April 24, 2025

Taggart Investments and
Algonquins of Ontario
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Attn: **Laura Maxwell, Taggart Investments**
Director, Land Development

Re: **Background Review and Drainage Characterization of Ramsay Creek**
Tewin Secondary Plan Area
City of Ottawa, Ontario
GEO Morphix Project No. 21063

This letter outlines a preliminary desktop assessment and supporting field assessment to define the geographical extent of the study area required to determine the potential impacts associated with the Tewin Secondary Plan Area on Ramsay Creek. We understand that the City of Ottawa and Rideau Valley Conservation Authority have both requested that a background review and gap analysis be completed to understand the extent of characterization completed to date for Ramsay Creek and the downstream receiving Green's Creek watershed. This letter summarizes a background review of existing fluvial geomorphological data, including data gap analysis, reach delineation, rapid and detailed field assessments, and provides overall drainage area characterization for the Ramsay Creek subwatershed. We examine the potential extent of impact for Ramsay Creek based on a methodology similar to what was previously presented to the City of Ottawa and the South Nation Conservation Authority for the Bear Brook watershed.

A background review of all documents about Ramsay Creek and the surrounding subwatersheds was completed. This work was completed to support planning studies for the Tewin Secondary Plan Area in the southeast of the City of Ottawa, Ontario (near Carlsbad Springs). It is understood that several environmental, planning, and engineering studies are required for the Tewin Secondary Plan Area. An initial assessment is needed to determine the appropriate spatial extent of geomorphological assessments to mitigate potential downstream impacts. At this stage of the project, our assessment focused on both the existing conditions within the Tewin Secondary Plan Area and a determination of the downstream areas that may be influenced by land use change within the Tewin Secondary Plan Area.

Our assessment consisted of a desktop analysis and field assessments to assess the potential sensitivity of the channels within and downstream of the Tewin Secondary Plan Area. The present letter provides a detailed background review and gap analysis based on other studies completed to date, as well as drainage characterization and assessment for Tewin drainage to Ramsay Creek. Rapid and detailed assessments were completed concurrently to provide a level of general characterization for the system. Our characterization of the sensitivity of watercourse features is undertaken from a geomorphological perspective, where sensitivity is assessed as a function of driving and resisting forces, as well as the controls that influence these forces. Driving forces are a product of drainage area, discharge, and slope (including valley gradient), whereas resisting forces are a product of physiography and surficial geology (including parent materials and substrate). It is important to note that modifications to driving and resisting forces also impact channel sensitivity. These modifications may include riparian vegetation and historical modifications to channel form and function.

For this drainage characterization and desktop assessment of Ramsay Creek, we completed a background review of drainage areas, physiography, geology, and channel networks for the Tewin Secondary Plan Area and downstream watercourses. It is assumed that other disciplines (i.e., Water Resource Engineering) would refine drainage areas and other hydrological factors as the project advances. We understand that a stormwater management plan will be developed for the site and that an effective stormwater management plan can mitigate the potential of development within the Tewin Secondary Plan Area to impact the hydrological and geomorphic regime of Ramsay Creek. Instream works could be required during development but will have broader environmental considerations. Any

instream works would be subject to agency review and approval during subsequent stages of the project review process.

This technical report summarizes the work completed to date to determine the downstream extent of the potential influence that the development of the Tewin Secondary Plan Area may have on the receiving watercourses. This memo does not provide a comprehensive study, and the assessment details provided below are preliminary in nature. They are intended to guide delineating an appropriate area for subsequent investigations and more detailed studies. The information reviewed as part of this preliminary assessment includes:

- Surficial Geology – Ministry of Northern Development and Mines (2010)
- Physiography of Southern Ontario – Chapman and Putnam (2007)
- Soil Survey Complex – OMAFRA (2020)
- Historical Aerial Imagery – City of Ottawa (2021)
- Watersheds Minor – City of Ottawa (2021)
- Subwatersheds – City of Ottawa (2021)
- Ottawa High-Resolution Digital Elevation Model – Natural Resources Canada (2020)
- Greens Creek Summary Report – City Stream Watch (2016)
- Ramsay Creek Catchment Report – City Stream Watch (2019)
- Establishing Static and Unit Thresholds for Erosion, Mud and McEwan Creeks – JTB Environmental Systems Inc. (2013)
- Fluvial Risk Mapping for Green's Creek Watershed – JTB Environmental Systems Inc. (2011)
- Integrated Fluvial Geomorphological and Hydrological Study for Green's Creek Watershed – JTB Environmental Systems Inc. (2009)
- NCC Greenbelt Lands within the Green's Creek Sub-Watersheds: Rehabilitation Projects – Douglas Associates Landscape Architects, and JTB Environmental Systems Inc. (2013)
- NCC Green's Creek Watershed Rehabilitation: Priority Rehabilitation Projects – Groupe Rousseau Lefebvre and JTB Environmental Systems Inc. (2014)

Site Description

The Tewin Secondary Plan Area is bound by Leitrim Road to the north, Farmers Way to the east, Thunder Road to the south, and Ramsayville Road to the west. The Tewin Secondary Plan Area covers an area of approximately 8.02 km^2. Land use within the subject area has not changed substantially from 1976 to present. Agricultural and natural areas occupy most lands, with few residential dwellings established along road networks. The Tewin Secondary Plan Area is primarily drained by Bear Brook, its tributaries, and headwater drainage features. Approximately 82% of the Tewin Secondary Plan Area drains to Bear Brook, with the remaining 18% draining to Ramsay Creek, a tributary to the Green's Creek watershed. The characterization and assessment for the Bear Brook drainage area are being addressed separately. Detailed descriptions of the hydrology and geomorphology associated with watercourse features within and outside of the Tewin Secondary Plan Area that drain to Ramsay Creek are provided in the subsequent sections. A review of relevant Ramsay Creek and Green's Creek watershed studies is provided below. Maps showing the 'Tewin Secondary Plan Area' and the 'Ramsay Creek and Green's Creek Watersheds' are provided in **Appendix A** for reference.

Background Review of Previous Studies and Ramsay Creek Gap Analysis

A detailed review of the documents below was conducted to understand relevant information associated with Ramsay Creek for current or future assessments. Past reports focused on conditions along the main Green's Creek subwatershed (downstream of Ramsay Creek) as well as the Mud Creek and McEwan Creek subwatersheds to Green's Creek. The information within these reports informs future studies as various information and data were collected near the Ramsay Creek subwatershed or within downstream locations. The studies provide insight into past historical information, meander bend studies, erosion threshold and overall erosion potential information, as well as past restoration strategies examined within the larger Green's Creek watershed. It should be noted that specific fluvial geomorphology data for the Ramsay Creek subwatershed has not been collected to date.

- *Integrated Fluvial Geomorphological and Hydrological Study for Green's Creek Watershed – JTB Environmental Systems Inc. and JF Sabourin and Associates (2009)*

A fluvial geomorphological and hydrological study of Green's Creek (downstream of Ramsay Creek subwatershed), Mud Creek, and McEwan Creek subwatersheds was completed by others in 2009 to inform strategies for the management of future stormwater impacts. The fluvial geomorphological component of the study included reach delineation, a long profile assessment, and field assessments. The hydrological component included drainage boundary delineation, land use area delineation, and flow monitoring. A sediment transport potential analysis was also completed throughout Green's Creek, Mud Creek, and McEwan Creek subwatersheds. Greens Creek showed fluctuations between erosion and deposition over short distances consistently along its profile. A meander bend assessment was also conducted to inform overall creek stability through each of the subwatersheds and concluded that meanders throughout the creek were generally stable. Based on the sediment transport potential analysis, sensitivity to erosion varies throughout the Green's Creek watershed and it was recommended that strategies be developed to prevent erosion or deposition beyond the extent of existing conditions. This study did not provide characterization data for the Ramsay Creek subwatershed specifically, but it does provide an indication of channel stability along the main Green's Creek further downstream.

RGA results for the Green's Creek reach immediately downstream of the confluence between Ramsay Creek and Green's Creek Headwaters (Reach 4) indicated that the channel in this area was Stable at the time of the assessment. The RGA score was 0.146, with Aggradation (2/7) being the limiting factor. The reaches downstream were both stable and transitional, with increasing RGA scores (i.e., increasing instability) and increasing distance downstream up to the confluence with Mud Creek. Based on aerial photography assessments, land cover within the Ramsay Creek subwatershed was determined to be approximately 98% pervious and 2% impervious. Agricultural fields and roads comprised the respective land uses contributing to those proportions. A flow monitoring site (Site #1) was located downstream of the confluence between the Ramsay Creek and Green's Creek Headwaters subwatersheds. The study also noted that the flow data was limited and should only be used for contemporaneous comparative assessments across the Green's Creek watershed. Additionally, it was noted that flow information for Site #1 was likely not representative due to significant beaver activity upstream.

