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Appendix M

Geomorphic Assessment Report

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GUIDING SOLUTIONS IN THE
NATURAL ENVIRONMENT

Geomorphic Assessment

Warden Avenue from Major Mackenzie Drive to Elgin Mills Road City of Markham

Prepared For:

Regional Municipality of York

Prepared By:

Beacon Environmental Limited

Date: *Project:*

June 2021 **220329**

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1. Introduction

Beacon Environmental Limited (Beacon) has been retained by the Regional Municipality of York to undertake a geomorphic assessment to inform the Class Environmental Assessment (Class EA) process for the improvements to Warden Avenue from Major Mackenzie Drive (Y.R. 25) to Elgin Mills Road in the City of Markham. It is our understanding that the Class EA Study Area includes all lands within the existing right-of-way (ROW) of Warden Avenue and extends 300 metres north of Elgin Mills Road, and 300 m south of Major Mackenzie Drive (**Figure 1**).

The Study Area is located within the North Markham Future Urban Area (FUA) and captures portions of the Berczy Creek and Bruce Creek subwatersheds; both watercourses are tributaries of the Rouge River. These subwatersheds are situated within the jurisdiction of the Toronto and Region Conservation Authority (TRCA). Beacon was involved extensively in the *Berczy, Bruce, Eckardt and Robinson Creeks Subwatershed Study (SWS)*, servicing and planning studies completed in support of the FUA. The purpose of this geomorphic assessment is to summarize available background information and confirm existing conditions for watercourses relevant to the Warden Avenue Class EA Study Area to inform the road widening design process.

2. Policy Context

The following policies were reviewed as they relate to the Class EA Study Area.

2.1 Federal *Species at Risk Act*

The federal *Species at Risk Act* (SARA; 2002) is intended to prevent federally Endangered or Threatened wildlife (including plants) from becoming extinct in the wild, and to help in the recovery of these species. The Act is also intended to help prevent species listed as Special Concern from becoming Endangered or Threatened. To ensure the protection of Species at Risk (SAR), SARA contains prohibitions that make it an offence to kill, harm, harass, capture, take, possess, collect, buy, sell or trade an individual of a species listed in Schedule 1 of SARA as endangered, threatened or extirpated.

The federal SARA applies primarily to lands under federal jurisdiction and relies on Provincial laws to protect federal SAR habitat. On private land, SARA prohibitions apply only to aquatic species and migratory birds that are also listed in the *Migratory Birds Convention Act* (1994). The intent of SARA is to protect critical habitat as much as possible through voluntary actions and stewardship measures.

Redside Dace was uplisted in May 2017 to Schedule 1 of SARA meaning its status is confirmed as federally Endangered.

Regulations of SARA (2002) also apply to the Subject Lands property in relation to the *Migratory Birds Convention Act* (1994).

2.2 Federal Fisheries Act

Fish and fish habitat are protected under the federal *Fisheries Act* (1985) which was last amended on August 28, 2019 and is administered by Fisheries and Oceans Canada (DFO). The protection provisions of the *Fisheries Act* apply to all fish and fish habitat throughout Canada and the Act sets out authorities for the regulation of works, undertakings or activities that risk harming fish and fish habitat. Specifically, the protection provisions include two core prohibitions. One is against persons carrying on works, undertakings or activities that result in the “death of fish by means other than fishing” (subsection 34.4[1]), and the other is “harmful alteration, disruption or destruction of fish habitat” (subsection 35[1]; also referred to as “HADD”). The protection provisions are applied in conjunction with other applicable federal laws and regulations related to aquatic ecosystems, including the federal *Species at Risk Act*.

Fish habitat is defined in subsection 2(1) of the *Fisheries Act* to include all waters frequented by fish and any other areas upon which fish depend directly or indirectly to carry out their life processes. The types of areas that can directly or indirectly support life processes include, but are not limited to, spawning grounds and nursery, rearing, food supply and migration areas.

Under subsection 35(1) a person may carry on such works, undertakings or activities without contravening this prohibition, provided that they are carried on under the authority of one of the exceptions listed in subsection 35(2), and in accordance with the requirements of the appropriate exception. In most cases, this exception would be Ministerial authorizations granted to proponents in accordance with the Authorizations Concerning Fish and Fish Habitat Protection Regulations under the *Fisheries Act*.

Proponents are responsible for planning and implementing works, undertakings or activities in a manner that avoids harmful impacts, specifically the death of fish and HADD. Where proponents believe that their work, undertaking or activity will result in harmful impacts to fish and fish habitat, DFO will work with proponents to assess the risk of their proposed work, undertaking or activity resulting in the death of fish or HADD of fish habitat and provide advice and guidance on how to comply with the *Fisheries Act*.

