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Memorandum

Date: December 8, 2022

Project #: 17056012

To: Nimit Mittal, M.Eng., P.Eng.

From: Alex Scott, M.Sc. & Robin McKillop, M.Sc., P.Geo., CAN-CISEC

cc: Mike Brierley, M.Sc.

Re: Fluvial Geomorphic Crossing Assessment for the Town of Caledon Growth Roads Program – Chinguacousy Road

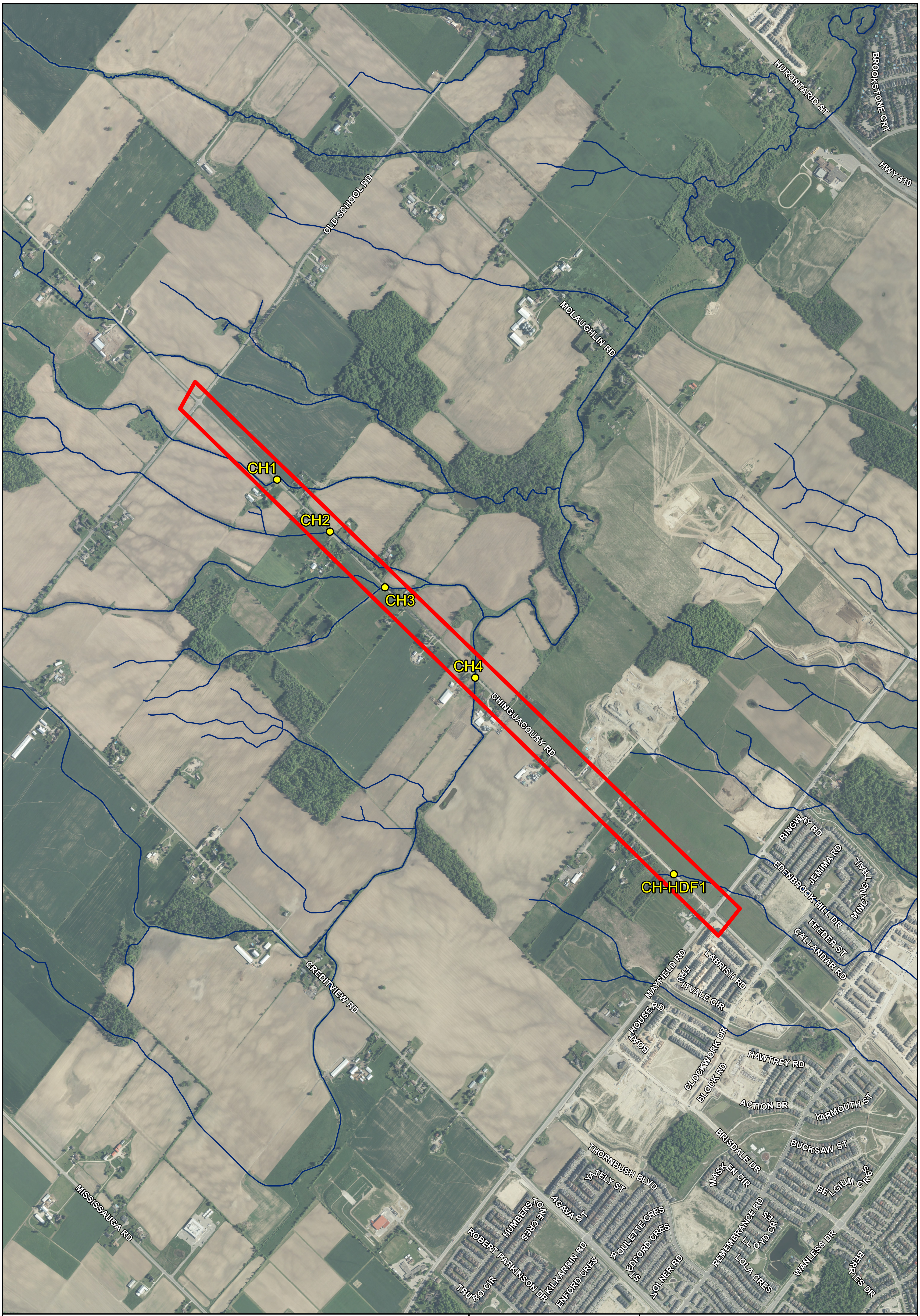
1. Introduction

Palmer is pleased to provide Ainley Group with the results of our geomorphological assessment for the five identified water crossings identified within the Chinguacousy Road (CH) improvement area (**Figure 1**). The water crossings are low-order tributaries of Etobicoke Creek and Fletchers Creek (**Figure 1**). The study area has been identified as part of the Town of Caledon Growth Roads Project Class EA and Detailed Design Input for Watercourse Crossings.

