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# Appendix O

# Structural Condition Memorandum

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# Technical Memorandum

# Structure 65-08 C1940 Condition Memo

**Date:** January 12, 2022 **Project No.:** 300052314.0000

**Project Name:** Warden Avenue and Kennedy Road Environmental Assessment Studies

**Client Name:** Region of York

**Submitted To:** Region of York

**Submitted By:** Andrew Dawson, P.Eng.

**Reviewed By:** Chris Knechtel, P.Eng.

This memorandum provides a summary of the structural condition of structure 65-08 C1940 based on information provided by the Region on the 2020 OSIM forms and photo records and provides comment and recommendations regarding the options of rehabilitation or replacement of the structure for consideration in the Environmental Assessment (EA) process.

## 1.0 Description

Structure 65-08 C1940 was built in 1978 and is located on Warden Avenue (York Regional Road 65), just south of the intersection with Major Mackenzie Drive East (York Regional Road 25). The structure is a vertical ellipse, structural plate corrugated steel pipe (SPCSP) culvert with a span of 4.9 m (+/-), and an overall length of approximately 73 m.

The structure is located approximately 50 m south of the intersection and carries four lanes of through traffic, two turning lanes, a concrete median, concrete boulevards and sidewalks. The culvert has a maximum cover of approximately 7.5 m, measured from the centreline of road elevation to the obvert of the pipe. An elbow is also present within the culvert, which deflects the horizontal alignment of the culvert.

## 2.0 Structural Condition

The recent 2020 OSIM inspection assigned a Bridge Condition Index (BCI) of 54.01 to this structure and identified several deficiencies of structural concern within the culvert barrel. Specifically, the galvanized coating of the structural plates has experienced light to severe breakdown, which has allowed moderate to severe corrosion to occur. Most severe corrosion has occurred near the waterline, where several perforations (localized 100% section loss) occurring over a length of approximately 22.5 m within the roadway. Severe corrosion also exists on the obvert, surrounding the drain outlets. Global deformations, tears and separation of joints were also noted along the obvert of the culvert.

The above noted defects result in reduction of the structures load carrying capacity. Section loss associated with corrosion reduces the overall capacity that the corrugated profile is able to carry. Additionally, the strength of these CSP structures rely on the rounded shape and interaction with the surrounding soil to carry loads. Perforations through the culvert result in severe reduction to the soil-steel interaction by interrupting the ring-compression load path, as well as by allowing the compacted granular backfill an avenue to create voids and reduce compaction of fill surrounding the pipe.

Additionally, improper lapping / bolt layout was identified at the longitudinal plate connections. Although bolt-hole tearing was not identified within the OSIM at the location of the improper lapping / bolt layout locations at the time of inspection, these conditions provide increase potential for bolt-hole tearing and may be a risk throughout the remaining service life of the structure.

Corrugated steel plate cut-off walls are present at the inlet and outlet, which retain backfill and provide scour protection. walls were noted to be in generally good to fair condition and have light corrosion and minor deformations, with the exception of the northwest wall, which has experienced significant rotation and has localized perforations. However, it is noted that a gabion basket retaining wall exists behind the corrugated steel plate cut-off walls, and these walls have not experienced rotation on any quadrants, which indicated the backfill is still being adequately retained, despite the cut-off wall rotation.

Based on the overall condition of the culvert and the noted structural deficiencies, a major rehabilitation or replacement would be recommended for this culvert within five years, preferably in 1 to 2 years.

## 3.0 Recommended Work

Given the extent of perforations and severe corrosion identified during the 2020 inspection, the structural capacity of the structure is reduced and, as such, localized repairs are no longer considered cost effective and recommended action would consist of re-lining or replacement options, as outlined below.

### 3.1 Culvert Lining

The option of lining the existing culvert allows an opportunity to install a new culvert, within the existing culvert, such that no excavation work is required to complete the installation. Inversion cured-in-place lining techniques are not feasible at this location due to the size of this structure. Another lining option to be considered consists of installing a liner pipe of slightly smaller dimensions within the original pipe and filling the annular area between the existing ("host") and the new ("liner") pipes. The new liner pipe is designed to support the overburden and traffic loads as an individual pipe, with the remaining strength of the existing host pipe, and the grout within the annular areas not considered. The elimination of deep excavations allows the work to be completed with minimal disruption to traffic, without staging and associated roadway protection systems, and without additional soils testing related to requirements associated with management of excess.