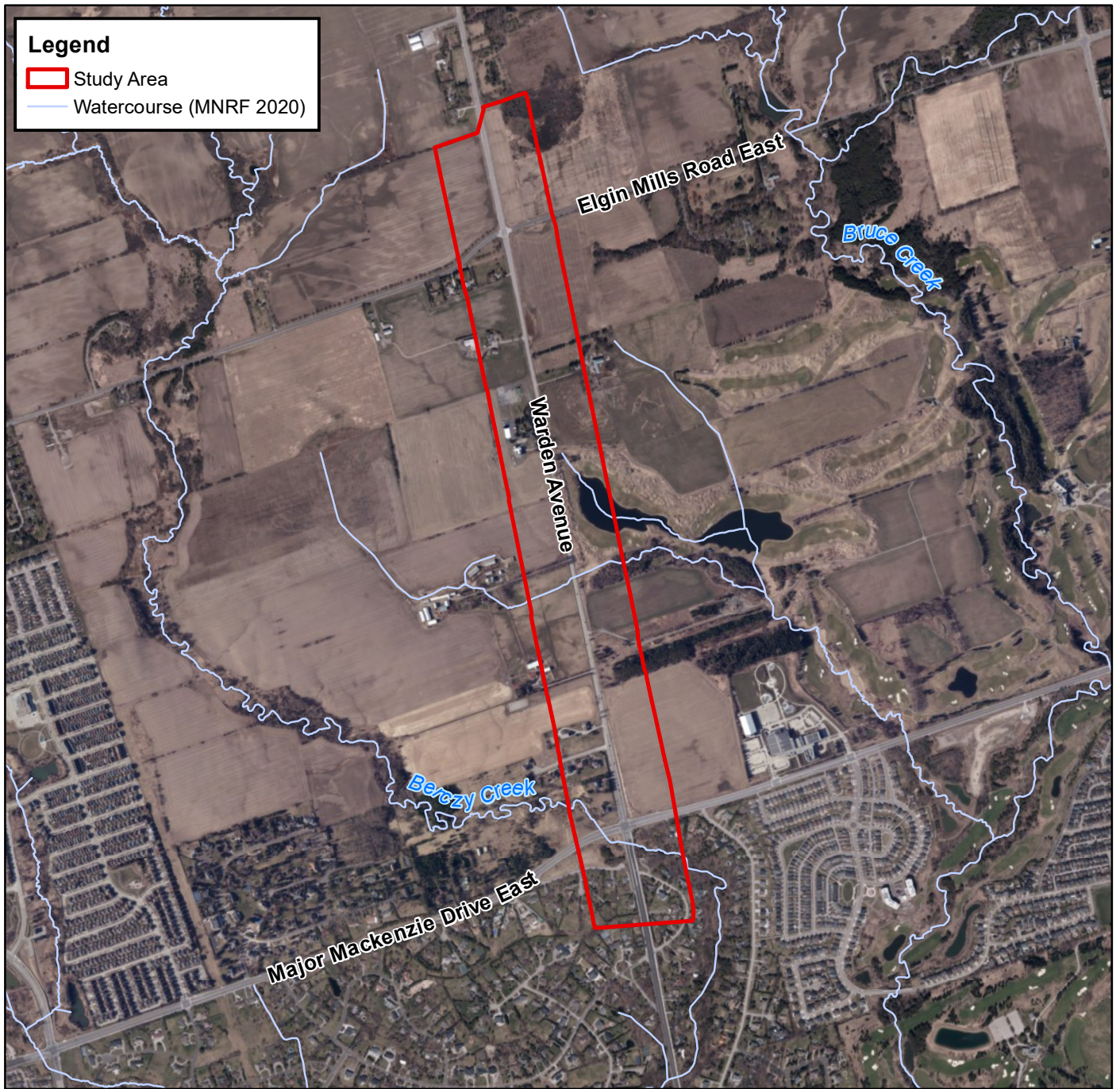
2.3 Provincial Policy Statement (2014)



Policy 2.1 of the Provincial Policy Statement (PPS; MMAH 2014) provides direction to regional and local municipalities regarding planning policies for the protection and management of natural heritage features and resources. The PPS defines seven natural heritage features and provides planning policies for each. The *Natural Heritage Reference Manual* (OMNR 2014) is a technical document used to help assess the natural heritage features listed below:

- a) Significant wetlands;
- b) Significant coastal wetlands;
- c) Significant woodlands;
- d) Significant valleylands;
- e) Significant Areas of Natural and Scientific Interest (ANSIs); and
- f) Significant wildlife habitat.

Legend

- Study Area
- Watercourse (MNR 2020)



Site Location	Figure 1	
Warden Avenue Geomorphic Assessment		
	Project: 220329.1 Last Revised: May 2021	
Client: Regional Municipality of York	Prepared by: DU Checked by: SG	
	1:20,000	Inset Map: 1:120,000
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Each of these features is afforded varying levels of protection subject to guidelines, and in some cases, regulations. Of these features, significant wetlands and ANSIs are designated by the Ministry of Natural Resources and Forestry (MNRF). MNRF also provides criteria for the determination of Significant Woodlands, which may also be identified by the municipality. Habitat of Endangered or Threatened species is governed by Ministry of Environment, Conservation and Parks (MECP) and is addressed through the *Endangered Species Act* (ESA). Fish habitat is governed by DFO. The identification and regulation of the remaining features is the responsibility of the municipality or other planning authority.

2.4 Provincial Greenbelt Plan (2017)

Portions of the Subject Lands lie within the Protected Countryside designation of the *Greenbelt Plan* area. Protected Countryside areas are those lands outside of Settlement Areas which are not prime agricultural areas and generally consist of a mixture of agricultural lands, natural features and recreational and historic rural land uses. Portions of the Subject Lands are also located within the Natural Heritage System (NHS) area as defined in Section 3.2 of the *Greenbelt Plan*.

The NHS policies protect areas of natural heritage, hydrologic and/or landform features to support biodiversity and overall ecological integrity. Section 3.2.2.3 of the *Greenbelt Plan* states that:

New development or site alteration in the Natural Heritage System (as permitted by the policies of this plan) shall demonstrate that:

- a. *There will be no negative effects on Key Natural Heritage Features (KNHFs) or Key Hydrologic Features (KHF) or their functions;*
- b. *Connectivity along the system and between KNHFs and KHF located within 240 m of each other will be maintained, or where possible, enhanced for the movement of native plants and animals across the landscape;*
- c. *The removal of other natural features not identified as KNHFs and KHF should be avoided. Such features should be incorporated into the planning and design of the proposed use wherever possible; and*
- d. *The disturbed area, including any buildings and structures, of the total developable will not exceed 25 percent, and the impervious surface of total developable area will not exceed 10 percent, except for uses described in and governed by Section 4.1.2 and 4.3.2.*

With some exceptions, the *Greenbelt Plan* prohibits development or site alteration in KNHFs and KHF within the NHS, including any associated Vegetation Protection Zone (VPZ). In accordance to Section 4.2.3.3, "...naturalized stormwater management systems may be permitted within the VPZ of a significant valleyland, provided they are located a minimum of 30 m from the river or stream, and they are located outside of the VPZ of any KNHFs and KHF."

