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February 26, 2021

David Schaeffer Engineering Ltd.
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Attention: Stephen Pichette

Re: Meander Belt Width Assessment
Marlborough Creek
City of Ottawa, Ontario
GEO Morphix Project No. 21012

GEO Morphix Ltd. was retained to complete a meander belt width assessment for Marlborough Creek to support the proposed development at 6038 Ottawa Street in the City of Ottawa (Richmond), Ontario. The proposed development includes residential, commercial, and natural land uses, as well as associated road networks. The proposed development is approximately 67 hectares in area. Stormwater management facilities are proposed on site, which will direct flows to the subject watercourse. Given the proposed development is adjacent to the main branch of Marlborough Creek, the City of Ottawa has requested a meander belt width delineation to identify the erosion hazard and channel migration limit. Further, this assessment would inform the general location for a stormwater outfall to facilitate stormwater management facilities.

To address the City of Ottawa's concerns related to natural hazards, and identify the meander belt width associated with the subject property, the following activities were completed:

- Review available background reports and mapping (e.g., watershed/subwatershed reporting, geology, and topography) related to channel form and function and controlling factors related to fluvial geomorphology
- Delineate watercourse reaches based on a desktop assessment (to be confirmed during field reconnaissance)
- Review of recent and historical aerial photographs of the site to understand historical changes in channel form and function
- Complete site reconnaissance to understand general property and watercourse characteristics
- Delineate preliminary limits of the meander belt width/erosion hazard on a reach basis using the results of the desktop assessments
- Prepare a report and mapping product to characterize the watercourse, delineate the meander belt width, and summarize all findings

It is important to note that due to seasonal conditions, a complete field investigation was not included. Rather, these preliminary findings are based on a desktop analysis of available information. To confirm existing site conditions, finalize the geomorphic assessment, and inform the preferred location for the stormwater outfall, field reconnaissance will be completed in spring 2021. It is unlikely the field assessment will significantly change the conclusions of the desktop assessment.

Background Review and Desktop Assessment

Background Information

The subject property is within the Rideau Valley watershed, and more specifically, the Jock River subwatershed (Richmond catchment). The Jock River-Richmond subwatershed drains an area of

approximately 31 square kilometers and occupies 60 km of channel (including both Jock River and tributaries) (RVCA, 2016). According to the Rideau Valley Conservation Authority (RVCA), the majority of the Jock River (Richmond system) is in generally good condition. Further, the majority of the system along the Jock River main branch and Marlborough Creek has low erosion levels and an established forested riparian corridor (RVCA, 2016). Specific to riparian vegetation, Marlborough Creek has a riparian buffer of greater than 30 along 99% of both the right and left banks (RVCA, 2016).

Geology and Physiography

Geology and physiography act as constraints to channel development and tendency. These factors determine the nature and quantity of the availability and type of sediment. Secondary variables that affect the channel include land use and riparian vegetation. These factors are explored as they not only offer insight into existing conditions, but also potential changes that could be expected in the future as they relate to a proposed activity.

Within the subject property, Marlborough Creek is dominated by the Clay Plains physiographic region of Ontario (Chapman and Putnam, 2007). In terms of surficial geology, the subject lands are characterized by fine-textured glaciomarine deposits (OGS, 2010). Soils within these areas include silt and clay, minor sand, and gravel (OGS, 2010). Upstream, Marlborough Creek flows through lands characterized by Paleozoic bedrock and till (OGS, 2010). Local surficial geology is represented in **Appendix A.** Bedrock exposures are identified downstream from the subject property, and given the channel cuts through local geology, it is likely that bedrock exposures exist within the bed of the channel as well. The surficial geology associated with Marlborough Creek largely contributes to its planform and stability over time.

Historical Assessment

A series of historical aerial photographs were reviewed to determine changes to the channel and surrounding land use and land cover. This information, in part, provides an understanding of the historical factors that have contributed to current channel morphodynamics.