A long profile of the Green's Creek main channel from Site #1 to the confluence with the Ottawa River was delineated using 1-meter resolution LiDAR-derived surface models. It was noted that the long profile should only be interpreted as a depiction of relative slope. The slope downstream of Site #1 at the upstream end of the long profile is relatively moderate and transitions to a relatively low slope at the next downstream measurement site, approximately 1 kilometer downstream. The sediment transport potential analysis took the long profile into account. It concluded that the section of Green's Creek from Site #1 to approximately the confluence with Borthwick Creek was one in which deposition was expected to occur.

- *Fluvial Risk Mapping for Green's Creek Watershed – JTB Environmental Systems Inc. (2011)*

A 2011 fluvial study was completed as a follow-up to the 2009 study completed for Green's Creek, Mud Creek, and McEwan Creek subwatersheds. The study addressed 81 reaches throughout the subwatersheds. Existing conditions were documented with respect to their sensitivity to land use changes within or adjacent to the creeks. Several assessments were presented in this report to address the risk sensitivity, including meander calculations, historical aerial photo analysis, rapid geomorphic assessments, and overall reach risk and sensitivity. Slope stability and meander risk setbacks were determined based on the Ontario Ministry of Natural Resources Hazards guide to assessing natural hazards. It was recommended that reaches that are determined to be highly sensitive require detailed assessments to mitigate safety risks due to the likelihood of responding to changes in surrounding land use. The results concluded that the Green's Creek watershed is sensitive to the forces acting upon it, which in the past has resulted in large-scale changes like landslides. Again, this study also did not

provide characterization data for the Ramsay Creek subwatershed specifically, but it does provide an indication of channel stability along the main Green's Creek downstream.

Rapid assessments were conducted, and results updated based on new observations. The results indicated that the reach immediately downstream of the confluence between Ramsay Creek and Green's Creek Headwaters (GCMR1) was stable. The RGA score was 0.193, with Aggradation (3/7) being the limiting factor. This updated score was greater than that of the 2009 assessment (i.e. 0.146), with a 1-point increase in Aggradation compared to the 2009 assessment (i.e. 2/7) and a 1-point decrease in Widening. The reaches downstream were both Stable and Transitional, with the greatest RGA score of 0.379 in the reach immediately upstream of the confluence between Green's Creek and Mud Creek. The sensitivity analysis determined that reach GCMR1 was moderately sensitive to land use changes, stormwater outfall inputs, transportation corridor runoff, and the impacts of irrigation on local shallow groundwater supply. Overall, GCMR1 was determined to be moderately sensitive to risk.

- *Establishing Static and Unit Thresholds for Erosion, Mud and McEwan Creeks – JTB Environmental Systems Inc. (2013)*

A 2013 study was also completed to determine erosion thresholds for the Mud Creek and McEwan Creek subwatersheds. The entirety of the Mud Creek watershed and the lower portions of McEwan Creek were assessed. Six sites on Mud Creek and three sites on McEwan Creek were selected for erosion threshold assessments based on the most sensitive reaches. The threshold values were determined to be low due to the geology through which the creeks flow (especially Leda Clay). It was recommended that exceedance analysis be required to determine the impacts of any stormwater design, including the proposed stormwater monitoring strategy. This information may be used to understand erosion sensitivity and potential in other locations within the overall Green's Creek watershed. The information and methodology, in part, may be used to inform mitigation strategies within the Ramsay Creek subwatershed.

- *NCC Greenbelt Lands within the Green's Creek Sub-Watersheds: Rehabilitation Projects – Douglas Associates Landscape Architects, and JTB Environmental Systems Inc. (2013)*

A 2013 study was also completed with the purpose of identifying potential restoration opportunities to address stressors occurring throughout the Green's Creek Watershed. JTB's (2013) study identified watershed goals and objectives and potential restoration opportunities. Reaches were assessed for potential restoration opportunities based on aerial photographs, topographic mapping, and various site visits. Each opportunity was also classified as having a specific level of risk associated. Many different types of opportunity categories were identified within the report including but not limited to wetland creation and toe erosion control. Overall, the study identified 377 potential restoration opportunities in the study area. Note that this study did not review any part of the Ramsay Creek subwatershed.

- *East LRT Planning and Environmental Assessment – Fluvial Geomorphology Report - AECOM (2015)*

A fluvial geomorphological study of Green's Creek, Cyrville Drain (tributary of Green's Creek), Voyager Creek (West Bilberry Creek), East Bilberry Creek, and Taylor Creek subwatersheds was completed by AECOM in 2015 to inform the design process and environmental commitments for the EPR. The assessment included review of existing conditions, reach delineation, historical assessment, field assessments. Based on the assessments completed the report concluded that the construction related to the LRT and / or highway widening would provide an opportunity to improve the watercourses. Improvements could include removal of failed engineering material and the implementation of natural channel design along the watercourses. This study also addressed potential watercourse constraints and considerations. The study recommended that should any changes to watercourse crossings occur then where possible new designs should avoid new crossings, channel realignment, meander bends, minimize the length of channel enclosure, and maintain channel form and function. The Ramsay Creek

subwatershed was not characterized specifically, but it does provide an indication of channel stability along the main Green's Creek downstream.

- *Ramsay Creek Catchment Report – City Stream Watch and RVCA (2019)*

The Ramsay Creek Catchment Report summarizes desktop and field assessments conducted during the spring and summer of 2019 by City Stream Watch. The summary shows the Ramsay Creek watershed from the headwaters south and west of Letrim to downstream of the confluence with McEwen Creek near the Walkley ramp to Highway 417. Approximately 10 kilometers of the main channel and 1 kilometer of a tributary were walked for the field assessment. Observations included riparian and aquatic flora, stream shading, riparian and aquatic fauna, bank erosion, channel substrate, channel morphology, in-channel woody debris, beaver dams, water chemistry, water temperature, groundwater indicators, and pollution. Opportunities for riparian and stream restoration and enhancement were identified based on these observations.

The desktop assessment assessed land use within the Ramsay Creek watershed, determining that agriculture comprises the largest land use class at approximately 37%, while forest is the next largest class at approximately 33%. The riparian buffer was classified into 3 categories of Highly Altered, Altered, and Natural, with approximately 19% of the riparian area along the length surveyed falling into the Highly Altered class. Relative bank stability was assessed based on the presence of common erosion indicators, and approximately 89% of the length of the survey showed evidence of bank erosion. Active beaver dams were identified at 9 locations along the length of creek surveyed. Native clay deposits were found to comprise the dominant substrate along approximately 75% of the length surveyed, while silt comprised 22%, and gravel and cobble comprised 3% cumulatively. Moderate amounts of woody debris were found throughout the length surveyed. Erosion mitigation and habitat enhancement were recommended for the most impacted sections along Ramsay Creek.

- *Fluvial Geomorphology Study Tewin Lands Existing Conditions Summary Report Bear Brook and Ramsay Creek Watersheds - GEO Morphix Ltd. (2023)*

A fluvial geomorphological study of Ramsay Creek and Bear Brook was completed by GEO Morphix in 2023 in support of a proposed development within the headwaters of the respective watercourses. The objectives were to establish an understanding of existing conditions and identify opportunities and strategic considerations that will inform the design process and future site-specific technical studies. The work included a historical assessment, rapid assessments, detailed assessments of select reaches, hazard delineation, and an assessment of drainage crossings along proposed servicing line routes. The historical assessment found that land use within the Ramsay Creek watershed has been comprised largely of agricultural fields throughout the available imagery record from 1965 to present. RGAs were completed within the headwaters of Ramsay Creek and all reaches were classed as being in Transition, with scores ranging from 0.28 to 0.40. Widening was commonly found to be the dominant form of systematic adjustment. A detailed assessment was completed along reach RC1, immediately upstream of the Highway 417 crossing over Ramsay Creek. The hazard delineation found a mix of unconfined and confined reaches for which preliminary meander belt widths or toe erosion allowances were determined. The crossing assessment identified locations where watercourses and drainage ditches intersected with proposed servicing lines routed along existing roadways. Overall, the fluvial geomorphological assessment concluded that watercourses within the Ramsay Creek headwaters are impacted by historic agricultural activities, with many straightened channels surrounded by degraded riparian areas. These conditions were noted to present opportunities to enhance channel stability and habitat through stormwater management and natural channel design.

In summary, previous studies have been completed within the Ramsay Creek subwatershed as well as downstream of the Ramsay Creek subwatershed in association with Green's Creek or other subwatersheds that drain to Green's Creek. These studies have included various elements of fluvial geomorphological analysis, including reach delineation, erosion hazard or meander migration analysis, and erosion potential and sensitivity analysis.

Subsequent sections of this letter provide an overview of our preliminary desktop characterization for sections of Ramsay Creek downstream of the Tewin Secondary Plan Area and outline recommendations for additional study of Ramsay Creek.