The Key Natural Heritage Features and Key Hydrologic Features Policy identified in section 3.2.2.3 of the *Greenbelt Plan* also identifies new development or site alteration in the NHS (as permitted by the policies of this Plan) shall demonstrate that:

- a. *There will be no negative impacts on KNHF or KHF or their functions;*
- b. *Connectivity along the system and between KNHFs or KHF located within 240 m of each other is maintained or possible enhanced for the movement of native plants and animals across the landscape; and*

- c. *The removal of other natural features not identified as KNHF and KHF should be avoided. Such features should be incorporated into the planning and design of the proposed use wherever possible;*
- d. *Except for uses described in and governed by the polices of sections 4.1.2 and 4.3.2;*
- e. *At least 30 per cent of the total developable area will remain or be returned to natural self-sustaining vegetation, recognizing that section 4.3.2 establishes specific standards for the uses described there.*

Policies outlined in both section 3.2.2 relating to Natural Heritage System Polices and Section 3.2.5 Key Natural Heritage Features and Key Hydrologic Feature polices apply. As such, development or site alteration is not permitted in KHF and KNHF within the NHS, including the associated MVPZ with certain exceptions including infrastructure in accordance with Section 4.2.

2.5 Provincial Endangered Species Act

Ontario's ESA came into effect on June 30, 2008, with over 200 species in Ontario identified as extirpated, endangered, threatened, or of special concern. The MECP provides oversight of the ESA for the regulation of SAR in Ontario. Under the ESA, native species that are in danger of becoming extinct or extirpated from the province are identified as being extirpated, endangered, threatened and special concern. These designations are defined as follows:

- Extirpated – a species that no longer exists in the wild in Ontario but still occurs elsewhere;
- Endangered – a species facing imminent extinction or extirpation in Ontario which is a candidate for regulation under Ontario's ESA;
- Threatened - a species that is at risk of becoming endangered in Ontario if limiting factors are not reversed; and
- Special Concern – a species with characteristics that make it sensitive to human activities or natural events.

Under the ESA, protection is provided to threatened or endangered species and their habitat, as well as providing stewardship and recovery strategies for species. Permitting is required to conduct works within habitat regulated for threatened or endangered species.

Within the Study Area, the Berczy Creek valley corridor provides direct habitat for the Endangered Redside Dace (*Clinostomus elongatus*). The portion of Bruce Creek Tributary stream corridor within the Study Area is regulated as contributing Redside Dace habitat.

2.6 Regional Municipality of York Official Plan – Office Consolidation (2019)

The York Region Official Plan (YROP) is a document that outlines the policies of the Regional Municipality of York to guide economic, environmental and community building decisions which inform the strategic decisions of York Region and its nine local municipalities. The basis of the natural environment protection system in York Region is the Regional Greenlands System. This system is comprised of KNHFs and KHFs. The function of the Greenlands System is to protect these features and appropriate adjacent lands, corridors and linkages.

Map 1 Regional Structure and *Map 2 Regional Greenlands System* designates the main branch valley corridors of Berczy Creek and Bruce Creek as part of the Regional Greenlands System. Lands designated as Regional Greenlands System (Greenlands) in the YROP are subject to development constraints. Development applications within or on lands close to the Greenlands must be accompanied by an environmental evaluation of impacts the development will have or is expected to have on the environmental functions, attributes, or linkages of the Greenlands System. The evaluation must also provide the details of any mitigation measures that will ensure that the Greenlands features will not be adversely impacted.

The boundaries and extent of the Greenlands identified on YROP Map 2 are approximate. Specific delineation or clarification of Greenlands boundaries may be undertaken when applications for development are received. Refinements to the boundaries may occur through environmental evaluation, and do not require an amendment to the plan.

YROP Map 4 identifies Key Hydrologic Features, including wetlands and watercourses. YROP Map 4 identifies the portion of Berczy Creek and Bruce Creek Tributary within the Study Area as permanent or intermittent watercourses.

2.7 City of Markham Official Plan (2014)

The City of Markham Official Plan (MOP) was approved on June 12, 2014 and was subject to appeals. On November 24, 2017, the Ontario Municipal Board issued a Partial Approval Order which was updated on April 9, 2018 by the Local Planning Appeal Tribunal. *Map 3 – Land Use* designates the majority of the Subject Lands as Future Neighbourhood Area and Greenway System.

In accordance with section 3.1.2.10 of the MOP is largely approved and identifies key natural heritage features and key hydrologic features as the following:

- a) *Wetlands;*
- b) *Habitat of threatened and endangered species;*
- c) *Significant portions of the habitat of:*
 - i. *Special concern species in the Oak Ridges Moraine Conservation Area and Greenbelt Plan Area; and*
 - ii. *Provincially rare species in the Oak Ridges Moraine Conservation Plan Area;*
- d) *Fish habitat;*
- e) *Life Science Areas of Natural and Scientific Interest;*
- f) *Significant valleylands;*
- g) *Significant woodlands;*
- h) *Significant wildlife habitat;*
- i) *Sand barrens, savannahs and tallgrass prairies;*
- j) *Permanent and intermittent streams; and*
- k) *Seepage areas and springs.*

The MOP designates the portion of Berczy Creek valley corridor within Study Area, and portion of Bruce Creek Tributary stream corridor east of Warden Avenue as Greenway System. Generally, development, redevelopment and site alteration are prohibited within key natural heritage features and key hydrologic features and their vegetation protection zones. The extent of features and their protection zones are to be determined through an environmental impact study. Prescribed vegetation zones and

definitions of “significant” features (e.g., woodlands and valleylands) are provided in Chapter 3 of the OP.