Of the five water crossings identified within the study area, four are within Toronto and Region Conservation Authority (TRCA) jurisdiction. The remaining crossing is at the southern extent of Chinguacousy Road, within Credit Valley Conservation (CVC) jurisdiction. Four of the crossings are associated with actual watercourses (CH1, CH2, CH3, and CH4). The remaining crossing (CH-HDF1) was determined to be a headwater drainage feature (HDF), which warranted assessment from a fluvial perspective.

Our assessment confirms the status of each crossing as either a watercourse or an HDF. It also informs crossing siting, sizing, and orientation, and provides recommendations for culvert replacements at the four actual watercourse crossings. Our crossing assessment recommendations are based on field reconnaissance and desktop analysis completed in accordance with TRCA and CVC guidelines.

A background review (Section 2) is followed by a summary of methods (Section 3); a description of channel morphology and erosional processes (Section 4); establishment of meander belts, as applicable (Section 5); a fluvial perspective on crossing siting, sizing, and orientation for the four watercourse crossings (Section 6); and a summary of key findings (Section 7).



LEGEND

Road Corridor

Culvert Crossing Site

Watercourse (MNRF)

Key Map

0 250 500

Metres

North American Datum 1983
Universal Transverse Mercator Projection Zone 17

Scale: 1:15,000
Page Size: Tabloid (11 x 17 inches)

Drawn: SM
Checked: AS
Date: Jun 22, 2022

NORTH

Source Notes:
Background imagery (2020) from the Peel Region Webmap service.

CLIENT

Ainley Group

PROJECT

Caledon Growth Roads Program

TITLE

Study Area and Identified Crossings (Chinguacousy Road)

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REF. NO. 1705612-MR-001

Figure 1

REV. A

Document Path: G:\Shared drives\Projects 2017\17056 - Ainley Group\1705612 - Caldeon Growth Roads\Mapping\Figures\5_ArcGIS\Fluvial\Task 2 - Report 2 - Chinguacousy Rd\1705612_1-1_Study Area.mxd

1.1 Study Area

The Town of Caledon is experiencing rapid growth in its population, which is stressing existing infrastructure. In order to accommodate more traffic and new development in the area, the Town has decided to implement the Growth Related Roads program. The roads identified for this study are to be designed in accordance with the Town of Caledon's 2019 Development Charge (DC) Background Study by Watson & Associates Ltd. dated March 22, 2019. The DC Background Study recommends the improvement type (rural road upgrade and urban reconstruction with desired geometrics). This geomorphic assessment contributes to the comprehensive assessment of the Town's 750 km of roads to better inform road design and culvert siting, sizing, and orientation.

2. Background Review

The study area comprises an approximately 3 km road corridor along Chinguacousy Road from Mayfield Road to Old School Road (**Figure 1**). The entire study area exhibits low relief and is drained by a network of headwater drainage features and small tributaries that ultimately enter Credit River or Etobicoke Creek. The Credit River and Etobicoke Creek watersheds drain an area of approximately 1000 km^2 and 210 km^2, respectively. Both watersheds are dominated by urban landcover (CVC, 2011; TRCA, 2010). Both watersheds originate in agricultural lands on the southern extent of the Oak Ridges Moraine and terminate in Lake Ontario. Surficial geology of the region is composed of fine-textured glaciolacustrine deposits and till (OGS, 2010a). Physiography is drumlinized till plains (OGS, 2010b). The water crossings along the road corridor were historically altered in association with local agricultural activity, including extensive plowing though HDFs and watercourses as seen in 1954 aerial imagery (https://yuriyczoli.com/Toronto1954/). None of the drainages along the road corridor have exhibited any significant natural planform change over the period of record.

3. Methods

The fluvial geomorphology of the creeks in the vicinity of crossings CH1, CH2, CH3, and CH4 were assessed through a combination of desktop and field investigations. Palmer reviewed a number of important background information sources for the study area, including Toronto and Region Conservation Authority (TRCA) policy document, Crossings Guideline for Valley and Stream Corridors (TRCA, 2015); Technical Guidelines for Watercourse Crossings – Version 1 (Credit Valley Conservation (CVC), 2019); Ontario Geological Survey bedrock and surficial geology mapping (Ontario Geological Survey, 2014a and 2014b, respectively), and the Ontario Ministry of Natural Resources Technical Guide for Erosion Hazard Limits (OMNR, 2002). Palmer then completed a historical assessment of conditions, conducted field reconnaissance, and calculated toe erosion allowances and empirical meander belt widths, as outlined below.

3.1 Historical Assessment and Channel Delineation

Historical aerial photography from 1954 and 2020 imagery from the Town of Caledon were initially reviewed. The imagery provided a basis for characterizing historical land use and channel conditions. The region comprises agricultural lands, which have resulted in the alteration of existing drainage patterns (**Figure 1**). Notably, there is evidence of tile drainage around the study corridor observed in historical aerial imagery. Active diversion of water through tile drains into roadside ditches was also observed along the road corridor. The channel banks were delineated with the intention of observing the nature and degree of any channel adjustments. Only the centreline was delineated along the narrow channels. A comparative review was completed of channel characteristics from 1954 imagery, 2020 imagery, and observed field data. Further review of aerial imagery was not completed as there was no significant morphological changes between the 1954 and 2020 imagery.