Various aerial photographs and satellite images from 1954 to 2017 were retrieved to complete the historical assessment and inform the meander belt width delineation. Specifically, aerial photographs from 1954 (McMaster University), 1976, 1999 (City of Ottawa), and satellite imagery from 2017 (Google Earth Pro) were reviewed. All historical aerial photographs are provided in **Appendix C** for reference.

In 1954, Marlborough Creek was identified as a single-thread channel with a meandering planform and limited sinuosity. The subject lands were occupied for agricultural use with few residential dwellings established along Ottawa Street. A woodlot was present at the furthest downstream extent of the watercourse. The Canada National Railway (CNR) ran through the north west extent of the subject property, and crossed Marlborough Creek downstream from the subject property. A limited riparian buffer was observed surrounding Marlborough Creek, which consisted of sparse tree/shrub species.

By 1976, the riparian buffer associated with Marlborough Creek was more extensive, with established tree species throughout the reach and clustered around the crossings at McBean Street and Ottawa Street. Channel planform was generally unchanged; however, the development of geomorphic units was more pronounced. Channel geometry was reduced at the crossing with McBean Street but increased moving downstream into a pool feature. This pattern was repeated moving downstream through the subject property. A crossing over Marlborough Creek was constructed through private lands, which was likely large enough to facilitate small vehicles and pedestrians.

There were no changes in land use or channel planform by 1999. However, the development of geomorphic units and the fluctuation in channel geometry moving downstream became more evident. Particularly through the downstream extent of Marlborough Creek within the subject property, channel geometry was consistently widened. This may have been attributed to the time of year the photograph was taken (i.e., following snowmelt or a high rainfall event). The riparian buffer was more established through the system, with very few banks exposed with limited vegetation.

In 2017, a similar sized crossing was constructed approximately 90 m downstream from the existing bridge. There were no changes in land use or channel planform, and riparian vegetation was more established. The sequence of geomorphic units (i.e., riffles and pools) was less defined, however, this may be due to the time of year the photograph was taken (summer).

Given the limited changes in channel planform over time, the development of geomorphic units, the extent of riparian vegetation, and the underlying geology controlling the form and function of Marlborough Creek, it was determined that the system is generally stable.

Watercourse Characteristics

Reaches are homogeneous segments of channel used in geomorphological investigations. Reaches are studied semi-independently as each is expected to function in a manner that is at least slightly different from adjoining reaches. This method allows for a meaningful characterization of a watercourse as the aggregate of reaches, or an understanding of a particular reach, for example, as it relates to a proposed activity.

Reaches are typically delineated based on changes in the following:

- Channel planform
- Channel gradient
- Physiography
- Land cover (land use or vegetation)
- Flow, due to tributary inputs
- Soil type and surficial geology
- Historical channel modifications

Reach delineation follows scientifically defensible methodology proposed by Montgomery and Buffington (1997), Richards et al. (1997), and the Toronto and Region Conservation Authority (2004) as well as others. Based on a desktop assessment, there was limited change in channel geometry, planform, or riparian cover associated with Marlborough Creek within the subject property (between McBean Street and Ottawa Street). Additionally, there were no significant tributaries contributing flows to the system. As such, one (1) singular reach was delineated as **MC1**. It is important to note that there may be sub-reaches within **MC1**, which will be confirmed during field verification. Reach delineation is graphically defined in **Appendix B**.

Meander Belt Width Assessment

Most watercourses in southern Ontario have a natural tendency to develop and maintain a meandering planform, provided there are no spatial constraints. A meander belt width or erosion hazard assessment estimates the lateral extent that a meandering channel has historically occupied and will likely occupy in the future. This assessment is therefore useful for determining the potential hazard to proposed activities in the vicinity of a watercourse.

When defining the erosion hazard for a watercourse, Ministry of Natural Resources and Forestry (MNRF, 2002) guidelines treat unconfined and confined systems differently. Unconfined systems are those with poorly defined valleys or slopes well outside where the channel could realistically migrate. Confined systems are those where the watercourse is contained within a defined valley, where valley wall contact is possible.