2.8 Conservation Authorities Act (Ontario Regulation 166/06)

The TRCA regulates land use activities in and adjacent to wetlands, watercourses and valleylands under Ontario Regulation 166/06 (*Regulation for Development, Interference with Wetlands and Alterations to Shorelines and Watercourses*) made under the *Conservation Authorities Act*.

Subject to conformity with the municipality’s Official Plan, the completion of appropriate studies and application for Conservation Authority permits, TRCA may grant permission for development within these areas if it can be proven that control of flooding, erosion, pollution or the conservation of land will not be affected by the development.

2.8.1 The Living City Policies (2014)

The TRCA’s Living City Policy (LCP) was approved in November 2014 and replaced the Valley and Stream Corridor Management Program (1994). The LCP document, among other matters, implements current federal, provincial and municipal legislation, policies and agreements affecting conservation authorities; and implements the policies for TRCA’s updated section 28 of Ontario Regulation 166/06. For purposes of implementing TRCA’s Environmental Management Policies:

- Confined River or Stream Valleys are considered Valley Corridors; and
- Unconfined River or Stream Valleys are considered Stream Corridors.

According to the LCP, the boundaries of a valley or stream corridor generally require a minimum 10 m setback from the greater of:

- Physical top of the valley feature;
- Long term stable top of slope, where geotechnical concerns exist (which must be confirmed through an appropriate geotechnical analysis);
- Regulatory floodplain;
- Meander belt; and
- Limits of significant vegetation which is contiguous with the valley corridor.

It is the policy of TRCA:

That erosion hazard limits will be determined through site specific field investigations and technical reports where required, in accordance with the text of TRCA’s Regulation and Provincial and TRCA standards. Where erosion hazard limits are required and not available, or where existing erosion hazard information does not meet current Provincial or TRCA standards, TRCA may require the erosion hazard to be determined by a qualified professional, at the expense of the proponent, to the satisfaction of TRCA.

The Belt Width Delineation Procedures (TRCA 2004) document outlines standards for delineating the meander belt in TRCA jurisdiction.

3. Background Review

As noted, the Study Area has been studied extensively as part of the Berczy, Bruce, Eckardt and Robinson Creeks SWS, as well as the Berczy Glen and Angus Glen Master Environmental Servicing Plan studies. Fluvial geomorphology background information was obtained from the following documents:

- *Berczy, Bruce, Eckardt and Robinson Creeks Subwatershed Study – Final Reports (Phases 1, 2 and 3), prepared by AMEC Foster Wheeler SWS Study Team (2019);*
- *Berczy Glen Master Environmental Servicing Plan (Berczy Glen MESP), prepared by Stonybrook Consulting et al. (2020); and*
- *Angus Glen Master Environmental Servicing Plan (Angus Glen MESP), prepared by SKA, et al. (2017).*

3.1 Berczy, Bruce, Eckardt and Robinson Creeks SWS (AMEC Foster Wheeler 2019)

The SWS, undertaken by the AMEC Foster Wheeler (now Wood) Study Team was initiated in 2014 and was completed in three phases.

Phase 1 characterized natural resources within each of the subwatersheds in the FUA, addressing hydrology, hydraulics, groundwater, water quality stream morphology, aquatic and terrestrial ecology. Studies submitted by the Landowner consultants were reviewed, and supplemental field investigations were completed to identify the form, function and linkages of environmental resources, environmental constraints and opportunities and establish criteria and constraints for the formulation of management strategies supporting the proposed future development of the FUA lands. Preliminary goals, objectives and targets were defined for all subwatersheds. This work was used as input for the formulation of management strategies supporting the proposed future development of the FUA lands.

Phase 2 of the SWS involved testing of the Preliminary Land Use concepts through two iterations, to determine if these met various preliminary subwatershed targets identified in the Phase 1 report. Testing included the completion of hydrology, hydraulics, and groundwater modelling, as well as aquatic, fluvial geomorphic, and terrestrial evaluations to formulate preliminary management strategies to avoid, minimize, and mitigate potential impacts. This included assessment and recommendations related to watercourses and headwater drainage features, stormwater management, LID measures, fisheries, aquatic and terrestrial mitigation and management, fluvial geomorphology assessments, SAR, identification of meander belts, and preliminary road crossing alignment reviews.

Phase 3 of the study utilized findings from the impact assessment to refine/define a set of preferred management strategies, address future study requirements, environmental monitoring recommendations, and MESP requirements.

3.2 Berczy Glen Master Environmental Servicing Plan (Stonybrook Consulting et al. 2020)

The Berczy Glen MESP was prepared in support of an Official Plan Amendment (OPA) application to permit urban residential land uses to allow the development of a residential community within the Berczy Glen Block. Building on the findings of the SWS, additional fieldwork was completed by the Berczy Glen MESP study team to address any identified data gaps. The Berczy Glen MESP outlined existing conditions relating to surface water, groundwater, terrestrial and aquatic resources, defined the Berczy Glen Greenway System, and recommended stormwater management, grading, transportation, water and wastewater servicing requirements. It also identified potential impacts and mitigative measures, including conceptual design requirements for SWM ponds, LID measures, site grading, management of headwater drainage features, wetland water balance and restoration/enhancement opportunities.