3.2 Field Reconnaissance

Palmer's Fluvial Processes Specialists completed field reconnaissance on March 30th, 2021. There was no precipitation the day of field work and the conditions were overcast and windy. Flow conditions were above baseflow, with significant precipitation within the 24 hours prior to the site visit. Bent vegetation and rafted organic debris on the floodplain indicated a recent significant flow event. The purpose of the visit was to observe channel conditions, examine patterns and processes of local erosion, measure channel dimensions and ground truth aerial photograph-based interpretations of site conditions. During the site visit, each crossing was characterized as either a watercourse or an HDF. The information gathered in the field was used to inform the selection of an appropriate empirical formula for estimating meander belt widths, and to determine appropriate channel crossing characteristics.

3.3 Empirical Meander Belt Width

Four watercourses identified within the study area (i.e., CH1, CH2, CH3, and CH4) required meander belt delineation in association with the completion of a crossing assessment in accordance with TRCA guidance (TRCA, 2015). Comparative overlay analysis of the four watercourses indicates that the channels have maintained mostly straight planforms in the vicinity of the crossing sites since at least 1954.

Historical straightening and alteration of watercourses in association with agricultural activity precluded delineation of meander belts based on historical imagery or through reference to a nearby surrogate reach. As such, all meander belts were established based on estimation of their widths using applicable empirical formulae.

A number of meander belt equations were evaluated, based on applicability of the source data set and comparative checks of the results against other similar watercourses, and the most appropriate equation was selected. First priority was given to checking the reasonableness of meander belts estimated based on the formula derived Natural Resource Conservation Services (NRCS) (2007). This formula relies solely on drainage area as an input parameter as opposed to current channel width, which may not be fully representative in this case of historically channelized watercourses. The estimates based on NRCS (2007) were clearly over-conservative, based on the characteristics of the existing watercourses and professional experience with similarly sized watercourses in the region. In the end, the meander belt width for all reaches was deemed most appropriately determined using the William's Width method (1986), which relies on channel width as the input parameter:

$$W_B = 4.33 W_C^{\ 1.12}$$

Where W_B is the meander belt with (m), and W_C is the channel width (m) and 4.33 and 1.12 are constants empirically derived from a sample dataset of channel dimensions, one of these being channel width. The lack of extensive erosion or sedimentation along the watercourses, despite having existed in their current form for more than half a century, suggests their widths may be roughly in equilibrium and reflective of the datasets on which the William's Width method (1986) is based. The final meander belt was delineated through a further, parallel set-back of the boundary lines by a 20% factor of safety to account for potential future changes in the hydrological regime associated with upstream development and climate change.

3.4 Crossing Sizing

Alternative crossing spans were evaluated based on site-specific observations and measurements and historical conditions (e.g., air photo interpretation). Factors including channel width, boundary conditions, and indicators of instability (e.g., bank erosion), and meander belt width (empirically derived based on Williams, 1986) were incorporated into final crossing recommendations. Bankfull width was reported as the absolute minimum width for a culvert that could be considered, but it is generally insufficiently conservative. One approach to accommodate lateral adjustment was to ensure a minimum culvert width equivalent to the bankfull width plus an erosion allowance based on the empirical values compiled by OMNR (2002) for different bank materials and erosional activity. Another, which follows CVC's (2019) guidelines, was to ensure culverts were sized with widths/diameters of three times the bankfull width for channels up to 4 m wide. The final meander belts were also reported, as context, but they tend to be unnecessarily wide to accommodate fluvial processes within the expected lifespan of the structure.

4. Description of Channel Morphology

There are five sites along Chinguacousy Road with road crossing culverts within the study corridor (**Table 1**). They are labelled CH1, CH2, CH3, CH4 and CH-HDF1 from north to south (**Figure 1**). The predominant flow direction across the road is from west to east. CH1 through CH4 are watercourses that cross Chinguacousy Road within the study corridor (**Figure 1**). CH-HDF1 is a roadside ditch and wetland drainage without any fluvial characteristics.

Table 1. Chinguacousy Road culvert and channel characteristics

Site ID	Width of culvert(s) (m)	Mean channel depth* (m)	Mean channel bankfull width (m)
CH1	6.5	0.4*	4.2*
CH2	3.8	0.2*	2.7*
CH3	4.0	0.3*	4.0*
CH4	6.5	0.6	5.7
CH-HDF1	0.6	0.1	2.2**

*Measurement estimated using the LiDAR-derived DEM, orthophotography, and site photos.
**Measurement is only one value, not an average.