Watershed Scale and Discharge Assessment

Tewin Secondary Plan Area (8.90 km^2) is situated in the headwaters of the Bear Brook and Ramsay Creek watersheds. Bear Brook is a tributary of the South Nation River and drains an area of approximately 446 km^2. Ramsay Creek is a tributary of Green's Creek which drain areas of approximately 14 km^2 and 120 km^2 respectively; Green's Creek is a tributary of the Ottawa River. The Tewin Secondary Plan Area occupies roughly 12% of the Ramsay Creek watershed area and roughly 1% of the watershed area for the entire Green's Creek watershed.

To provide a preliminary assessment of the relative discharge contributions of the Tewin Secondary Plan Area to and within the Ramsay Creek subwatershed, we employed a methodology derived from the Canada/Ontario Flood Damage Reduction Program – Regional Flood Frequency Analysis for Ontario Streams published by Environment Canada (Moin and Shaw, 1985). We used this methodology to provide discharge estimates for (i) the inlets/outlets to the Tewin Secondary Plan Area; and (ii) at key confluences downstream of the Tewin Secondary Plan Area. This approach provides estimates of low, mean, and flood flows by employing a series of regional hydrological models and empirical relationships. Flow prediction is executed following drainage area delineation. Drainage areas were derived using subwatershed boundaries from the City of Ottawa and RVCA (2019). It is important to note that all information derived using this approach is for preliminary analyses only and will require further verification using more detailed flow assessment methodologies. The specific locations selected for this discharge assessment were identified to contextualize the flow contributions from the Tewin Secondary Plan Area with regard to the stepwise increase in the discharge of Ramsay Creek at key tributaries downstream. These assessment locations are specific to this preliminary assessment and are not necessarily those which would be used for future monitoring programs.

The results of our desktop hydrological comparison are summarized in the table below with reaches and discharge assessment locations (i.e., Nodes A to H) shown on the figures titled 'Ramsay Creek Reach Delineation' and 'Ramsay Creek and Green's Creek Watersheds', respectively, in **Appendix A**. Below we have highlighted the Q_2 discharge metric which refers to the flood discharge with a theoretical return period of two years (i.e., exceedance probability of 50% in any given year). Regarding stream geomorphology, the Q_2 flood discharge estimate provides a reasonable approximation of the bankfull discharge in alluvial stream channels. For the Ramsay Creek watershed, the Q_2 flood flow for the two outlets draining the Tewin Secondary Plan Area are estimated at 0.28 and 0.56 m^3/s respectively for a net contribution of ~0.84 m^3/s of the Q_2 discharge. These flow contributions of Ramsay Creek discharge originating from the Tewin Secondary Plan Area account for roughly: (i) 35% of the discharge immediately downstream of the first confluence located 600 m north of Leitrim Road (Node C); (ii) 18% of the discharge immediately downstream of the first major confluence located at Highway 417 and approximately 2.8 km downstream of the Tewin Secondary Plan Area (Node D); (iii) 9% of the discharge at the confluence at east of Ramsayville Road and Highway 417 and approximately 4.5 km downstream of the Tewin Secondary Plan Area (Node E); (iv) 4% of the discharge immediately downstream of the confluence with Green's Creek and Borthwick Creek and west of the Highway 417, approximately 7.5 km downstream of the Tewin Secondary Plan Area (Node F); (v) 3% of the discharge at Green's Creek east of Cyrville Road, approximately 10 km downstream of the Tewin Secondary Plan Area (Node G); and (vi) 2% of the Q_2 discharge of Green's Creek at its confluence with the Ottawa River, approximately 15 km downstream of the Tewin Secondary Plan Area (Node H).

Location	Upstream Drainage Area (km^2)	Tewin Portion of Drainage Area (%)	Mean Annual Flow (m^3/s)	Q_2 Flood Flow (m^3/s)	Q_2 Fraction (Block/ Location)
Tewin Secondary Plan Area; outlet at Leitrim Road west of Anderson Road (Node A)	0.52	100	0.008	0.28	--
Tewin Secondary Plan Area; outlet at Leitrim Road east of Ramsayville Road (Node B)	1.12	100	0.017	0.56	--
Confluence of Ramsay Creek tributaries north of Leitrim Road (Node C)	5.72	28.67	0.051	2.43	0.35
Hwy 417 at Ramsayville Road (Node D)	12.18	13.46	0.148	4.79	0.18
Ramsay Creek subwatershed (Node E.1)	14.02	11.69	0.171	5.43	0.15
Confluence with Ramsay Creek Tributary from Mer Bleue (Node E.2)	25.26	6.49	N/A*	9.21	0.09
Green's Creek at the confluence of Borthwick Creek and Green's Creek; west of Hwy 417, north of Walkley Road (Node F)	63.89	2.57	0.616	21.15	0.04
Green's Creek East of Cyrville Road (Node G)	83.52	1.96	0.918	26.88	0.03
Green's Creek North of Innes Road (Node H)	119.88	1.37	1.445	37.16	0.02

*Mean annual flow values were initially derived using the Ontario Flow Assessment Tool, which has since been discontinued. No mean annual flow estimate is available for the new Node E.2 as a result.

To identify an appropriate geographical extent of analysis for determining impacts from changes to hydrology, the Toronto and Region Conservation Authority (TRCA) prepared a guiding document for the planning and design of stormwater management infrastructure (TRCA, 2012). The guiding document provides an outline of processes and infrastructure required to address flooding, water quality, erosion, water balance, and natural heritage (TRCA, 2012). This TRCA document suggests that the limit of significant downstream impacts is associated with the capacity of the downstream watercourse to assimilate changes in hydrology (2012). Generally, assimilation capacity will be lower in smaller streams and smaller drainage areas (i.e., more sensitive) and higher in larger streams and drainage areas (i.e., less sensitive) with the degree of impact is related to the relative size (or ratio) between the drainage areas that will undergo landscape changes and the drainage area of the receiving watercourse. Therefore, a straightforward approach for assessing potential impacts is to calculate and compare drainage areas and 2-year flood flows at points along the length of the receiving/downstream watercourse (TRCA, 2012).

Similarly, the Credit Valley Conservation Authority (CVC) also prepared a guiding document for the planning and design of stormwater infrastructure (2022). Specific to the relationship between drainage area and the impact of development, CVC recommends that calculations for downstream impact assessment be provided up to a downstream confluence point, or alternatively by assessing the potential impact of development to a point downstream where the developed property accounts for 10% of the total drainage area (CVC, 2022).

Our watershed-scale discharge assessment and, preliminary assessment of geomorphological and geological characteristics of the channel network (provided below), indicate that potential downstream impacts from the Tewin Secondary Plan Area are unlikely to extend beyond the culvert crossing at Highway 417 (i.e., Node D). Our understanding is that any hydrological modifications from future land use changes are likely to be successfully addressed with appropriate stormwater management controls and that the planned development of the Tewin Secondary Plan Area is not expected to increase peak flows to Ramsay Creek. There are a significant number of additional tributaries that contribute flow downstream of the Tewin Secondary Plan Area and upstream of Highway 417 (i.e., Node D) such that the Tewin Secondary Plan Area accounts for 13% of the total drainage area and 18% of the Q2 flood flow at this location. Further downstream, the Tewin Secondary Plan Area accounts for approximately 12% of the drainage area and 15% of the Q_2 flood flow at the confluence with the Mer Bleue Tributary (i.e., Node E.1), and approximately 3% of the drainage area and 4% of the Q_2 flood flow at the confluence with Borthwick Creek (Node F).

Our assessment results suggest that an assessment along the channels upstream of the confluence with the headwaters of Green's Creek (i.e., Node E) should be sufficient to identify and evaluate any potential downstream impacts within the Tewin Secondary Plan Area to downstream watercourses. Although, given that there are no existing background studies of the farthest downstream portion of Ramsay Creek and upstream portion of Green's Creek (between Node D and Node F), we recommend reviewing those sections as well to provide a level of verification and supporting information.

Channel Network Characterization

The following subsections summarize the results of our desktop geomorphological assessment and field results of the mainstem of Ramsay Creek from the Tewin Secondary Plan Area through to its confluence with Green's Creek and ultimately the Ottawa River. River or channel morphology and planform are largely governed by the channels flow regime and the availability and type of sediments (i.e., surficial geology) within the stream corridor. Physiography, riparian vegetation, and land use also either directly or indirectly influence channel morphology. These factors are assessed and summarized below for each of the stream segments outlined in the table above. Our desktop assessment and field assessments provide insight into existing conditions and the extent and magnitude of potential changes to channel morphology that may result from the Tewin Secondary Plan Area.