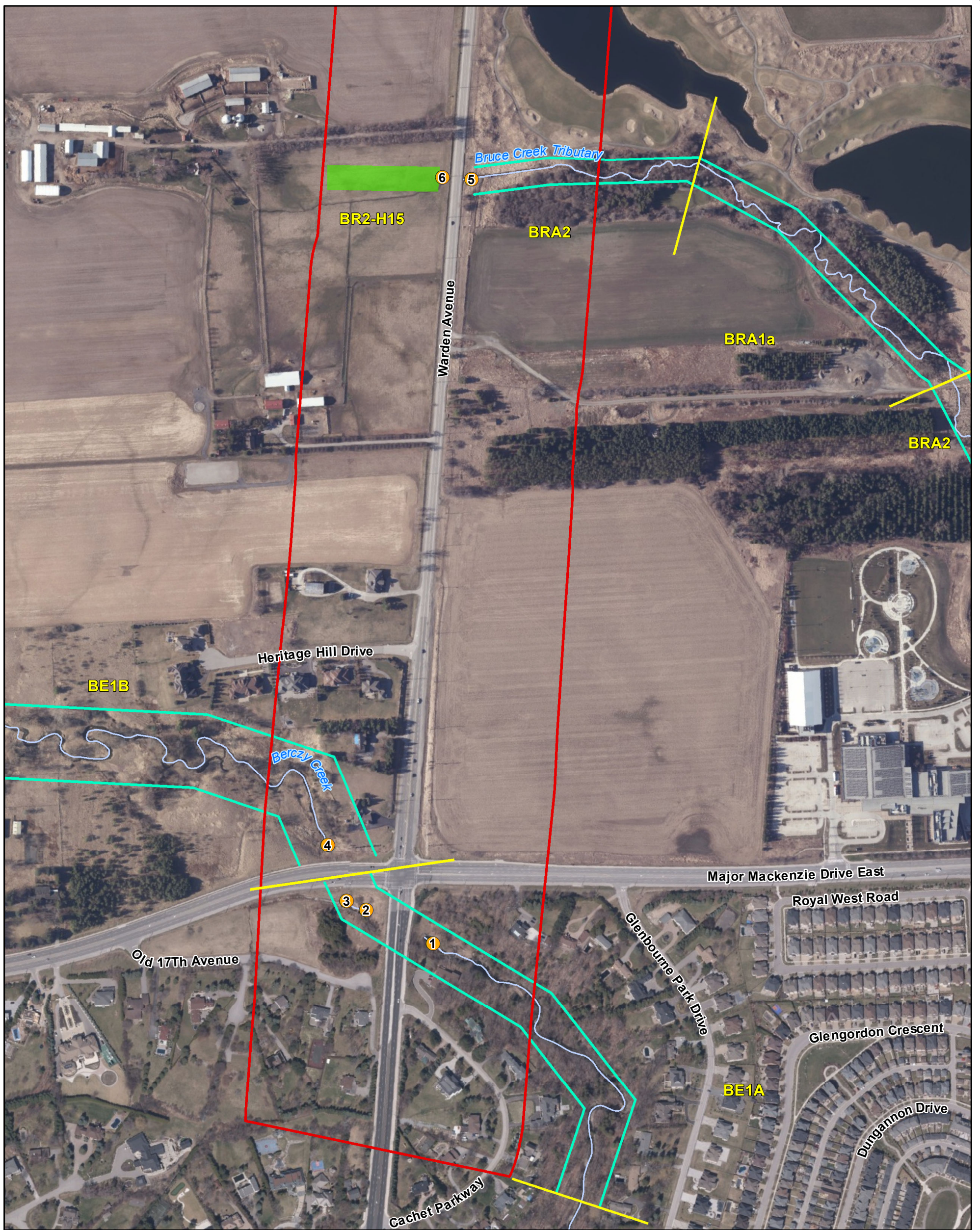
Two reaches of Berczy Creek as delineated through the MESP are relevant to the Warden Avenue Class EA Study area (**Figure 2**): Reach BE1A and Reach BE1B. Reach BE1A extends downstream of Major Mackenzie Drive and Warden Avenue adjacent to the Cachet Drive subdivision, while Reach BE1B extends upstream of Major Mackenzie Drive.

3.2.1 Existing Conditions

3.2.1.1 Reach BE1A

In support of the MESP, assessment of Reach BE1A was limited to those portions of the reach located within public ownership (ROW). Referencing those observations, Reach BE1A was characterized as a well-defined channel, flowing through a confined valley setting, with a moderate gradient and degree of sinuosity. Riparian vegetation consisted of trees, shrubs and grasses, which formed a continuous cover, extending more than five channel widths laterally. Riffle substrate consisted of gravel, cobbles, and boulders, while pool substrate consisted of clay, silt, and sand. Bank material consisted of clay, silt, sand, gravel, and small cobbles, and bank angles were found to range between 60-90°. Bankfull widths and depths ranged between 5.3-7.2m, and 0.55-1.2m, respectively.

This reach had a Rapid Geomorphic Assessment (RGA) score of 0.64, which indicated that the channel was in a state of active adjustment. Degradation, widening, and planform adjustment were the dominant modes of adjustment. The Rapid Stream Assessment Technique (RSAT) score of 24.5 indicated that the channel was in fair ecological health. Channel stability and channel scouring/sediment deposition were the limiting factors for this reach. The Down's model scored this reach as 'E' – enlarging, based on evidence of erosion along both banks, bed scouring and low embeddedness, and the lack of bar formation and alluvial terraces. Refer to **Section 4.1.1** for a detailed description of the RGA, RSAT and Down's rapid assessment methodologies.



