.

Base of Core:
Rough, irregular surface; coring fracture traverses through coarse and fine aggregate revealing. White secondary mineralization noted within cementitious paste of fracture face and lining smooth, round sockets created from the removal of hard coarse particles. Steel wire with a measured diameter of 2 mm was observed protruding from the core circumference 160 mm from the exposed surface to the base of the core, steel wire showed signs of corrosion. Cementitious paste within the body of the concrete core was strong, difficult to scratch with metal probe under moderate pressure.

Coarse Aggregate

Percent of Total	30 to 35 % estimate by volume of concrete					
Preferred Orientation	Not Observed	Distribution	Even	Grading	Even
Material Type	Gravel	Nominal Maximum Size	20mm	Shape	Rounded

Observations
Weathering rims around perimeters of rounded coarse aggregate

Lithological Types	Percentage of Coarse Aggregate	Alteration Rims (AR)/ Reaction Products (RP) / Fractures	Remarks
Carbonate (crystalline)	34	Internal fractures propagate into adjacent cementitious paste	Contains intracrystalline voids, rare CaCO3 encrustation
Carbonate (fossiliferous)	2		Contains silicified fossil fragments, rare CaCO3 encrustation
Carbonate (granular)	34	Internal fractures propagate into adjacent	
Silty Carbonate	5		
Sandstone	16	Internal fractures propagate into adjacent cementitious paste; occasional AAR gel	Alteration Rims, rare $CaCO_3$ encrustation
Greywacke	5		
Quartzite	2	Internal fractures propagate into adjacent cementitious paste	
Chert	2	Internal fractures propagate into adjacent cementitious paste	

Fine Aggregate

Percent of Total	40 to 45 % estimate by volume of concrete				
Preferred Orientation	Not Observed	Distribution	Even	Grading	Even
Material Type	Natural	Shape	Rounded		

Observations

Lithological Types	Percentage of Fine Aggregate	Reaction Rims / Reaction Products / Fractures	Remarks
Carbonate (crystalline)	4		
Carbonate (granular)	40		
Sandstone	4		
Shale	4		
Quartzite	3		
Chert	3		
Ochreous	1		
Opaque Minerals	1		
Quartz (Individual Crystal	28		
Feldspar (Individual Crystal	8		
Amphibole (Individual Crystal	4		

Cement Paste

Percent of Total	30 to 35	%	estimate by volume of concrete
Bleeding	Not Observed		
Slag	Not Observed	Fly Ash	Observed
Strength	Strong		
Retempering	Not Observed		

Colour	Light	Grey
Colour Distribution		Uniform
Appearance in Broken Concrete		Not Broken
Carbonation		Outer Skin

Observations

Phenolphthalein Indicator: Carbonation of cementitious paste limited to 20 mm below exposed surface

Presence of partly hydrated (remnant) grains of Portland cement and partly hydrated fly ash particles; flat, platy, equant calcium hydroxide crystals frequently observed along cementitious paste-aggregate interface. Fine calcium hydroxide crystals frequently observed disseminated within cementitious paste .

Voids

Percent of Total	<3	%	estimate by volume of concrete
Percent with Mineralization	40% (associated with macro-crack)		
Interior Luster	Dull		
Grading	Even		

Mineralization	Ettringite		
Interior Condition	Filled and Partly Lined		
Shape	Round	Average Size	0.110 mm

Observations

Air void system characterized by predominantly evenly spaced, circular air voids, frequently lined or filled with well-formed, elongate, needle-like crystals optically identified as ettringite crystals.

Cracks

Location	0 mm to 190 mm		
Orientation	Sub-Parallel to Exposed surface		
Continuity, Distribution	Through and Around Aggregate Particles		
Maximum Width-micro crack (mm)	2	Amount	Frequent
Minimum Width-micro crack (mm)	0.1	Filling	None
Associated with Embedded Items	Yes	Describe	Steel Wire

Observations:

Cracking is found around and through granite and carbonate aggregate. Top 10 mm of the core is delaminated and broken into multiple pieces. Branching macrocracks orientated sub-parallel to the exposed surface found at depths approximately 5 mm, 17 mm, 25 mm, 40 mm, 55 mm, 62 mm, 80 mm, 110 mm, 140 mm, 152 mm, 160 mm, 170 mm, and 190 mm (core base). The aperture of the cracks varies from 0.1 mm to 2 mm; occasionally lined or filled with ettringite