Rapid geomorphic assessments were completed between in June 2022 and December 2023, and included the following reach-by-reach observations along the downstream portions of Ramsay Creek from Leitrim Road to the confluence with Green's Creek:

- Confirmation of desktop reach delineation extents
- Descriptions of riparian conditions
- Estimates of bankfull channel dimensions
- Determination of bed and bank material composition and structure
- Observations of erosion, scour, or deposition
- Collection of photographs to document the watercourses, riparian areas and/or valley, surrounding land use, and channel disturbances such as crossing structures
- Application of the Ontario Ministry of the Environment's (2003) Rapid Geomorphic Assessment (RGA) which identifies dominant geomorphic processes and documents stream health and stability
- Application of the Rapid Stream Assessment Technique (RSAT) (Galli, 1996) to provide a broader view of the system with regards to ecological function

These observations and measurements are summarized in **Table 1** and **Table 2** under **Appendix B**. Representative photographs of each reach are also included in **Appendix C**.

Two (2) detailed geomorphological assessments (i.e., channel surveys) were also completed to provide an additional level of detail on overall channel form and function along Ramsay Creek. One survey along reach **RC1** was completed approximately 120 meters upstream of Highway 417 in June 2022. This reach was selected for a detailed assessment as it was the farthest downstream reach where access was practical at the time of the Existing Conditions report (GEO Morphix, 2023). A second site along reach **RCB** was surveyed approximately 660 meters downstream of Highway 417 in December 2023. This reach was selected for the assessment as it has the highest RGA score compared to all other downstream reaches along Ramsay Creek and is therefore deemed the most erosion sensitive. Activities completed for the detailed assessments included the following:

- Longitudinal survey of the channel centre line
- Eight detailed cross-section surveys of the watercourse
- Detailed instream measurements at each cross-section location including bankfull channel geometry, riparian conditions, bank material, bank height/angle, and bank root density
- Bed material sampling at each cross-section following a modified Wolman (1954) pebble count or substrate sample, as appropriate

The resulting measured channel parameters are summarized in **Table 3** in **Appendix B**. A site map demonstrating watercourse reach delineation and locations of the detailed assessments titled 'Ramsay Creek Reach Delineation' can be referenced in **Appendix A**. A summary of both desktop and field assessment information is provided below based on various channel segments as referenced in **Appendix A**.

Tewin Secondary Plan Area (to Nodes A and B)

In the northern portion of the Tewin Secondary Plan Area, approximately 3.7 km of drainage features discharge to Ramsay Creek. These features have been assessed through both desktop and field-based assessments. The reaches across this portion of the Tewin Secondary Plan Area are predominantly low gradient, remnant agricultural drainage features, approximately 4-6 m wide that sit 0.2-0.5 m below the adjacent land surface. These upstream reaches flow through lands that are now forested. Here, the underlying surficial geology is fine-textured glaciomarine deposits comprised of silt and clay with minor deposits of sand and gravel (OGS, 2010). Channel beds of silt and clay are cohesive and less susceptible (more resistant) to erosion than non-cohesive sediments (i.e., sand/gravels).

Confluence of Ramsay Creek north of Leitrim Road (Node C)

Two unconfined, single threaded channels exit the Tewin Secondary Plan Area under Leitrim Road and flow in a northerly direction through agricultural fields until they merge approximately 600 m downstream. These features have been assessed through both desktop and field-based assessments. The field-based assessments are associated with **Reach RC4** (**Appendix A**)**.** The western most of the two channels is a straight agricultural low order drainage feature that transfers to a sand plain. It is 4-6 m wide in an unconfined setting with no obvious valley form or floodplain. The channel is incised 1.5 m below the elevation of adjacent agricultural lands and has a slope of ~0.2%. Across the channel there is a 9-13 m wide well-vegetated riparian zone extent. To the east, the second of the two channels is also a straightened agricultural low order drainage feature that is approximately 5 m wide and incised ~2.0 m below the adjacent agricultural fields. This channel has an average slope of ~0.3%, and a slightly wider riparian zone extent that is approximately 17-19 m in total width. Both channels are incised into cohesive Champlain Sea silts and clay deposits (OGS, 2010). Given the relatively shallow channel gradients and cohesive channel sediments, we can expect that the instream erosion thresholds for these two channels to be higher here than downstream reaches that are steeper and/or underlain by coarser grained less cohesive sediments.

Hwy 417 at Ramsayville Road (Node D)

From the first major confluence downstream of the Tewin Secondary Plan Area (i.e., Node C) Ramsay Creek flows north for ~2.2 km until it flows into a culvert under Highway 417. This length of Ramsay Creek was assessed through both desktop and field-based assessments and consists of **Reach RC1** to **RC3 (Appendix A)**. Flow contributions to this segment of the channel are almost exclusively from

tributaries that drain agricultural lands to the west of the channel. Here the channel is partially confined, ~2-6 m wide with a well-defined 30-40 m wide floodplain at the base of a ~80-100 m wide ravine. The average channel slope along this segment of Ramsay Creek is approximately 0.3% with the valley depth ranging from approximately 6-8 meters deep. Along this segment the channel is characterized by irregular meanders that have formed within a well-defined floodplain. Localized slumping was observed along the channel banks. Existing hydrogeomorphic conditions have caused the channel and ravine to incise into cohesive Champlain Sea silts and clay deposits and these deposits were exposed along localized valley wall contacts observed within the reach (OGS, 2010). While the bed and bank materials and channel slopes along this segment are similar to those immediately upstream, the morphology of the channel and floodplain suggest that there is potential for continued erosion in areas where the channel is in contact with or in close proximity to the walls of the ravine. Although, given that changes in erosive flow regime are not expected as a result of upstream land use changes with the Tewin Secondary Plan Area, we do not anticipate any issues with regards to channel stability.

Confluence with Ramsay Creek Mer Bleue Tributary (Node E)

Downstream of the Highway 417 culvert (i.e., Node D), Ramsay Creek is channelized for 550 m along Ramsayville Road where it then flows under Russel Road. Downstream of Russel Road Ramsay Creek flows for 1.6 km to its confluence with a tributary of Ramsay Creek which drains a portion of the Mer Bleue Bog to the northeast. These features have been assessed through both desktop and field-based assessments. The field-based assessments are associated with **Reach RCA** and **RCB** (**Appendix A**). Flow contributions to this segment of Ramsay Creek come almost exclusively from tributaries that drain agricultural lands. In contrast with the stream segment upstream of Hwy 417 where the channel is nested in a ravine, here the channel flows across a broad floodplain with gently sloping agricultural fields either side of the riparian corridor. The channel is incised into clay plains with the channel flowing within a paleochannel. Here the riparian corridor is roughly 70 m wide with channel widths in the range of approximately 6 to 8 m.

The morphology along this segment of the channel is initially characterized by irregularly shaped meanders downstream of Russell Road followed by a 550 m long relatively straight section with the channel again becoming more meandering upstream of the confluence (i.e., at Node D). Along this channel segment slopes vary from 0.1–0.3 %. The surficial geology here is again characterized by cohesive Champlain Sea silts and clays with a relatively short section of channel (i.e., 130m) flowing across coarser grained paleo-floodplain sediments (i.e., medium grained sands; OSG, 2010).

Our estimates indicate that immediately downstream of Highway 417, the Tewin area that drains to Ramsay Creek contributes approximately 18% of the Q_2 flood flows. As such, the channelized section of channel along Ramsayville Road may be susceptible to morphological changes in response to potential changes in hydrological regimes. Note that the lands within the straightened section of the channel are publicly owned lands belonging to the NCC. The occurrence and rate of channel change will be dependent on the cohesiveness of the bed and banks of the channel along this reach. If peak flows to Ramsay Creek from the Tewin Secondary Plan Area were expected to increase, more detailed assessment should be conducted along this reach. Similarly, channel reaches downstream of Russell Road would also be subject to more detailed study as the presence of potentially less cohesive paleo-floodplain sediments and irregular but well-developed meander sequences, including the presence of abandoned meanders, indicates the potential for accelerated rates of morphological change related to changes in hydrology. However, our current understanding is that peak flows from the Tewin Secondary Plan Area are expected to be maintained, and therefore detailed studies along this segment of Ramsay Creek are not required.

Green's Creek at the confluence with Borthwick Creek (Node F)

The Mid Reach of Green's Creek begins downstream of the confluence with the Ramsay Creek tributary flowing from the Mer Bleue Bog (i.e., Node E) and flows 3.8 km westward through wooded and cropped land to its confluence with Borthwick Creek which is located immediately to the northwest of the Hwy 417 interchange at Walkley Road. Flow contributions to this segment of Green's Creek come from tributaries that drain a combination of agricultural, forested, and build-up areas. Between the beginning of this stream segment and its intersection with Hwy 417 (approximately 2.2 km downstream of the Tewin Secondary Plan Area) the channel planform is characterized by a sequence of meanders with a wavelength and amplitude of roughly 130 m and 70 m respectively. At one location along this segment,

satellite imagery shows that the outside apex of a meander bend (Google Earth, June 2018) has been fortified with riprap. Approximately 900 m downstream of this location, Ramsay Creek flows through paired culverts under the westbound lanes of Hwy 417. From here, the creek flows under and along a hydro corridor for 1.5 km, through culverts under Walkley Road and then onto its confluence with Borthwick creek.