When a meandering channel is confined, erosion of the valley wall needs to be considered. The Ontario Ministry of Natural Resources and Forestry (MNRF) outlines an approach for establishing the erosion hazard for confined valley systems. This approach defines an appropriate erosion setback or toe erosion allowance from the channel bank where the creek is within 15 m from the toe of slope (MNRF, 2001).

In unconfined systems, the limit of the erosion hazard and migration potential can be delineated based on the meander amplitude. Meander amplitude is defined by Leopold et al. (1964) as the lateral distance between tangential lines drawn to the center channel of two successive meander bends. This differs from meander belt, which is measured for a reach between lines drawn tangentially to the outside bends of the laterally extreme meander bends (TRCA, 2004). Both the meander belt width and amplitude quantify the lateral extent of a river's occupation on the floodplain (TRCA, 2004).

Using recent aerial photographs from Google Earth Pro, the amplitude of two meander bends was measured. This measurement was used to inform the meander belt width delineation and address natural erosion hazard. Meander amplitudes were measured from the largest extent of the historical to most recent meanders. As such, the meander amplitude measurement accounts for both potential migration over the historical record (i.e., 63 years) and the largest apparent expression of the channel. Meander amplitudes ranged from 39.2 m to 60.5 m. Further, a 10% factor of safety was applied to the largest meander amplitude (60.5 m) to account for changes in creek morphology over time. With a 10% factor of safety, the hazard limit is approximately 67 m. The meander belt width delineation is provided in **Appendix D.** We recommend confirming conclusions with field observations when conditions permit (i.e., spring 2021).

Summary and Conclusions

Marlborough Creek flows through an unconfined valley system within the northwestern extent of the subject property and was delineated into one (1) reach for the purpose of a fluvial geomorphological assessment and meander belt width delineation. Due to seasonal conditions, a complete field investigation was not included. Rather, these preliminary findings are based on a desktop analysis of available information and a brief site visit. To confirm reach delineation and existing site conditions, finalize the geomorphic assessment, and inform the most suitable location for a stormwater outfall to accommodate stormwater management facilities, field reconnaissance will be completed in spring 2021.

As a component of the desktop assessment, a review of historical aerial photographs was completed. It was determined that land use, channel planform, and riparian vegetation did not undergo substantial changes over the period of time from 1954 to 2017. Rather, geomorphic units (i.e., riffles and pools) were developed and the riparian buffer zone became more established. Given the surficial geology of the area and the limited change in channel morphology over time, it is anticipated that the watercourse is largely controlled by underlying bedrock. This suggests that Marlborough Creek is generally stable and will not likely experience significant changes in channel form and function in the future.

To delineate the meander belt width associated with Marlborough Creek through the subject property, the amplitude of two (2) meander bends were measured. Meander amplitudes ranged from 39.2 m to 60.5 m. Further, a 10% factor of safety was applied to the largest meander amplitude (60.5 m) to account for changes in creek morphology over time. With a 10% factor of safety, the hazard limit is

approximately 67 m. These conclusions are to be confirmed when seasonal conditions permit (i.e., spring 2021).

We trust this memo meets your requirements at this time. Should you have any questions, please contact the undersigned.

Respectfully submitted,

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Junior Environmental Scientist