4.1 CH1

CH1 is a 6.5 m-wide concrete box culvert installed in 2020 that conveys a watercourse across Chinguacousy Road (**Figure 1; Table 1**). The watercourse is unconfined and has a low gradient. Historically the channel has been realigned with a straight planform and has a locally over-widened cross-section in the vicinity of the culvert (**Appendix A CH1 US**). Just upstream of the culvert, the channel bends abruptly (90^{o}) along its approach to the box culvert. The channel is anomalously wide immediately upstream and downstream of the culvert before returning to a narrower, more typical dimension 5 m downstream (**Appendix A CH1 DS**). Both upstream and downstream of the culvert, there is no bank stabilization and restorative plantings were in poor condition at the time of the visit. There is also evidence of rill formation and sediment mobilization into the channel from the banks. Sediment has accumulated where the channel is locally over-widened (**Photo 1**). The average bankfull width and depth of the channel measured downstream of the culvert are 4.2 m and 0.4 m, respectively (**Table 1**). Dense in-stream vegetation just beyond the culvert inlet/outlet local impedes flow of water and sediment (**Appendix A CH1 US & DS**). <u>This site will need fluvial consideration for crossing replacement as outlined in Section 6</u>.

Photo 1. Evidence of sediment accumulation in a locally over-widened section of channel near the culvert (CH1).

4.2 CH2

CH2 is a 3.75 m-wide concrete box culvert installed in 2020 that conveys flows along a straightened watercourse beneath Chinguacousy Road (**Figure 1; Table 1**). The watercourse is unconfined, has a low gradient, and has a mostly vegetated bed (**Appendix A CH2 US**). Restorative plantings in the vicinity of the crossing are absent or in poor condition. The naturally narrow channel widens abruptly at its approach to the culvert inlet (**Appendix A CH1 DS**). Downstream of the culvert, the channel bends abruptly (90°) to follow an excavated trench parallel to a gabion wall-flanked road (**Appendix A CH1 DS**). There is evidence of sediment accumulation within the box culvert, suggesting that throughflow is anomalously deep and wide compared to along the natural channel. The average bankfull width and depth of the channel measured downstream of the culvert are 2.7 m and 0.20 m, respectively (**Table 1**). <u>This site will need fluvial consideration for crossing replacement as outlined in Section 6</u>.

4.3 CH3

CH3 is a 4.0 m-wide concrete box culvert installed in 2020 downstream of the confluence of two straightened watercourses (**Figure 1; Table 1**). The watercourses are unconfined, have low gradients, and have mostly vegetated beds upstream of the confluence. Downstream of the confluence, the bed of the channel flows through a narrow wetland before reaching the box culvert (**Appendix A CH3 US**). Restorative plantings in the vicinity of the crossing are absent or in poor condition. The channel is anomalously wide immediately upstream and downstream of the culvert where it may be at risk of being outflanked (**Appendix A CH3 US and DS**). Downstream of the culvert the channel flows into a wetland. There is evidence of erosion upstream and deposition downstream of the box culvert, suggesting a change in at least low-flow channel grade through the culvert. The average bankfull width and depth of the channel measured downstream of the culvert are 4.0 m and 0.3 m, respectively (**Table 1**). <u>This site will need fluvial consideration for crossing replacement as outlined in Section 6</u>.

4.4 CH4

CH4 is a 6.5 m-wide concrete box culvert that conveys a watercourse across Chinguacousy Road (**Figure 1**). The watercourse is unconfined and has a low gradient. Historically the channel had a slightly sinuous planform, but it has since been realigned and straightened with a uniformly trapezoidal cross-section (**Appendix A CH4 US**). Just upstream of the culvert, the channel is over-widened and beginning to outflank the box culvert. The channel is also anomalously wide immediately downstream of the culvert before narrowing and regaining sinuosity about 10 m further downstream (**Appendix A CH4 DS**). The average bankfull width of the channel measured upstream of the culvert is 5.7 m and the bankfull depth measured at the culvert inlet is 0.6 m (**Table 1**). The channel bed is unvegetated and the banks are vegetated with grasses and a few trees (**Appendix A CH4 US & DS**). <u>This site will need fluvial consideration for crossing replacement as outlined in Section 6</u>.

4.5 CH-HDF1

CH-HDF1 is a 0.60 m-diameter CSP culvert that conveys the outflow from a cultural meadow directly adjacent to Chinguacousy Road (**Figure 1; Table 1**). A roadside ditch converges with the wetland drainage at the inlet of the culvert (**Appendix A CH-HDF1 US**). Downstream of the culvert, urban development has altered the flow path and drainage patterns (**Appendix A CH-HDF1 DS**). The channel is undefined upstream of the culvert and enters a roadside ditch immediately downstream of the culvert (**Appendix A CH-HDF1 US & DS**). The width of the ditch downstream of the culvert is 2.20 m and the depth is 0.1 m (**Table 1**). A thick layer of organic material and fine-grained sediment has accumulated downstream of the culvert, and the cultural meadow is heavily vegetated. The lack of fluvial characteristics indicates that this crossing does not require fluvial input for culvert sizing.