The channel widths along this segment are much wider, owing to the combined upstream inputs from the Ramsay Creeks, and range from 8 to 12 m with average channel slopes in the range of approximately 0.1%. Riparian vegetation along the channel corridor is highly variable with some reaches having more than 100 m of forest cover adjacent to the channel (i.e., in woodland areas) while along other reaches there is an absence of woody vegetation. Along this segment the channel and floodplain are crossed by various infrastructures (i.e., railway, highway, roadways). The channel is situated within a partially confined valley setting with the channel incised into a paleochannel. The surficial geology of the channel and floodplain areas are again characterized by cohesive Champlain Sea silts and clays (OSG, 2010). The bed and bank substrate in the field was observed to consist of clay, silt, and sand.

With the implementation of appropriate stormwater management facilities and strategies for the Tewin Secondary Plan Area that aim to match pre-development hydrology, it is anticipated that there will be no potential erosion concerns for this segment of Green's Creek nor with any of the subsequent stream segments discussed below.

Green's Creek at Cyrville Road (Node G)

From the confluence of Borthwick Creek and Green's Creek (i.e., Node F), Green's Creek continues to flow northeast for ~2.7 km through a forested hydro corridor, where it then passes under Highway 417 and then Cyrville Road. The channel is situated within a partially to fully confined valley setting with the channel incised into a paleochannel. Here the well-defined channel is approximately 20 m wide, with a floodplain approximately 100 m wide. For approximately 1 km downstream from the confluence with Green's Creek the channel planform is characterized by a sequence of meanders, whereas downstream of this point the channel has low sinuosity. The average channel gradient along this segment is approximately 0.1%. Downstream from Highway 417 to Cyrville road, the channel has been straightened for approximately 600 m and displays a trapezoidal cross-section with urban areas on either side of the channel corridor. As with most of the upstream segments the channel flows through and over cohesive glaciomarine deposits comprised of silt, clay, and sand (OGS, 2010).

Green's Creek from Cyrville Road to Confluence with the Ottawa River (Node H)

This segment of Green's creek flows primarily through woodlots/green space associated with the Ottawa Green Belt. The channel is situated within a partially to fully confined valley setting. The average channel widths through this section are in the range of 15-20 m, and the channel is nested in a valley that is approximately 200 m wide. Flow contributions to this segment of Green's Creek come from tributaries that drain primarily built-up areas to the northwest. The channel flows for approximately 1.8 km until it crosses under Innes Road for a second time. Downstream of this crossing the valley widens, and channel morphology is characterized by a sequence of meanders as the stream valley parallels a Golf Course for ~2.5 km. The channel then passes through culverts under St. Joseph Blvd. and Highway 174. The average channel gradient along the upper portion of this segment is approximately 0.7%; immediately downstream of St. Joseph Blvd. the average channel gradient increases to approximately 1% and Green's creek flows into a steeply sided ravine which runs from here through to its outlet at the Ottawa River. Here the channel has developed regular meanders with average amplitudes and wavelengths of 150 m and 300 m respectively. This portion of Green's Creek flows through glaciomarine deposits comprised of silt, clay and sand (OGS, 2010).

For reference, an additional figure titled 'Ramsay Creek Topography' is provided in **Appendix A** which shows a LiDAR derived hillshade digital elevation model for Ramsay Creek downstream of the Tewin Secondary Plan Area. The hillshade model provides a high-resolution delineation of the stream channels and valley corridors throughout the Ramsay Creek subwatershed. **Appendix A** also includes a figure titled 'Ramsay Creek and Green's Creek Surficial Geology' showing the distinct surficial geological units

underlying the Tewin Secondary Plan Area and Ramsay and Green's Creek watersheds and which are referenced in the text above.

Summary and Recommendations

This technical memo provides a review of relative drainage contributions and channel network characteristics along Ramsay Creek downstream of the Tewin Secondary Plan Area. The assessment is comparative in nature. The hydrological analysis is based on a region-specific hydrological relation between drainage area and stream discharge, and it should be expected that there will be updates and refinements to drainage areas and discharge estimates in future more detailed assessments.

Our watershed-scale assessment evaluated the relative potential for downstream impacts in the mainstem of Ramsay Creek through to its confluence with the Ottawa River via Green's Creek. Previous studies completed throughout the Green's Creek watershed have addressed fluvial geomorphic characterization and potential downstream impacts associated with development activities and overall land use change. However, there is a lack of previous study completed within the Ramsay Creek subwatershed specifically, with the exception of the recent study completed by GEO Morphix within the Ramsay Creek headwaters (2023).

To assess the extent of further study required, drainage area, physiography, surficial geology, and gradient (channel and valley) were examined at reach through to watershed spatial scales. The driving and resisting forces related to erosion potential that are influenced by changes in hydrology were reviewed based on a desktop analysis of these components. The physiographical and geological characteristics of the Ramsay Creek system were reviewed within and downstream of the Tewin Secondary Plan Area. The surficial geology within the subject lands consist primarily of cohesive silts and clays associated with offshore marine deposits.

In general, the greater the downstream drainage area relative to the development area the greater the assimilation capacity of the stream channel and therefore the less sensitive the channel is to changes in upstream land use and hydrology. Based on our analysis, it was determined that the drainage area associated with the Tewin Secondary Plan Area accounts for 11.7 % of the total drainage area of the Ramsay Creek watershed, and approximately 1% of total drainage area of the Green's Creek watershed at its confluence with the Ottawa River. As such, the Tewin Secondary Plan Area occupies a relatively small portion of the Ramsay Creek drainage area. It is anticipated that any inputs from future development will be minor and effectively managed with appropriate stormwater management controls. Reach-scale channel gradients within and downstream of the Tewin Secondary Plan Area are relatively shallow (i.e., generally <0.5%) throughout the Ramsay Creek system.

The results of this geomorphic assessment and drainage network characterization indicate that potential downstream impacts from the Tewin Secondary Plan Area are unlikely to extend beyond the culvert crossing at Highway 417 (i.e., Node D). Our assessment indicates that at this downstream extent, the Tewin Secondary Plan Area accounts for approximately 18% of the Q_2 flows and 13% of the upstream drainage area. However, we recommended that the extent of future studies consider Ramsay Creek downstream to Node F, given that there are no existing background studies of the farthest downstream portion of Ramsay Creek. These reaches were assessed as part of the work completed for the Updated Report and forthcoming studies in order to satisfy that recommendation.

Based on our understanding of proposed land use changes in the Tewin Secondary Plan Area and that flows will be controlled in the future condition we do not believe that additional detailed study is required for Ramsay Creek or Green's Creek downstream of Node D. However, given that there is limited information available for the Ramsay Creek subwatershed, out of an abundance of caution, we have completed field assessments along the middle section of the Green's Creek watershed, downstream of Hwy 417 to the confluence with Borthwick Creek (Node F). This activity was completed to document existing channel and valley conditions.

The present memo details a scoping exercise to identify the extent of the watercourse downstream that may be impacted by proposed future development within the Tewin Secondary Plan Area. An existing conditions report has been completed since the initial submission of this memo. We anticipate that defining an erosion threshold along the upper sections of Ramsay Creek (upstream of Hwy 417) may be

more appropriate given the smaller overall drainage area being assessed in that area. If changes in hydrology are limited or there is a proposed reduction in flows, then additional work downstream of Hwy 417 is likely not required. However, detailed field assessments within the reaches downstream of Node D were conducted out of an abundance of caution and an erosion threshold can be defined along this section of Ramsay Creek as well. Within the scoped study area (upstream of Hwy 417), we can complete further sensitivity analyses for specific reaches as required. We anticipate that erosion exceedance analyses using continuous hydrological modelling data will be completed as required.