Legend

- ▭ Study Area
- Photo Location
- ▭ BR2-H15 Enhanced Corridor
- Reach Break
- Meander Belt
- Watercourse

Reach	Meander Belt (m)
Berczy Creek	
BE1A*	55
BE1B	90
Bruce Creek Tributary	
BR2-H15	10
BRA1a	36
BRA2	30
* Desktop approach	

**Fluvial Geomorphology
Existing Conditions**

Figure 2

Warden Avenue Geomorphic Assessment



Project: 220329.1
Last Revised: March 2021

Client: Regional
Municipality of York

Prepared by: DU
Checked by: SG



1:4,500

0 50 100 m

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Ontario Orthoimagery Basemap: 2020

3.2.1.2 *Reach BE1B*

In support of the MESP, assessment of Reach BE1B was limited to those portions of the reach visible from the Berczy Glen Lands, and the Major Mackenzie Drive ROW, this reach was characterized as a well-defined channel, flowing through a confined valley setting. The channel was characterized by having a moderate gradient and degree of sinuosity. Riparian vegetation consisted of trees, shrubs, grasses and herbaceous species, which formed a continuous cover, extending 1-5 channel widths laterally. Bank angles ranged between 60-90°, and bank materials were composed of clay and silt. Bankfull widths ranged between 2.8-3.6m, and bankfull depths ranged between 0.65-0.8m. Substrate in riffles consisted of clay, silt, small cobbles and boulders, while pool substrate consisted of clay and silt.

The RGA score of 0.32 for Reach BE1B indicated that the channel was in a transitional/stressed state, with aggradation and widening being the most dominant forms of adjustment. The RSAT score of 25 indicated that this reach was in good ecological health, with channel stability and riparian habitat conditions being the primary limiting factors. The Down's model characterized this reach as 'U' – undercutting, based on evidence of erosion along the outer bank, deposition along the inner bank, scoured bed and low embeddedness, and the presence of alluvial terraces.

3.2.1.3 *BR2-H15*

The MESP described BR2-H15 as a tile drain/granular ditch system which collects surface runoff and shallow groundwater from the Berczy Glen Lands and pipes it under Warden Avenue where it discharges to the Bruce Creek Tributary via an outlet approximately 90 m east of Warden Avenue. BR2-H15 was characterized as piped except for a small open conveyance section measuring approximately 135 m in length. Based on groundwater modelling results and field-based flow measurements, the open conveyance portion of BR2-H15 was identified by MNR as Redside Dace contributing habitat. To replicate this baseflow contribution function post-development, the MESP proposed the relocation and replication of BR2-H15 within an enhanced corridor.

3.2.2 *Meander Belt*

Meander belt limits were determined for Reach BE1B to delineate occupied habitat limits for Redside Dace in relation to the Berczy Glen MESP Lands. Meander belt limits were not delineated for Reach BE1A.

3.2.2.1 *Reach BE1B*

Redside Dace occupied habitat is defined under Ontario Regulation 242/08 as any part of an "occupied" stream or other watercourse; the area encompassing the meander belt width of said watercourse, and the vegetated area or agricultural lands that are within 30 m of the meander belt width. In confined valley settings, such as Reach BE1B, the valley wall acts a constraint to channel migration. As Ontario Regulation 242/08 does not distinguish between confined and unconfined systems, the procedure to determine the meander belt for confined valley setting reaches referenced historic and current channel processes, but also considered valley floor (floodplain) dimensions. This procedure is in accordance with applicable guidelines (TRCA 2004).

The MESP identified a meander belt width of 90 m was delineated for Reach BE1B based on the lateral extent of the outermost meander bends along the reach over the available historical record (1946, 1978 and 2010). This dimension was reviewed to ensure it was sufficient to capture the active (bankfull) channel and evidence of lateral occupation of the floodplain at the reach scale. As the recommended meander belt widths referenced existing field conditions and including average bankfull dimensions, the MESP identified the Reach BE1B meander belt as field-verified.

3.2.3 BR2-H15 Enhanced Corridor

In accordance with Minutes of Settlement executed through the SWS for BR2-H15, the proposed 135 m long BR2-H15 enhanced corridor will have a top width of 30 m and a floodplain dimension of 12 m. The floodplain width is sufficient to accommodate a 10 m meander belt, as delineated for BR2-H15 through the MESP.

The detailed design process for the BR2-H15 enhanced corridor considered the future widening of Warden Avenue. Detail designs for the enhanced corridor are currently under review by relevant regulatory agencies.

3.3 Angus Glen Master Environmental Servicing Plan (Sabourin Kimble & Associates Ltd. *et al.* 2017)

The Angus Glen MESP was prepared in support of an Official Plan Amendment (OPA) application to permit urban residential land uses to allow the development of a residential community within the Angus Glen Block. Building on the findings of the SWS, additional fieldwork was completed by the Angus Glen MESP study team to address any identified data gaps. The MESP outlined existing conditions relating to surface water, groundwater, terrestrial and aquatic resources, defined the Greenway System, and recommended stormwater management, grading, transportation, water and wastewater servicing requirements. It also identified potential impacts and mitigative measures, including conceptual design requirements for SWM ponds, LID measures, site grading, management of headwater drainage features, wetland water balance and restoration/enhancement opportunities.

Two reaches of the Bruce Creek Tributary are relevant to the Warden Avenue Class EA Study Area (**Figure 2**): Reach BRA1a and Reach BRA2. Reach BRA2 extends downstream of Warden Avenue within the Angus Glen Block, while Reach BRA1a extends downstream of Reach BRA2.

3.3.1 Existing Conditions

3.3.1.1 Reach BRA1a

Reach BRA1a was characterized as a moderately sinuous, well-defined channel flowing through an unconfined valley system. The reach displayed a moderate gradient and low degree of entrenchment. Riparian vegetation was characterized as a continuous, established buffer that extended 1-5 channel widths laterally, and consisted of trees, shrubs, grasses, and herbaceous plants. Bank angles ranged between 30-90 degrees with 5-30% of banks identified as exhibiting indicators of active erosion. Riffle-pool morphology was poorly developed. Bank materials were dominated by clay and silt, while channel

substrate was comprised of clay, silt, small gravel, and occasional boulders, with zones of exposed underlying clay till throughout the reach.