References

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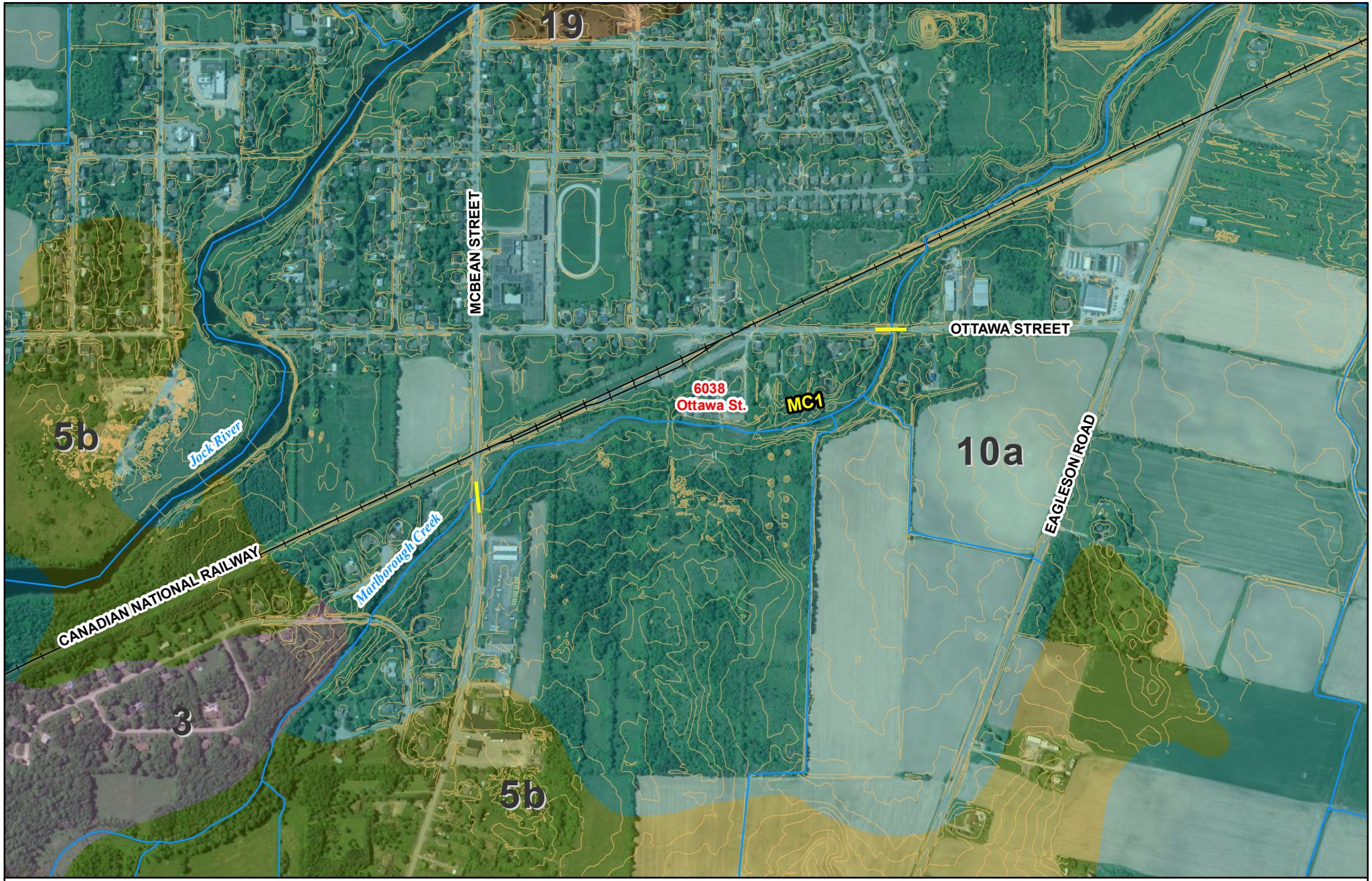
Appendix A
Surficial Geology



Legend

- MC1 Reach Break and Label
- Watercourse
- Railway
- 0.5 m Contour

Surficial Geology

- 3: Paleozoic bedrock
- 5b: Stone-poor, carbonate-derived silty to sandy till
- 10a: Massive-well laminated
- 19: Modern alluvial deposits

Surficial Geology

Marlborough Creek

6038 Ottawa Street
Richmond, Ontario

GEO MORPHIX™

0 50 100 200
Metres

Imagery: Google Earth Pro, 2018.
Reach Break and Label: GEO Morphix Ltd., 2021.
0.5 m Contour: DSEL, 2021. Surficial Geology: MNDM, 2020.
Watercourse, and Railway: MNRF, 2021.
Printed: February 2021. PN21012. Drawn by: M.H., J.M., P.V.