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

Respectfully submitted,

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Jan Franssen, Ph.D.
Senior Watershed Scientist

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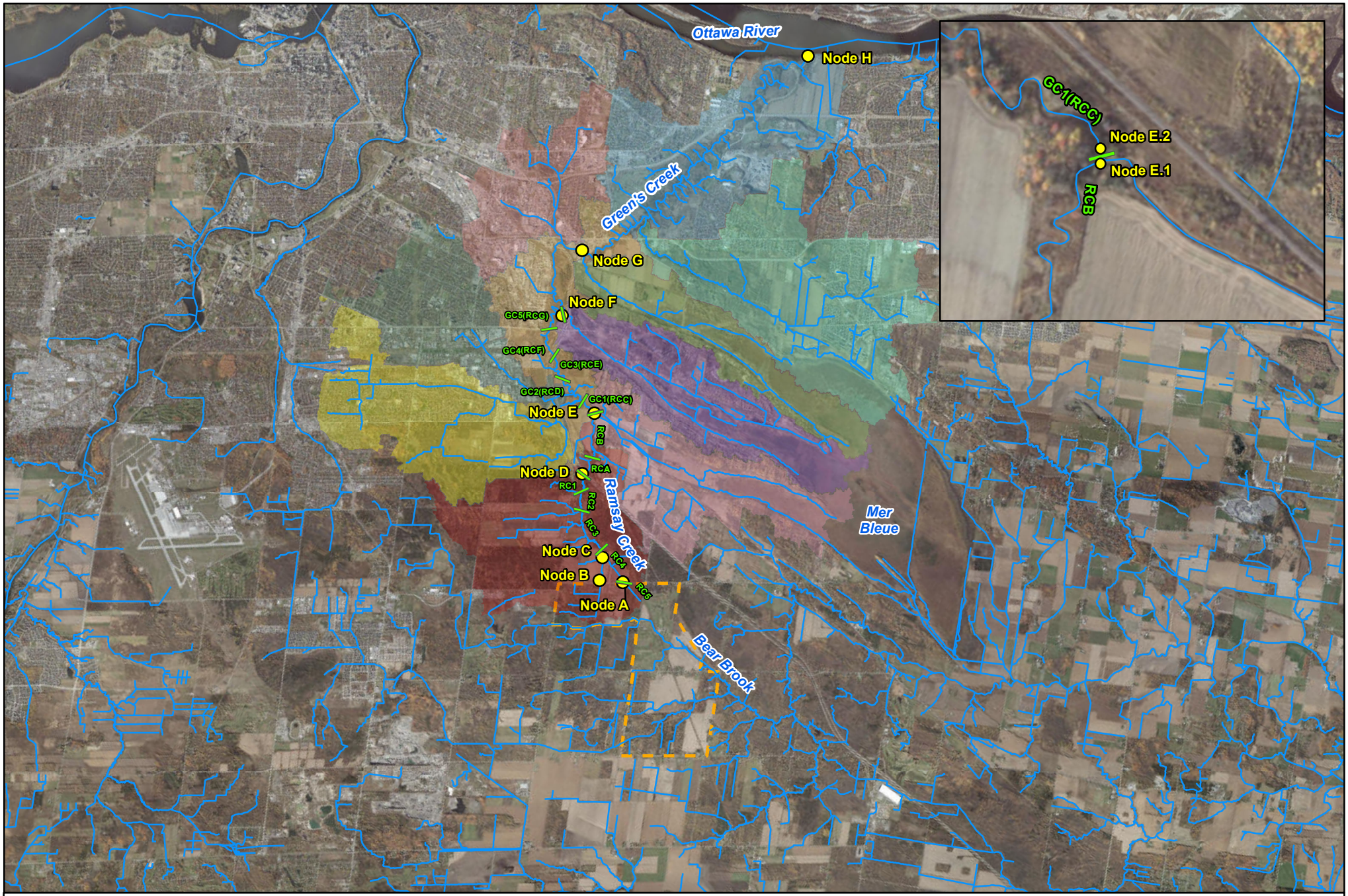
Appendix A
Figures



Legend

- Watercourse
- Reach Break and ID (Main Branch)
- Tewin Secondary Plan

Subwatershed

- Black Creek
- Borthwick Creek
- Cyrville Drain
- Green's Creek Downstream Reach
- Green's Creek Headwaters
- Green's Creek Mid Reach
- Mather Award
- McEwan Creek
- Mud Creek (Green's Creek)
- Ramsay Creek

Ramsay Creek and Green's Creek Watersheds

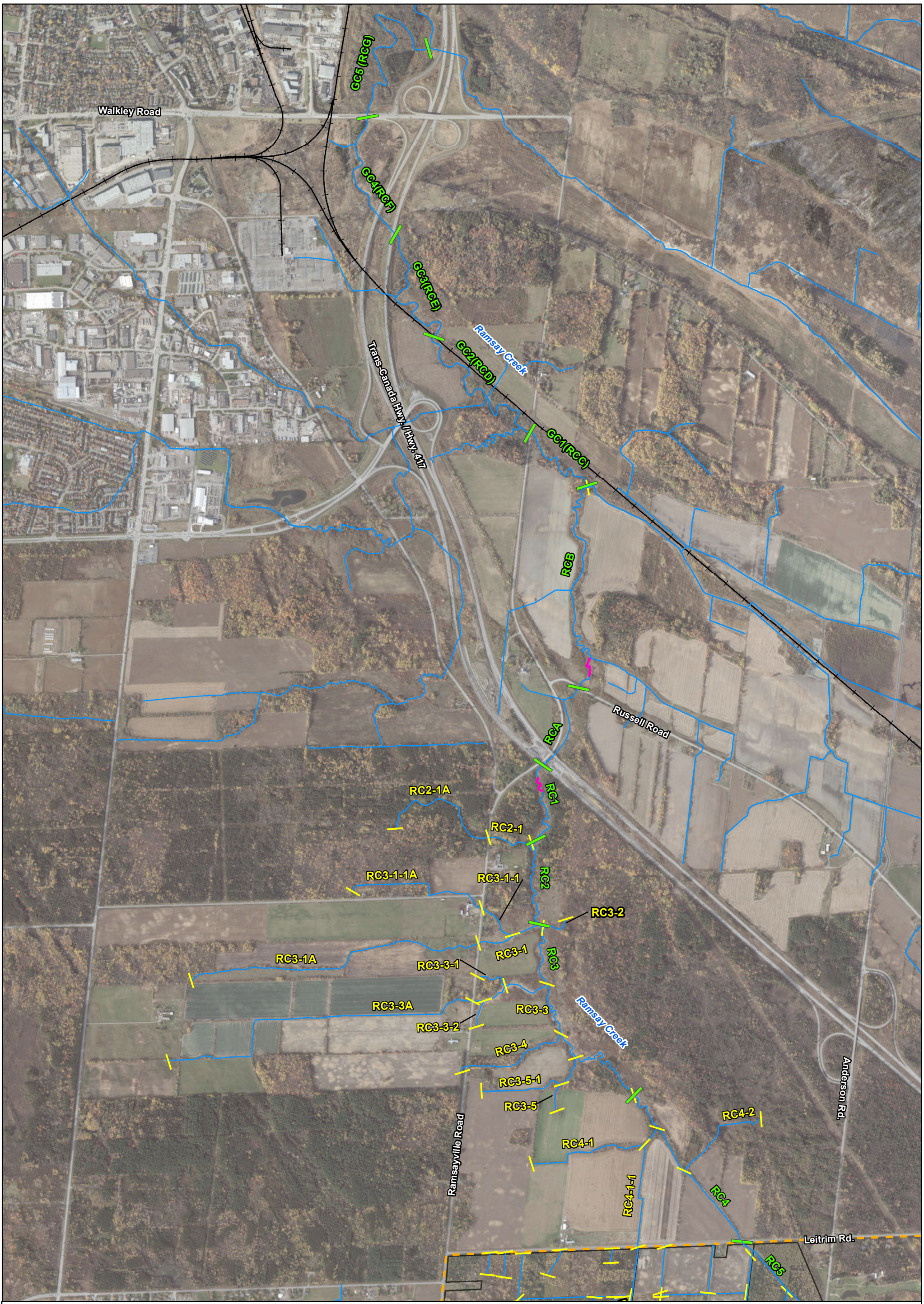
Ottawa, Ontario

0 1,500 3,000

Metres

GEO MORPHIX™

Imagery: City of Ottawa, 2019.
Boundary Areas: Algonquins of Ontario/Taggart, 2021., GEO Morphix Ltd., 2021. Subwatershed: RVCA, 2019. Pour Point: GEO Morphix Ltd., 2022.
Reach Break: GEO Morphix Ltd., 2024.
Watercourse: MNRF, 2020/GEO Morphix Ltd., 2022.
Print Date: April,2025. PN22024. Drawn By: M.O., K.Se.