5. Meander Belt

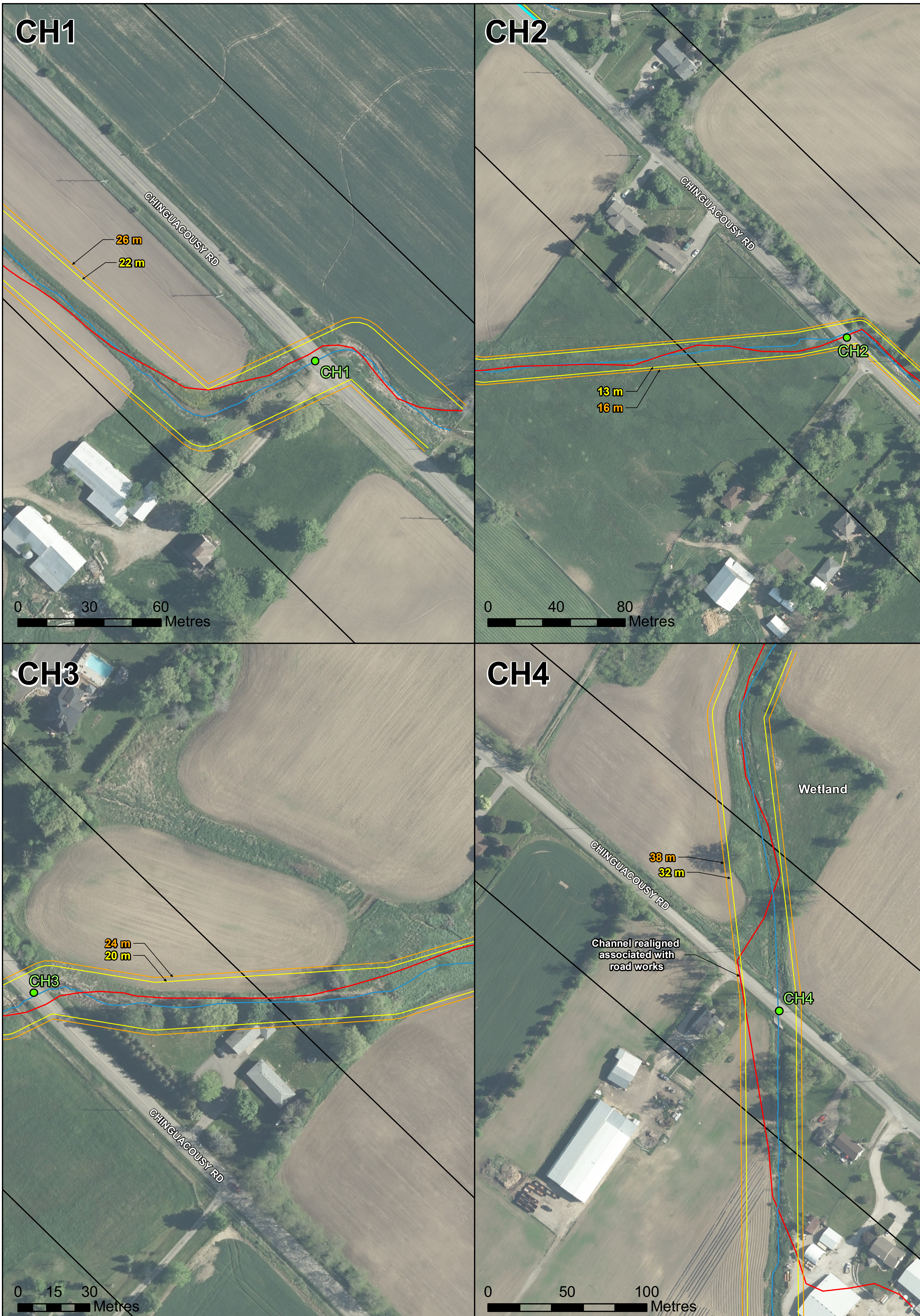
An existing meander belt width was delineated for the four watercourses located along Chinguacousy Road (CH1, CH2, CH3, and CH4) (**Table 2; Figure 2**). The final belt widths include a 20% factor of safety (**Table 2**).

Each watercourse exhibits a history of anthropogenic modification in association with agricultural activities. Channel planforms have remained relatively unchanged with no observed precursors to meander development (e.g., erosion coincident with sinuous thalweg contacting channel banks). Based on site reconnaissance, the physical factors influencing channel morphology (i.e., channel slope, discharge, bed and bank material and vegetation) and evidence of the long-term stability of the channels, the meander belt widths derived from the Williams (1986) empirical equation sufficiently captures future geomorphic adjustment.

Table 2. Empirical meander belt widths

Water Crossing	Existing Belt Width* (m)	Final Belt Width** (m)
CH1	22	26
CH2	13	16
CH3	20	24
CH4	32	38

*Based on Williams (1986).
**Based on Williams (1986) and a 20% factor of safety to allow for the effects of urbanization and climate change.