Location	Within Aggregate Particles		
Orientation	Variable		
Continuity, Distribution	Through fine matrix or around crystal grains		
Maximum Width-micro crack (mm)	0.05	Amount	Occasional
Minimum Width-micro crack (mm)	0.02	Filling	See Below
Associated with Embedded Items	-	Describe	n/a

Observations:

Micro-cracks frequent within coarse aggregate carbonate, sandstone, and chert particles occasionally extending into adjacent cementitious paste; frequently opened; occasionally lined or filled with ettringite +/- AAR gel

Location	Cementitious Paste		
Orientation	Variable		
Continuity, Distribution	Through cementitious paste, around aggregate		
Maximum Width-micro crack (mm)	0.01	Amount	Frequent
Minimum Width-micro crack (mm)	0.01	Filling	None
Associated with Embedded Items	-	Describe	n/a

Observations:

Frequent fine, open microcracks branching in variable orientations within the cementitious paste. Upon intersection with coarse aggregate and fine aggregate particle, the microcracks trend along the interface between the cementitious paste and aggregate particle. Rarely observed traversing thorough fine aggregate particles.

Embedded Items

Description	Steel Wire				
Location	29 mm below exposed surface				
Size (mm)	2	Condition	Corroded	Associated Features	Sub-Parallel Cracking

Observations

Interior of steel wire is clean; exterior shows sign of corrosion; iron oxide staining in cementitious paste adjacent to steel wire

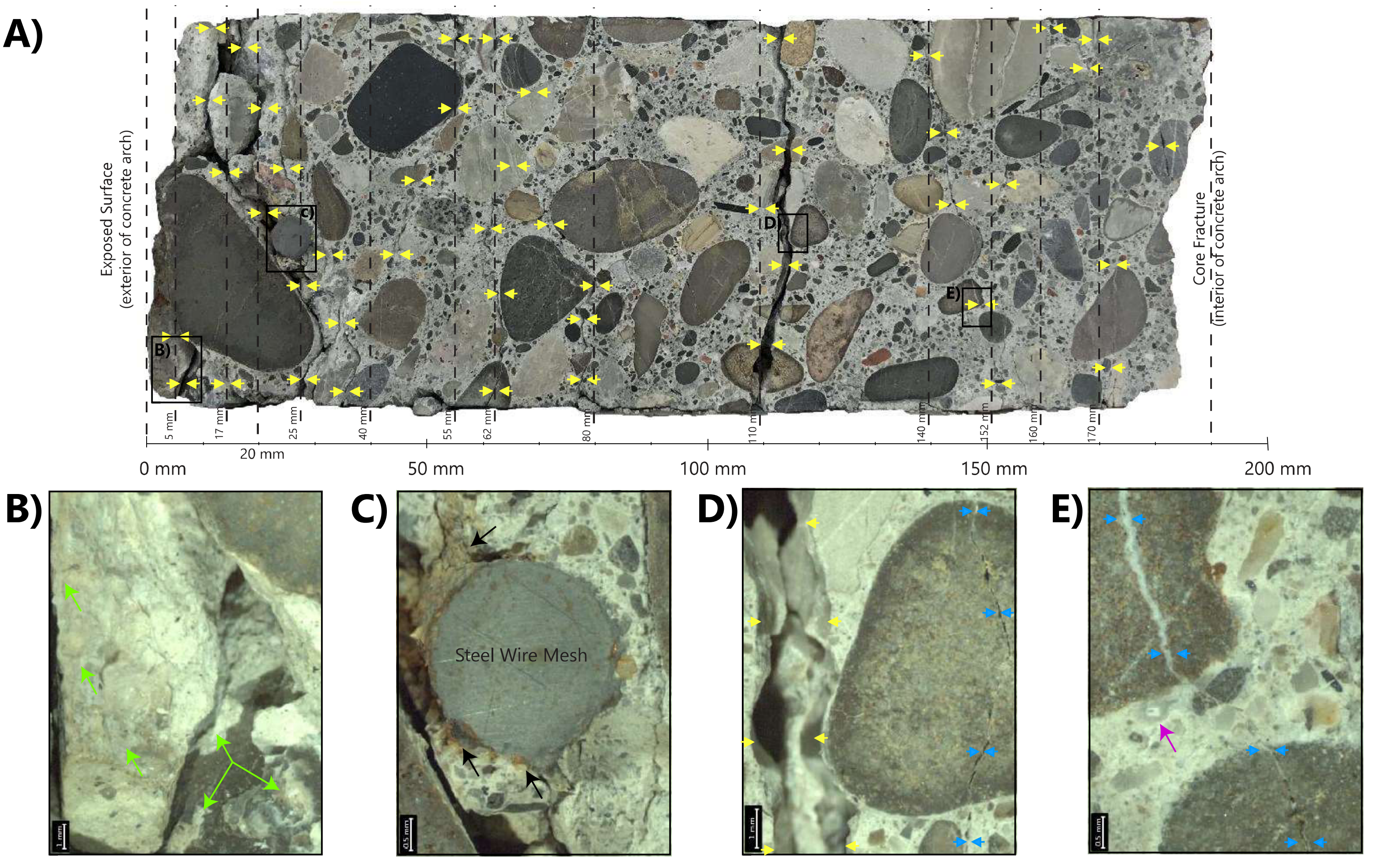
Description	Steel Wire				
Location	29 mm below exposed surface; 160 mm to 190 mm below exposed surface				
Size (mm)	2	Condition	Corroded	Associated Features	Sub-Parallel Cracking