Legend

- Reach Break and ID (Tributaries)
- Reach Break and ID (Main Branch)
- Watercourse
- Detailed Assessment Conducted
- Tewin Secondary Plan Area

Ramsay Creek
Reach Delineation

Ottawa, Ontario

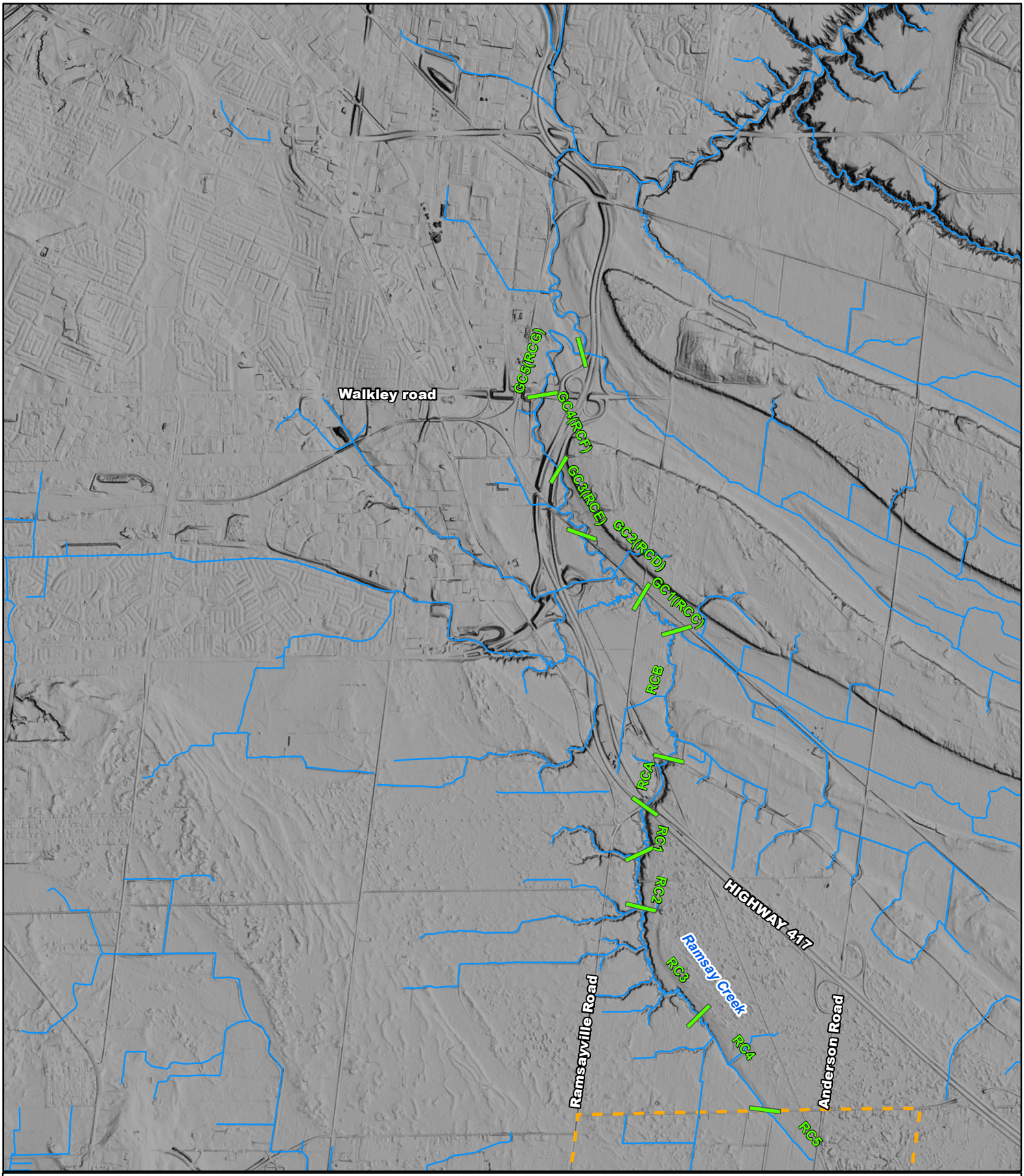
GEO MORPHIX™

N

0 310 620

Metres

Imagery: City of Ottawa, 2019.Watercourse: MNRF, 2021
Reach Break and ID: GEO Morphix Ltd., 2021/2023.
Detailed Assessment: GEO Morphix Ltd., 2021-2023.
1.0 m Contour: JFSA, (DEM interpolation), 2023.
Print Date: April 2025. PN22024. Drawn By: R.A., M.O., K.Se.



Legend

- Reach Break and ID (Main Branch)
- Watercourse
- Tewin Secondary Plan

Ramsay Creek Topography

Ottawa, Ontario

GEO MORPHIX™

N

0 500 1,000

Meters

Imagery: Google Earth, 2018. LiDAR: NRCan, May, 2020.
Bear Brook Main Branch: MNRF/GEO Morphix Ltd., 2022.
Watercourse: MNRF, 2020. RB: GEO Morphix Ltd., 2024.
Printed: April 2025. PN22024. Drawn By: M.O., K.Se.

Appendix B
Tables

Table 1. General reach characteristics summary

Reach Name	Avg. Bankfull Width (m)	Avg. Bankfull Depth (m)	Riffle Substrate	Pool Substrate	Valley Type	Dominant Riparian Condition	Node	Notes
RCA	5.6	1.7	Clay/silt-Boulder	Clay/silt-sand	Unconfined	Grasses, Herbaceous	Node E	• Riffle pool sequences (most likely added) at US extent • Scour and exposed tree roots on both banks throughout
RCB	8.2	1.8	Clay/silt-Cobble	Clay/silt	Unconfined	Grasses, Herbaceous	Node E	• Little riffle-pool morphology • Frequent slumping and scours, a few large cutfaces • Observations of several cutoff channels and old meanders through straitened sections • Bed composed of soft silt over compact clay
GC1 (RCC)	6.7	1.4	Clay/silt, Sand		Unconfined	Trees, Grasses	Node E	• Mostly runs • Bank scour on both banks throughout • Channel bed soft silt over compact clay
GC2 (RCD)	11.8	1.5	Clay/silt, Sand		Unconfined	Trees, Shrubs, Grasses	Node E	• Mostly runs • Large cutfaces where channel is in contact with agricultural field or rail line • Scour and undercuts throughout the reach • Beaver dam at downstream extent
GC3 (RCE)	10.1	1.8	Clay/silt, Sand		Unconfined	Trees, Shrubs, Herbaceous	Node E	• Mostly runs • Large cutfaces at 1-2 locations • Undercutting and slumps throughout • Woody debris frequent at the downstream extent
GC4 (RCF)	14.0	2.1	Clay/silt, Sand		Partially Confined	Trees, Grasses	Node E	• Channel enters a confined system with wide, flat floodplain • Large beaver dam at downstream extent • Valley wall contact at 1-2 locations at the upstream extent • Scour and slumps minor compared to upstream reaches

Reach Name	Avg. Bankfull Width (m)	Avg. Bankfull Depth (m)	Riffle Substrate	Pool Substrate	Valley Type	Dominant Riparian Condition	Node	Notes
GC5 (RCG)	13.8	1.8	Clay/silt, Sand		Confined	Trees	Node E	• Wide, flat channel • Basal scour and exposed tree roots common • 1-2 valley wall contact • Dense and frequent woody debris jams • Channel bed soft silt over compact clays
RC1	2.17	2.08	Clay-silt to cobble	Clay-silt, sand	Partially confined	Grasses	Node D	• Basal scour and undercutting are commonly observed throughout the reach. • Channel was eroding into the clay overburden. • Highly entrenched channel
RC2	7.09	1.45	Clay-silt to cobble	Clay-silt, sand	Partially confined	Grasses	Node D	• Entrenched channel with high banks and tall grasses. • Riffle-pool sequences observed. • Slumping and valley wall contact occurred at localized areas along the reach. • Some debris and riprap were observed.
RC3	N/A	1.78	Clay-silt, gravel, and cobble	Clay-silt, sand and some boulders	Partially confined	Grasses and Trees	Node D	• Heavy encroachment of the riparian vegetation • Riffle pool morphology observed. • Organic debris was found throughout the channel • Accretion of sand and gravel on point bars
RC4	N/A	1.78	Clay-silt to gravel	Clay-silt, sand	Unconfined	Shrubs	Node C	• Shrubs were heavily encroaching the channel • Basal scour throughout the reach • Accretion of sand and gravel on point bars • Riffles, pools, and runs were observed at generally even ratios

Table 2. Rapid assessment summary

Reach Name	Node	RGA (MOE, 2001)			RSAT (Galli, 1996)		
		Score	Condition	Dominant Systematic Adjustment	Score	Condition	Limiting Feature(s)
RCA	Node E	0.30	In Transition	Evidence of Widening	20	Fair	Riparian Habitat Conditions
RCB	Node E	0.43	In Adjustment	Evidence of Widening	18	Fair	Riparian Habitat Conditions
GC1 (RCC)	Node E	0.33	In Transition	Evidence of Widening	21	Fair	Riparian Habitat Conditions
GC2 (RCD)	Node E	0.40	In Transition	Evidence of Widening	24	Fair	Physical Instream Habitat
GC3 (RCE)	Node E	0.33	In Transition	Evidence of Widening	18	Fair	Riparian Habitat Conditions
GC4 (RCF)	Node E	0.33	In Transition	Evidence of Widening	23	Fair	Physical Instream Habitat and Riparian Habitat Conditions
GC5 (RCG)	Node E	0.33	In Transition	Evidence of Widening	24	Fair	Physical Instream Habitat
RC1	Node D	0.28	In Transition	Evidence of Widening	16	Fair	Riparian Habitat Conditions and Channel Stability
RC2	Node D	0.38	In Transition	Evidence of Widening	15	Fair	Riparian Habitat Conditions and Channel Stability
RC3	Node D	0.40	In Transition	Evidence of Planimetric Form of Adjustment	20	Fair	Channel Stability
RC4	Node C	0.34	In Transition	Evidence of Widening	26	Good	Physical Instream Habitat and Water Quality

Table 3. Average channel parameters for detailed assessment sites

Channel Parameter	RC1	RCB
Average bankfull channel width (m)	6.30	5.85
Average bankfull channel depth (m)	0.87	0.80
Average cross-sectional area (m^2)	7.2	7.2
Bankfull channel gradient (%)	0.20	0.26
Bed material D_{50} (mm)	<2	<2
Average bankfull velocity (m/s)	1.03	1.26
Average bankfull discharge (m^3/s)	5.13	5.89

Appendix C
Photographic Record

Photo 1
Ramsey Creek- Reach RCA, Ottawa, Ontario

Riffle pool morphology was observed well developed primarily along the downstream portion of the reach.