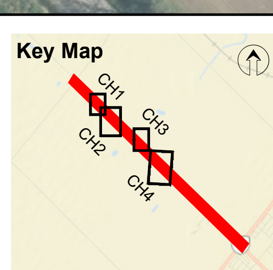
LEGEND

- Road Corridor
- Culvert Crossing Site
- Existing Meander Belt
- Final Meander Belt

Channel Centreline (year)

- 2020
- 1954

Key Map



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Checked: AS
Date: Jun 30, 2022

NORTH

Source Notes:
Background imagery (2020) from the Peel Region Webmap service.

CLIENT
Ainley Group

PROJECT
Caledon Growth Roads Program

TITLE
Watercourse Crossing Sites (Chinguacousy Road)

REF. NO. 1705612-MR-002

Palmer™

Figure 2

REV. B

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6. Crossing Assessment

Fluvial geomorphological considerations must be incorporated into the design of replacement watercourse crossing structures (CVC, 2017; TRCA, 2015). This requirement is based on recognition that structures that are poorly sited, misaligned relative to the channel, or undersized hydraulically, geomorphologically or ecologically may compromise the natural form and function of the watercourse and the aquatic habitat it supports. Crossing structures that do not account for, and anticipate, fluvial processes may also become unnecessarily at risk from excessive erosion or sedimentation. Abutments can be outflanked, or undermined, closed-bottom structures can become perched at their outlets, and excessively wide structures can lose a significant portion of their hydraulic capacity through sediment build-up. The following sections outline considerations and recommendations for the siting, sizing, and orientation of the crossing structures.

6.1 Crossing Siting

The first consideration to make when proposing a new or replacement crossing structure is the actual location of the structure relative to the existing planform and longitudinal geometry of the channel it must accommodate. In this case, the existing alignment of the Chinguacousy Road corridor at CH2 and CH4 constrain the location to the culvert crossings. As such, no changes to these crossing locations are recommended. Re-siting of culverts CH1 and CH3 approximately 40 m and 7 m south along Chinguacousy Road, respectively, would be necessary to better position the crossings relative to the natural trend of the channel, but this would likely be cost-prohibitive and of only modest benefit to channel function.

6.2 Crossing Sizing

Several crossing width scenarios have been assessed from a fluvial geomorphological perspective (**Table 3 – Table 6**), including TRCA's (2015) recommended design approach. The existing culverts measure 6.5 m (CH1), 3.75 m (CH2), 4.0 m (CH3), and 6.5 m (CH4). The culverts at all four sites appears to be slightly undersized considering natural fluvial processes at the site. The four crossings impede water flow (especially during flood conditions), alter natural sediment transport patterns, and compromise local ecological functions.

Comparative overlay analyses completed for sites CH1, CH2, CH3, and CH4 reveal that the channel planforms have changed little over the historical record (1954 to 2020), with lateral adjustments generally within a few-metre margin of error associated with georeferencing old imagery and channel centerline delineation along densely vegetated floodplains (**Figure 2**). The channels are all characterized as having little to no sinuosity with no evidence of lateral erosion. Straightened and stable channel planforms over the past 70 years precluded the use of meander amplitude or site-specific 100-year migration rates to determine alternative crossing spans.

The long-term forecasting of lateral erosion near the culvert inlet at all four sites cannot be achieved through direct measurement, due to local anthropogenic modifications and a relative lack of observable changes in the small channel. However, gradual readoption of a more sinuous planform is possible following erosion along one or both banks. It would be most conservative to size the replacement culverts such that they accommodate potential lateral erosion.

Table 3. (CH1) Alternative road crossing spans and fluvial implications

Crossing Span	Fluvial Considerations	Fluvial Implications
Bankfull width **4.2 m**	Can accommodate natural water/sediment conveyance, but no allowance for natural lateral adjustments (bank erosion).	The culvert should not be sized to the bankfull width, as there would still be a risk of outflanking the culvert during unusually high and fast flood conveyance.
Bankfull width + Erosion Allowance **8.2 m** (4.2 m + 2 m applied to each bank)	Can accommodate natural water/sediment conveyance and a long-term fluvial erosion hazard limit.	Sizing the culvert to the bankfull width + erosion allowance would reduce scour and downstream erosion risks and would accommodate the early development of lateral adjustment.
Three times the bankfull width **N/A** (only applicable for channels <4 m wide)	N/A	N/A
Final meander belt width* **26 m**	Can accommodate water/sediment conveyance and all predicted natural channel adjustments.	A culvert the width of the entire meander belt would accommodate all expected lateral adjustments over the 100-year planning timeframe. This would prevent future long-term risk from fluvial processes and maintenance concerns associated with lateral adjustment.

*Based on Williams (1986), plus a 20% factor of safety to allow for effects of urbanization and climate change.