Channel morphology along the reach was heavily influenced by woody debris, resulting in the localized formation of secondary and multiple channels. Generally, bankfull widths and depths ranged from 3.0-5.0 m and 0.30-0.50 m, respectively, along the reach. Where woody debris jams had formed multiple channels and flow paths, bankfull widths ranged from 4.0-6.0 m.

Rapid assessment results indicated that the channel was in a stressed or “in transition” state, with a score of 0.24. The dominant mode of adjustment was identified as degradation. An RSAT score of 21 indicated that the channel exhibited a ‘fair’ degree of overall ecological health, with physical instream habitat identified as the primary limiting factor. The Downs model scored this reach as U – “undercutting”, based on evidence of erosion along the outer banks, low degree of embeddedness and lack of alluvial terrace.

3.3.1.2 *Reach BRA2*

Reach BRA2 was characterized as a well-defined channel flowing through an unconfined valley setting. Riparian vegetation extended 1-5 channel widths laterally and consisted of established (5-30 years old) trees and meadow grasses. Overall, the reach had a moderate gradient. Bank angles ranged from 60-90 degrees and were predominantly composed of fine sands, clay and silt, with minor gravel, cobble and boulder components. Riffle-pool bed morphology was poorly developed. Channel substrate was comprised of clay, silt, small to large cobble and occasional large boulders, along with localized sections of exposed clay till. Bankfull widths ranged from 3.0-4.0 m and bankfull depths ranged from 0.30-0.40 m. Existing channel disturbances included evidence of historical channelization in the vicinity of Warden Avenue.

The RGA scored the reach as being in a slightly stressed or “in transition” state, with a score of 0.22. The dominant forms of adjustment noted along the reach were aggradation and widening. The RSAT score for the reach indicated a “fair” degree of overall ecological health, with a score of 19. Riparian conditions and physical instream habitat were identified as the primary factors limiting ecological health. The Downs classification for this reach indicated “m – lateral migration” due evidence of erosion observed along outside banks.

3.3.2 *Meander Belt*

Meander belt limits were determined for the Bruce Creek Tributary to determine watercourse erosion hazard limit extents for the Angus Glen MESP Lands.

3.3.2.1 *Reaches BRA1a and BRA2*

A preliminary meander belt width was delineated for Reaches BRA1a and BRA2 referencing the governing meander amplitude from available 1960, 1966, 1971, 1978 and 2009 aerial imagery to ensure that the position of the meander belt boundaries account for the position of any historic floodplain features. The meander belt limits were then drawn tangential to the governing meander bend, parallel to the meander belt axis (central tendency) of the reach. As this delineated belt width referenced

mapping that portrayed only the centre-line of the channel and was not considered reflective of the degree of multiple channel formation observed along both reaches, the maximum bankfull width was then added to this value to establish the Existing Belt Width.

Due to the resolution of historic aerial imagery, and the degree of vegetative cover throughout the valley in recent aerial imagery, reliable quantification of 100-year erosion rates could not be determined on a reach basis for the Subject Lands. Following TRCA (2004) guidelines, a 20% factor of safety was added to the Existing Belt Width to account for long-term adjustments in channel form (migration). Meander belt widths were calculated as follows:

Meander belt width = (meander amplitude + bankfull width) * 1.2 factor of safety

$$\text{Reach BRA1a} = (25 \text{ m} + 5.0 \text{ m}) * 1.2 = 36 \text{ m}$$

$$\text{Reach BRA2} = (21 \text{ m} + 4.0 \text{ m}) * 1.2 = 30 \text{ m}$$

3.4 Data Gaps

Based on a review of available background reports, the following data gaps were identified in relation to the Warden Avenue Class EA Study Area:

- Meander belt recommendation for Reach BE1A.

In addition to addressing this data gap, field observations were collected in support of the Class EA to confirm existing watercourse conditions within the Study Area.

4. Existing Conditions

In support of the Class EA, a scoped field assessment was conducted on March 9, 2021 within the ROW. A photographic record of watercourse conditions at the time of assessment is provided in **Appendix A**. Rapid assessments were conducted to characterize existing geomorphic conditions.

4.1 Rapid Assessments

4.1.1 Methods

The following standardized rapid visual assessment methods were applied:

i. Rapid Geomorphic Assessment (RGA – MOE 2003)

The RGA documents observed indicators of channel instability by quantifying observations using an index that identifies channel sensitivity. Sensitivity is based on evidence of aggradation, degradation, channel widening and planimetric form adjustment. The index produces values that indicate whether

the channel is stable/in regime (score <0.20), stressed/transitional (score 0.21-0.40) or in adjustment (score >0.41).

ii. Rapid Stream Assessment Technique (RSAT – Galli 1996)

The RSAT uses an index to quantify overall stream health and includes the consideration of biological indicators (Galli 1996). Observations concerning channel stability, channel scouring/sediment deposition, physical in-stream habitat, water quality, and riparian habitat conditions are used to calculate a rating that indicates whether the channel is in poor (<13), fair (13-24), good (25-34), or excellent (35-42) condition.

iii. Downs Classification Method (Downs 1995)

The Downs (1995, outlined in Thorne *et al.* 1997) classification method infers present and future potential adjustments based on physical observations, which indicate the stage of evolution, and type of adjustments that can be anticipated based on the channel evolution model. The resultant index classifies streams as stable, laterally migrating, enlarging, undercutting, aggrading, or recovering.

4.1.2 Results

Rapid assessment results are summarized in **Table 1** and **Table 2** below.