Lining of an existing pipe will reduce the total hydraulic conveyance area available for watercourse flows. The viability of using a culvert lining system relies heavily on the extent of effects on hydraulic performance due to this reduction of conveyance area. As such, the largest available liner pipe that can fit within the existing host pipe is typically used to minimize the negative impacts on hydraulics. Additionally, if the culvert's hydraulic capacity is governed by inlet control, additional provisions can be made at the culvert inlet to help reduce losses at the inlet and improve hydraulic performance. Deformations of the overall shape through the culvert must also be considered when determining the sizing of the liner pipe. A detailed survey of the geometry of the culvert would be required prior to selection of the culvert liner sizing.

The lateral deflection within the culvert's horizontal alignment results in construction complexity and potentially limits the methodologies that can be used for installation of the liner. 'Slip-Lining' is typically the preferred methodology for installation when the site permits. This installation methodology consists of joining the plates to form the culvert shape outside of the existing culvert, and then progressively sliding the completed system into the pipe as more sections are constructed on the end. However, due to the lateral deflection in this alignment, this traditional method could only be utilized if liner pipe was progressed from both the inlet and outlet to the location of the elbow, and then joined with a custom elbow coupling, designed to be installed from the interior of the culvert.

As an alternative to slip-lining, tunnel liner plates could be utilized to construct the pipe liner directly within the existing host pipe, with customized tunnel liner plates for the elbow location. Similar to above, the use of tunnel liner plates still results in a reduction of the hydraulic conveyance area of the culvert and still requires similar clearance between the host and liner pipe to provide grouting of the annular area. However, tunnel liner plates also provide an option for locally removing deformed areas of the host pipe immediately prior to installation of the liner plates in such locations, which may allow for a larger dimension opening overall.

### 3.2 Culvert Replacement

The alternative to re-lining of the existing culvert would be full structure replacement. This option allows for the opportunity to make hydraulic, ecological or other improvements, that would not be available through lining. Such opportunities include increasing the span or rise of the structure to provide additional hydraulic conveyance, using an open-footing structure for benefit to aquatic habitat, adjusting alignments, etc.

However, this option would require significant construction staging to allow the structure to be replaced while maintaining two-way traffic at all times. Staging would require heavy shoring systems to be installed to considerable depths near the existing median to allow for excavation and installation of the culvert in two stages while shifting all traffic to one half of the roadway at a time and reducing the overall lanes available for traffic.

The size of the proposed structure will be based on hydraulic requirements at minimum and may be further increased as desired by the local conservation authority to provide additional ecological benefits or in consideration of hydrological geomorphology. Provided that the span of the proposed structure is determined to be similar or slightly larger than the existing structure, it is recommended that existing structure be replaced with one of the following structure types:

- Precast Concrete Box Culvert (if closed footing acceptable);
- Structural Plate Corrugated Steel Arch on Concrete Footings; and
- Precast Concrete Rigid Frame on Concrete Footings.

A geotechnical subsurface investigation will be required to provide recommendation on foundation type and bearing capacities for proposed structure replacement. Additionally, where replacement work will result in excess material requiring disposal off-site, appropriate soil sampling will be required to comply with O. Reg. 406/19.

## 4.0 Additional Studies

The following studies will be required to further determine the feasibility of some options and to allow for preliminary structure sizing to be selected.

- Hydraulic modelling to determine required liner or replacement pipe sizing to minimize hydraulic impacts while meeting minimum requirements of the Region and Conservation Authority;
- Life-cycle cost-analysis to determine whether re-lining or replacement is the preferred alternative;
- Detailed survey of structure geometry and deformations to determine whether installation of the minimum acceptable liner sizing is achievable based on culvert shape and deformations; and
- If replacement is required, a Geotechnical Subsurface investigation for foundation bearing capacities and soil sampling for management of excess fill requirements.

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