Appendix B
Study Site and Reach Delineation

Legend

- MC1 Reach Break and Label
- Watercourse
- Railway
- 0.5 m Contour

Study Site

Marlborough Creek

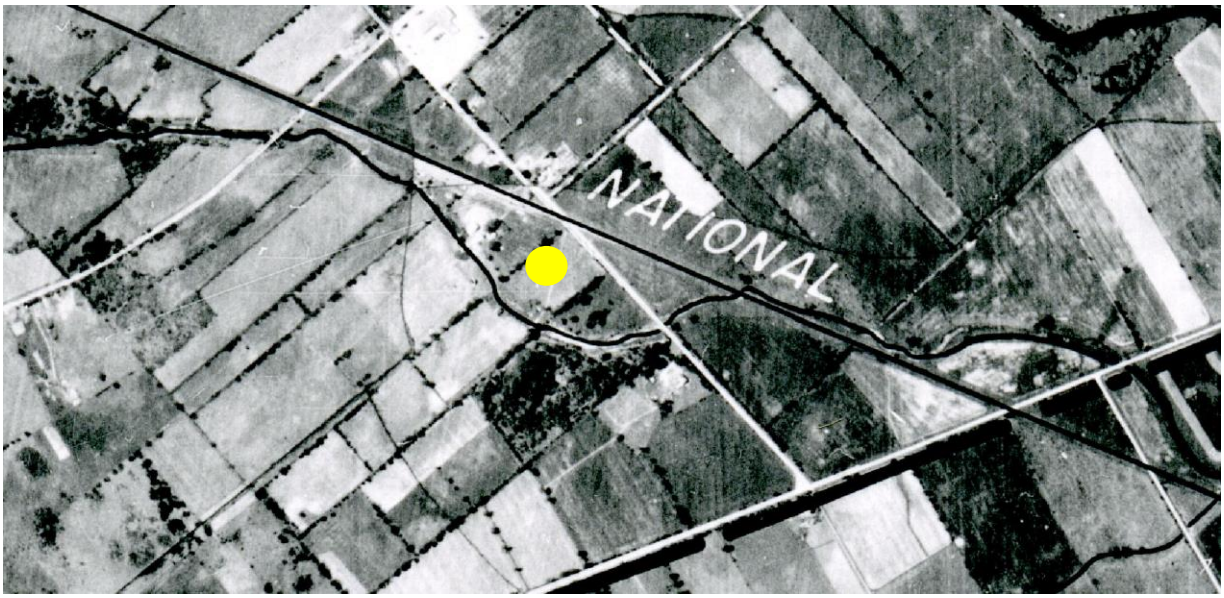
6038 Ottawa Street
Richmond, Ontario

GEO MORPHIX™

0 25 50 100
Metres

Imagery: Google Earth Pro, 2018.
Reach Break and Label: GEO Morphix Ltd., 2021.
0.5 m Contour: DSEL, 2021.
Watercourse and Railway: MNRF, 2021.
Printed: February 2021. PN21012. Drawn by: M.H., J.M., P.V.