Table 4. (CH2) Alternative road crossing spans and fluvial implications

Crossing Span	Fluvial Considerations	Fluvial Implications
Bankfull width **2.7 m**	Can accommodate natural water/sediment conveyance, but no allowance for natural lateral adjustments (bank erosion).	The culvert should not be sized to the bankfull width, as there would still be a risk of outflanking the culvert during unusually high and fast flood conveyance.
Bankfull width + Erosion Allowance **6.7 m** (2.7 m + 2 m applied to each bank)	Can accommodate natural water/sediment conveyance and a long-term fluvial erosion hazard limit.	Sizing the culvert to the bankfull width + erosion allowance would reduce scour and downstream erosion risks and would accommodate the early development of lateral adjustment.
Three times the bankfull width **8.1 m**	Can accommodate natural water/sediment conveyance and a long-term fluvial erosion hazard limit.	Can accommodate natural water/sediment conveyance and a long-term fluvial erosion hazard limit.
Final meander belt width* **16 m**	Can accommodate water/sediment conveyance and all predicted natural channel adjustments.	A culvert the width of the entire meander belt would accommodate all expected lateral adjustments over the 100-year planning timeframe. This would prevent future long-term risk from fluvial processes and maintenance concerns associated with lateral adjustment.

*Based on Williams (1986), plus a 20% factor of safety to allow for effects of urbanization and climate change.

Table 5. (CH3) Alternative road crossing spans and fluvial implications

Crossing Span	Fluvial Considerations	Fluvial Implications
Bankfull width **4.0 m**	Can accommodate natural water/sediment conveyance, but no allowance for natural lateral adjustments (bank erosion).	The culvert should not be sized to the bankfull width, as there would still be a risk of outflanking the culvert during unusually high and fast flood conveyance.
Bankfull width + Erosion Allowance **8.0 m** (4.0 m + 2 m applied to each bank)	Can accommodate natural water/sediment conveyance and a long-term fluvial erosion hazard limit.	Sizing the culvert to the bankfull width + erosion allowance would reduce scour and downstream erosion risks and would accommodate the early development of lateral adjustment.
Three times the bankfull width **N/A** (only applicable for channels <4 m wide)	N/A	N/A
Final meander belt width* **24 m**	Can accommodate water/sediment conveyance and all predicted natural channel adjustments.	A culvert the width of the entire meander belt would accommodate all expected lateral adjustments over the 100-year planning timeframe. This would prevent future long-term risk from fluvial processes and maintenance concerns associated with lateral adjustment.

*Based on Williams (1986), plus a 20% factor of safety to allow for effects of urbanization and climate change.

Table 6. (CH4) Alternative road crossing spans and fluvial implications

Crossing Span	Fluvial Considerations	Fluvial Implications
Bankfull width **6.0 m**	Can accommodate natural water/sediment conveyance, but no allowance for natural lateral adjustments (bank erosion).	The culvert should not be sized to the bankfull width, as there would still be a risk of outflanking the culvert during unusually high and fast flood conveyance.
Bankfull width + Erosion Allowance **10.0 m** (6 m + 2 m applied to each bank)	Can accommodate natural water/sediment conveyance and a long-term fluvial erosion hazard limit.	Sizing the culvert to the bankfull width + erosion allowance would reduce scour and downstream erosion risks and would accommodate the early development of lateral adjustment.
Three times the bankfull width **N/A** (only applicable for channels <4 m wide)	N/A	N/A
Final meander belt width* **38 m**	Can accommodate water/sediment conveyance and all predicted natural channel adjustments.	A culvert the width of the entire meander belt would accommodate all expected lateral adjustments over the 100-year planning timeframe. This would prevent future long-term risk from fluvial processes and maintenance concerns associated with lateral adjustment.

*Based on Williams (1986), plus a 20% factor of safety to allow for effects of urbanization and climate change.

6.3 Crossing Orientation

The existing CH1 and CH4 culverts are aligned perpendicular to their respective roads as opposed to the natural trends, or axes, of their respective watercourses (**Figure 2**). The watercourse just downstream of the CH2 culvert has an abrupt bend, likely a result of historic channel modification (**Figure 2**). The CH3 culvert is aligned perpendicular to the road but exists within a natural channel bend (**Figure 2**). The existing skew of the CH1, CH2 and CH4 culverts effectively reduces what may be the intended (designed) hydraulic capacity during flood conditions and locally alters sediment transport patterns.

Palmer recommends consideration be given to reorienting the CH4 culvert along the natural axis of the channel corridor. It is also recommended that the CH2 culvert be reoriented to reduce the abruptness of the downstream channel bend and mitigate potential erosion at the culvert outlet. Reorientation would add little to the required culvert length. Reorienting the CH1 culvert would realign the culvert with the natural watercourse axis, but it would necessitate substantial channel realignment both upstream and downstream that is likely cost-prohibitive and of only modest benefit to channel function. A slight reorientation of the CH3 culvert to reduce the abruptness of the channel bend would be beneficial, but this is not recommended unless completed in conjunction with other works (e.g., culvert resizing) due to the modest benefit. Any reorientation of the CH3 culvert should not impact the upstream confluence.