Observations

Exterior shows sign of corrosion

Conclusions

Concrete Core C4 removed from concrete arch (@ north-east) 201819-36 Wiley Bridge located at the Claireville Conservation Area, Brampton, Ontario shows damage features indicative of cyclic freezing and thawing inaddtion to Alkali-Aggregate Reactivity (AAR).



Photograph of the cross-sectional polished surface of concrete core C4, removed from the concrete arch (@ north-east) Wiley Bridge, showing (A) a series of open, branching macrocracks (yellow arrows) that measured up to 2 mm wide oriented sub-parallel to the exposed surface at depths of 5 mm, 17 mm, 25 mm, 40 mm, 55 mm, 62 mm, 80 mm, 110 mm, 140 mm, 152 mm, 160 mm, 170 mm, and 190 mm (core base). The pattern and orientation of these cracks is indicative of distress resulting from cyclical freezing and thawing while in a saturated condition during the service life of the concrete arch. Microphotographs of the near surface (B) revealed calcium carbonate coatings (green arrows) on particle perimeters and the broken faces of surface fragment (associated with efflorescence observed at the exterior surface of the concrete arch. Microphotograph of the 8M steel wire mesh (C) near surface that showed signs of corrosion and iron oxide staining in adjacent cementitious paste (black arrows). Microphotographs (D and E) showing sandstone particles that exhibited internal microcracking/fracturing observed extending into surrounding cementitious paste open and filled with Alkali-Aggregate Reactive (AAR) gel (blue arrows). Microphotogarph D aslo shows an air void filled with AAR gel (purple arrow).

Petrographic Examination of Hardened Concrete
201819-36 Wiley Bridge Concrete Arch (@ north-east)
Clairville Conservation Area, Brampton, Ontario

ENCLOSURE 3 (Core C4)	wood.
PROJECT No: SCB198391.209077	
SCALE: As Indicated	DATE : February 2020

A - pl)

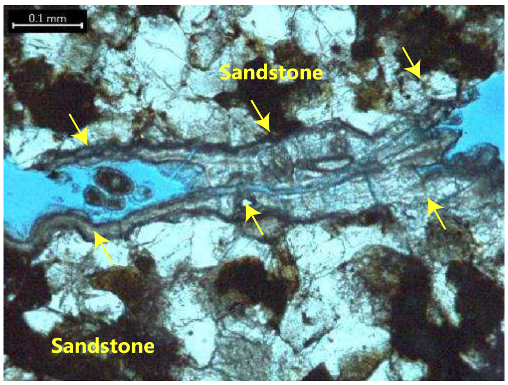


Image viewed under plain light

B - pl)