Photo 2
Ramsey Creek- Reach RCA, Ottawa, Ontario

Exposed roots were observed throughout the reach as were fallen and leaning trees.

Photo 3
Ramsey Creek- Reach RCA, Ottawa, Ontario

A significant armour layer was identified to be suspended within the banks.

Photo 4
Ramsey Creek- Reach RCA, Ottawa, Ontario

Slumping occurred in localized areas along the reach primarily in the downstream portion. Basal scour was also observed through more than 50% of the reach.

Photo 5
Ramsey Creek- Reach RCB, Ottawa, Ontario

The creek was run dominated with some pools and fewer riffles. Erosion and slumping was present along the banks commonly.

Photo 6
Ramsey Creek- Reach RCB, Ottawa, Ontario

Multiple cutoff channels and old meanders were noted throughout the reach.

Photo 7
Ramsey Creek- Reach RCB, Ottawa, Ontario

The substrate was observed to consist of clay, silt and sand through the pools and the banks. The few riffles observed generally ranged from clay, silt to cobbles.

Photo 8
Ramsey Creek- Reach RCB, Ottawa, Ontario

Beaver activity was present throughout this area with observations of pointed tree trunks and beaver dams along the creek.

Photo 9 Ramsey Creek- Reach GC1(RCC), Ottawa, Ontario	
	Basal scour and undercutting were observed throughout more than 50% of the reach with scour occurring along the inside of meander bends and through the riffles.
Photo 10 Ramsey Creek- Reach GC1(RCC), Ottawa, Ontario	
	The creek was observed to be run dominated with turbid water. No odour was detected at the time of site assessment.

Photo 11 Ramsey Creek- Reach GC1(RCC), Ottawa, Ontario	
	Midway through the reach a cut off channel was observed at a higher elevation with remnant water present.
Photo 12 Ramsey Creek- Reach GC1(RCC), Ottawa, Ontario	
	Leaning and fallen trees, organic debris, and exposed roots were commonly observed throughout the reach.

Photo 13
Ramsey Creek- Reach GC2(RCD), Ottawa, Ontario

At the upstream extent of the reach, two tributaries were inputting water to the main channel.

Photo 14
Ramsey Creek- Reach GC2(RCD), Ottawa, Ontario

The channel bank was observed to be eroding adjacent to the train tracks.

Photo 15
Ramsey Creek- Reach GC2(RCD), Ottawa, Ontario

Riffle pool morphology was not observed except for the depicted one riffle location which was approximately 12 metres long.

Photo 16
Ramsey Creek- Reach GC2(RCD), Ottawa, Ontario

Undermined fencing was observed along the reach due to erosion and basal scour. Basal scour and undercutting was observed commonly throughout the reach.

Photo 17 Ramsey Creek- Reach GC3(RCE), Ottawa, Ontario	
	Large cutfaces were observed where the channel came in contact with the edge of agricultural fields. Basal scour was observed along both banks throughout the reach.
Photo 18 Ramsey Creek- Reach GC3(RCE), Ottawa, Ontario	
	Large woody debris and down trees became more frequent relative to upstream reaches.

Photo 19 Ramsey Creek- Reach GC3(RCE), Ottawa, Ontario	
	Undercutting and exposed roots was observed at several locations along the reach. The channel substrate was composed of fine silts over compact clay.
Photo 20 Ramsey Creek- Reach GC3(RCE), Ottawa, Ontario	
	The downstream extent of the reach had grassy banks and exhibited a wide flat floodplain within a partially confined valley. The channel was dominated with runs and lack riffle-pool features.

Photo 21 Ramsey Creek- Reach GC4(RCF), Ottawa, Ontario	
	Throughout the reach, scour was observed, however not as continuous as observed at upstream reaches. The reach was dominated by runs and lacked riffle-pool features.
Photo 22 Ramsey Creek- Reach GC4(RCF), Ottawa, Ontario	
	A large beaver dam was observed towards the downstream extent of the reach, causing backwater. Extensive evidence of beaver activity was observed throughout the reach.

Photo 23 Ramsey Creek- Reach GC4(RCF), Ottawa, Ontario	
Undercutting was observed at 1-2 locations along the reach. Concentrated along inside banks. Exposed tree roots were commonly observed.	
Photo 24 Ramsey Creek- Reach GC4(RCF), Ottawa, Ontario	
Towards the downstream extent, the channel banks were well vegetated with little signs of erosion. The channel substrate was composed of fine silts over compact clay.	

Photo 25 Ramsey Creek- Reach GC5(RCG), Ottawa, Ontario	
	The reach travels within a forested area, leaning trees and exposed roots were commonly observed. The channel exhibited a meandering planform and was dominated by runs.
Photo 26 Ramsey Creek- Reach GC5(RCG), Ottawa, Ontario	
	Point bars were commonly observed along the inside meanders, most appeared stable, and a few were vegetated. The channel substrate was composed of clay and silt.

Photo 27 Ramsey Creek- Reach GC5(RCG), Ottawa, Ontario	
	Valley wall contact along outside meanders were observed at several locations along the reach.
Photo 28 Ramsey Creek- Reach GC5(RCG), Ottawa, Ontario	
	The downstream extent of the reach exhibited a straight planform and tall vertical banks.

Photo 29 Ramsey Creek- Reach RC1, Ottawa, Ontario	
	The reach exhibited a meandering planform throughout a large grassy meadow. The banks were well vegetated.
Photo 30 Ramsey Creek- Reach RC1, Ottawa, Ontario	
	Slumping was commonly observed throughout the banks on both sides of the channel.

Photo 31 Ramsey Creek- Reach RC1, Ottawa, Ontario	
	The reach was dominated by runs and no pool-riffle formations were observed. The water was turbid at the time of the assessment.
Photo 32 Ramsey Creek- Reach RC1, Ottawa, Ontario	
	Minor basal scour was common throughout the reach. The channel substrate was composed of fine silt over compact clays.

Photo 33 Ramsey Creek- Reach RC2, Ottawa, Ontario	
	The reach exhibits a meandering planform through a large meadow. The riparian zone is primarily grasses and the banks were well vegetated. The reach was dominated by runs.
Photo 34 Ramsey Creek- Reach RC2, Ottawa, Ontario	
	Instream vegetation was observed throughout the reach, and vegetation encroachment was heavy. Overbank deposition was observed at several locations along the downstream extent.

Photo 35
Ramsey Creek- Reach RC2, Ottawa, Ontario

Placed cobbles were observed halfway through the reach. This caused a back water effect upstream, where the channel is wide a flat.

Photo 36
Ramsey Creek- Reach RC2, Ottawa, Ontario

Minor basal scour was commonly observed along on or both banks at the upstream extent of the reach. The channel bed substrate throughout the reach was composed of fine silt over compact clay.

Photo 37
Ramsey Creek- Reach RC3, Ottawa, Ontario

The reach meanders through a large grassy meadow and had well vegetated banks. Vegetation encroachment was moderate to extreme in some locations.

Photo 38
Ramsey Creek- Reach RC3, Ottawa, Ontario

Deposition was commonly observed throughout the reach. Channel bed substrate was composed of fine silt over compact clays.

Photo 39
Ramsey Creek- Reach RC3, Ottawa, Ontario

A large, well established beaver dam was located halfway throughout the reach, causing a large area of backwater.

Photo 40
Ramsey Creek- Reach RC3, Ottawa, Ontario

Channel bank slumps and undercutting was observed frequently.

Photo 41
Ramsey Creek- Reach RC4, Ottawa, Ontario

The reach exhibits a straightened planform as it travels between two actively cultivated fields. The channel was dominated by runs with no riffle-pool features observed. The riparian edges were composed of grasses and trees in forested sections.

Photo 42
Ramsey Creek- Reach RC4, Ottawa, Ontario

Between sections of forest, the channel is narrow, and at times, poorly defined. Vegetation encroachment is extreme along most of the reach. Little signs of erosion were observed.

Photo 43
Ramsey Creek- Reach RC4, Ottawa, Ontario

A historic farm crossing was observed along the upstream extent of the reach. The buried culvert has caused backwatering.

Photo 44
Ramsey Creek- Reach RC4, Ottawa, Ontario

Along the upstream extent of the reach, the channel loses definition and flows interstitially though grasses and cattails.