Prioritizing alignment of culverts with their respective watercourses as opposed to perpendicularity to the road would improve hydraulic performance during floods, allow for a more natural form and function of the channel in the immediate vicinity of the crossing, and reduce risks to infrastructure and the need for excessive erosion protection.

6.4 Headwater Drainage Features

The crossing at site CH-HDF1 is a headwater drainage feature and is therefore not subject to the same evaluation criteria for culvert sizing. Since it does not exhibit fluvial characteristics, it does not require consideration of fluvial processes in determining a culvert size (CVC, 2017; TRCA, 2015). As such, Palmer recommends that the sizing of culvert for the CH-HDF1 be based on hydraulic modeling and any other inputs deemed necessary by the Town.

7. Summary

Five drainage crossings were identified along the Chinguacousy Road improvement corridor. Assessment of four of these, from a fluvial geomorphological perspective, culminated in recommendation for culvert replacements to better accommodate natural fluvial processes (e.g., sediment transport, erosion). The remaining culvert, which conveys flow along an HDF, should be re-sized based on hydraulic and/or ecological recommendations, if necessary.

Detailed crossing assessments for four culverts CH1, CH2, CH3, and CH4 were completed in accordance with TRCA's (2015) and CVC (2019) crossing assessment guidelines, to inform the appropriate siting, sizing, and orientation of replacement structures. The assessment included specification of the channel bankfull width, bankfull width plus an erosion allowance, three times bankfull width, and final meander belt width to provide the Town with crossing alternatives. The four alternatives for each crossing were evaluated from a fluvial geomorphological perspective, culminating in a guidance table to highlight risk for the proposed crossing replacements.

The TRCA crossing assessment guideline (2015) recommends crossing structures span bankfull width plus the site-specific erosion allowance. None of the watercourses, which are generally densely vegetated along both banks, has undergone any appreciable lateral adjustment in the vicinity of the crossings in more than half a century. As such, minimum culvert widths of 8.2 m (CH1), 6.7 m (CH2), 8.0 m (CH3), and 10.0 m (CH4) should adequately accommodate bank erosion and related lateral adjustment over a 100-year planning timeframe. Each of the replaced culverts should be open-footed or embedded box culverts with a defined low-flow channel along their entire lengths.

8. Certification

This memorandum was prepared and reviewed by the undersigned.

Prepared By:

Alex Scott, M.Sc.
Fluvial Processes Specialist

Reviewed By:

Robin McKillop, M.Sc., P.Geo., CAN-CISEC
Principal, Fluvial Geomorphologist

Palmer™

References

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Appendix A

Photo Log

Client Name:	Project No.	Site Location:
Ainley Group	1705612	Caledon Growth Roads Study Area – Chinguacousy Road

Photo #:	Date.
CH1	3/30/2021
Direction Photo Taken	US

Description

View of the watercourse upstream of the road crossing. The watercourse bends 90º from north to east.

Photo #:	Date.
CH1	3/30/2021
Direction Photo Taken	DS

Description

View of the watercourse downstream of the road crossing

Client Name:	Project No.	Site Location:
Ainley Group	1705612	Caledon Growth Roads Study Area – Chinguacousy Road

Photo #:	Date.
CH2	3/30/2021
Direction Photo Taken	US

Description

View of the anomalously wide watercourse (immediate foreground) upstream of the road crossing, with the more typically narrow channel beyond the fence (background).

Photo #:	Date.
CH2	3/30/2021
Direction Photo Taken	DS

Description

View of the watercourse downstream of the road crossing. The channel bends 90º from east to south to flow into an excavated trench parallel to the road.

Photograph Log

Palmer

Client Name:	Project No.	Site Location:
Ainley Group	1705612	Caledon Growth Roads Study Area – Chinguacousy Road

Photo #:	Date.
CH3	3/30/2021
Direction Photo Taken	US

Description

View of the watercourse upstream of the road crossing.

Photo #:	Date.
CH3	3/30/2021
Direction Photo Taken	DS

Description

View of the watercourse downstream of the road crossing.

Photograph Log

Client Name:	Project No.	Site Location:
Ainley Group	1705612	Caledon Growth Roads Study Area – Chinguacousy Road

Photo #:	Date.
CH4	3/30/2021
Direction Photo Taken	US

Description

View of the watercourse upstream of the road crossing

Photo #:	Date.
CH4	3/30/2021
Direction Photo Taken	DS

Description

View of the watercourse downstream of the road crossing

Photograph Log

Client Name:	Project No.	Site Location:
Ainley Group	1705612	Caledon Growth Roads Study Area – Chinguacousy Road

Photo #:	Date.
CH-HDF1	3/30/2021
Direction Photo Taken	US

Description

View of the roadside ditch and wetland upstream of the road crossing

Photo #:	Date.
CH-HDF1	3/30/2021
Direction Photo Taken	DS

Description

View downstream of the road crossing where the outflow joins a watercourse that flows along the roadside ditch