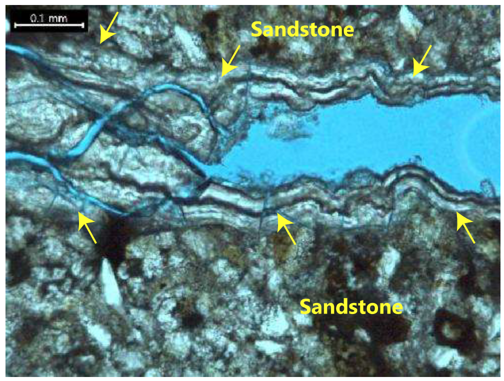


Image viewed under plain light

C - pl)

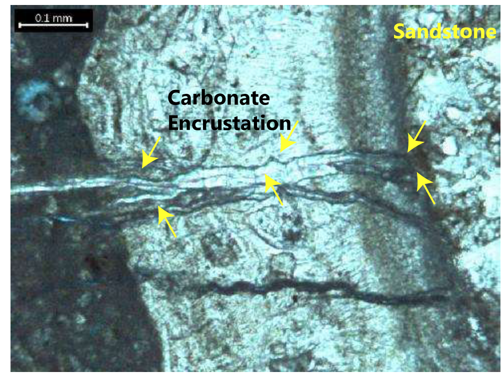


Image viewed under plain light

A - xpl)

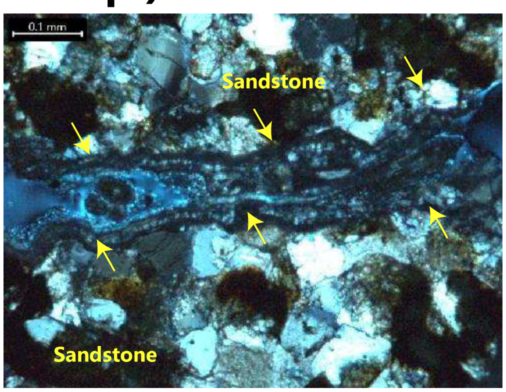


Image viewed under cross-polarized light

B - xpl)

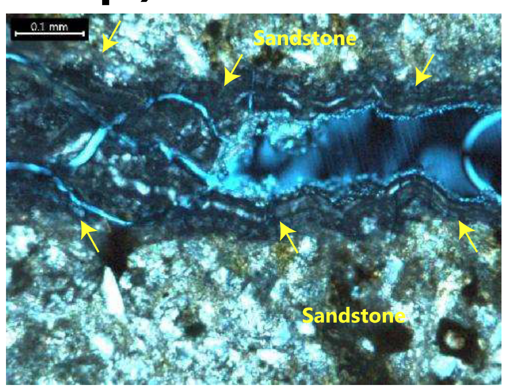


Image viewed under cross-polarized light

C - xpl)

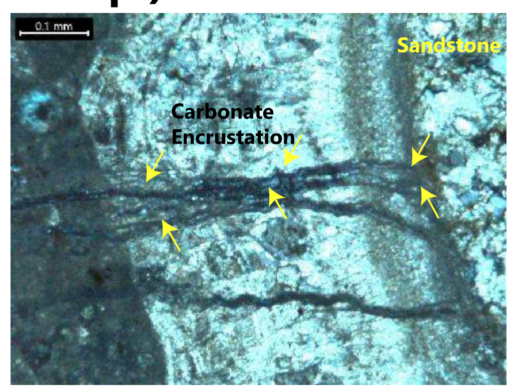


Image viewed under cross-polarized light

Micropictographs of the cross-sectional polished surface of concrete core C4, removed from the concrete arch (@ north-east) Wiley Bridge, viewed under plain light (A - pl, B - pl, and C - pl) revealing the presence of layered Alkali-Aggregate Reactive (AAR) gel within microcracks (yellow arrows) primarily associated with sandstone particles. The same micropictographs viewed under cross-polarized plain light (A - xpl, B - xpl, and C - xpl).

Petrographic Examination of Hardened Concrete
201819-36 Wiley Bridge Concrete Arch (@ north-east)
Clairville Conservation Area, Brampton, Ontario

ENCLOSURE 4
(Core C4)

PROJECT No: SCB198391.209077

SCALE: As Indicated

DATE : February 2020