Appendix C
Historical Aerial Photographs



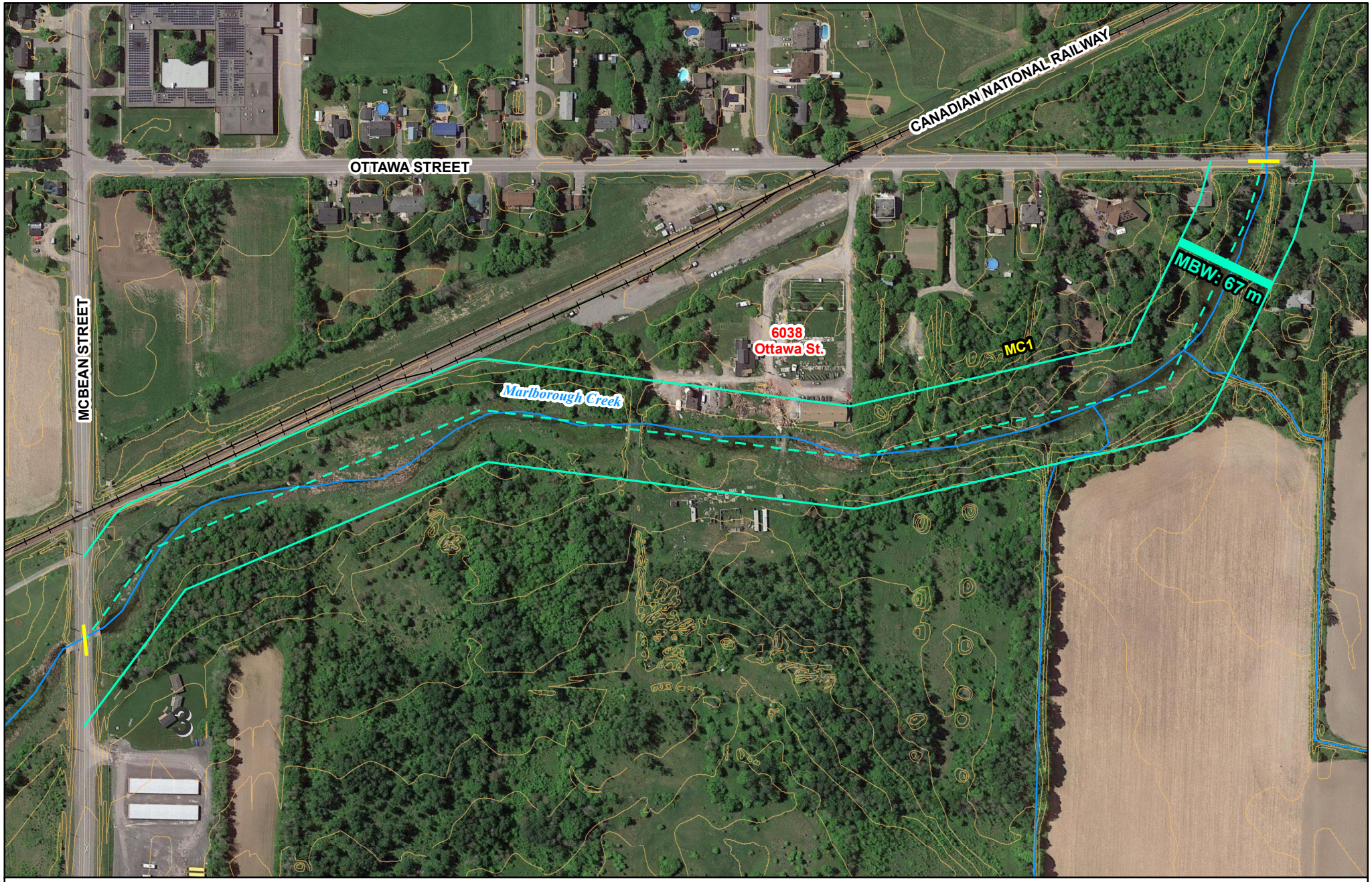
Location: 6038 Ottawa Street, Ottawa (Richmond), ON (yellow dot)
Year: 1954
Scale: 63,360
Source: McMaster University (Ontario Department of Lands and Forests)

Location: 6038 Ottawa Street, Ottawa (Richmond), ON (yellow dot)
Year: 1976
Source: City of Ottawa

Location: 6038 Ottawa Street, Ottawa (Richmond), ON (yellow dot)
Year: 1999
Source: City of Ottawa

Location: 6038 Ottawa Street, Ottawa (Richmond), ON (yellow dot)
Year: 2017
Source: Google Earth Pro

Appendix D
Meander Belt Width Delineation



Legend

- MC1 — Reach Break and Label
- Watercourse Central Tendency
- Meander Belt Width
- Watercourse
- Railway
- 0.5 m Contour

Meander Belt Width

Marlborough Creek

6038 Ottawa Street
Richmond, Ontario

GEO MORPHIX™

0 25 50 100
Metres

Imagery: Google Earth Pro, 2018.
Reach Break and Label, MBW, and Central Tendency: GEO Morphix Ltd., 2021.
0.5 m Contour: DSEL, 2021.
Watercourse and Railway: MNRF, 2021.
Printed: February 2021. PN21012. Drawn by: M.H., J.M., P.V.