4.1.2.1 Reach BE1A

Consistent with the Berczy Glen MESP, Reach BE1A was characterized as a well-defined channel flowing through a confined valley setting, with a moderate gradient and degree of sinuosity. Riparian vegetation consisted of trees, shrubs and grasses. Riffle substrate consisted predominantly of gravel and cobble, while pool substrate consisted of sand, gravel and exposed clay till. Bankfull dimensions for the portion of Reach BE1A between Major Mackenzie Drive and Warden Avenue ranged 3.3-4.6 m in width and 0.40-0.72 m in depth. These dimensions were narrower than those noted for BE1A downstream of Warden Avenue, where bankfull widths and depths corresponded to those reported in the MESP (5.3-7.2 m and 0.55-1.2 m, respectively). Existing channel disturbances included the existing Warden Avenue and Major Mackenzie Drive crossings, as well as an abandoned concrete arch crossing structure between the two roads. Downstream of Warden Avenue, a large scour pool was observed.

Consistent with the MESP, the RGA scored the reach as being in a state of active adjustment (0.45) with degradation, widening, and planform adjustment noted as the dominant modes of adjustment. The RSAT score of 25 indicated that the channel was in good ecological health, with riparian habitat conditions noted as the primary limiting factor. The Down's model scored this reach as a combination of "M – lateral migration" and "E – enlarging", based on eroding and slumping banks and valley wall contact points.

4.1.2.2 Reach BE1B

Reach BE1B was characterized as a well-defined channel, flowing through a confined valley setting. The channel was characterized by having a moderate gradient and degree of sinuosity. Riparian vegetation consisted of trees, shrubs, grasses and herbaceous species. Bankfull widths ranged between 3.3-3.8 m, and bankfull depths ranged between 0.65-0.80 m. Substrate in riffles consisted of gravel, cobble and boulders, while pool substrate consisted of sand, gravel, cobble and exposed clay till.

The RGA score of 0.26 for Reach BE1B indicated that the channel was in a transitional/stressed state, with aggradation and widening being the dominant forms of adjustment. The RSAT score of 30 indicated that this reach was in good ecological health, with channel stability and riparian habitat conditions being the primary limiting factors. The Down's model characterized this reach as "U – undercutting", based on evidence of erosion along the outer bank, deposition along the inner bank and scoured bed.

4.1.2.3 BR2-H15

As previously discussed, BR2-H15 is enclosed within a tile drain system within the Berczy Warden Holdings Inc. lands west of Warden Avenue. Within the ROW, BR2-H15 takes the form of a roadside ditch. Flows are conveyed under Warden Avenue twin CSP culverts.

4.1.2.4 BRA2

Within the ROW, Reach BRA2 was characterized as a well-defined, channelized watercourse flowing through an unconfined valley setting. Riffle-pool bed morphology was poorly developed. Overall, channel bankfull dimensions were characterized to be consistent with those reported in the MESP (3.0-4.0 m in width and 0.30-0.40 m in depth). Given the heavily modified nature of Reach BRA2 within the ROW, rapid assessment protocols were not applied.

4.1.2.5 BRA1a

Reach BRA1a could not be assessed from the Warden Avenue ROW as the reach characteristics were not discernible due to dense riparian and instream vegetation.

Table 1. General Reach Characteristics

Reach	Bankfull Width (m)	Bankfull Depth (m)	Substrate	Riparian Vegetation	Notes
BE1A	3.3-7.2	0.40-1.2	Sand, gravel, cobble and exposed till	Trees, shrubs and herbaceous plants	<ul style="list-style-type: none"> Scour pool downstream of Warden Avenue Abandoned historic crossing between Major Mackenzie Drive and Warden Avenue
BE1B	3.3-3.8	0.40-0.80	Sand, gravel, cobble and exposed till	Trees, shrubs and herbaceous plants	<ul style="list-style-type: none"> Existing CSP culvert crossing at Major Mackenzie Drive
BR2-H15	N/A – feature is enclosed within a tile drain system west of Warden Avenue.				
BRA1a	N/A – reach could not be assessed from ROW due to the presence of dense instream and riparian vegetation.				
BRA2	3.0-4.0	0.30-0.40	Sand, silt, clay, gravel	Grasses and herbaceous plants	<ul style="list-style-type: none"> Channelized within ROW Riffle-pool morphology poorly developed

Table 2. Rapid Assessment Results

Reach	Rapid Geomorphic Assessment			Rapid Stream Assessment Technique			Downs Classification Method
	Score	Condition	Dominant Mode of Adjustment	Score	Condition	Limiting Feature	
BE1A	0.45	In Adjustment	Degradation, widening, and planform adjustment	25	Good	Riparian habitat conditions	'M' – lateral migration and 'E' – enlarging
BE1B	0.26	Transitional	Widening and aggradation	30	Good	Channel stability, riparian habitat conditions	'U' – undercutting
BR2-H15	N/A – tile drain feature						
BRA1a	N/A – reach could not be assessed from ROW						
BRA2	N/A – channelized within ROW						

4.2 Meander Belt – Reach BE1A

To inform the delineation of Redside Dace occupied habitat as defined under Ontario Regulation 242/08, the meander belt was delineated for Reach BE1A using a desktop approach. As Reach BE1A is situated within a confined valley setting, the procedure to determine the meander belt referenced historic and current channel processes, but also considered valley floor (floodplain) dimensions.

A review of available historic aerial imagery for Reach BE1A (1960-present) was undertaken, however, due to degree of tree cover along the reach, the historic watercourse planform could not be traced. A 55 m meander belt dimension was recommended for Reach BE1A based on the lateral extent of the outermost meander bends and evidence of lateral occupation of the floodplain at the reach scale. This dimension was then reviewed within the context of available topographic mapping to ensure that the dimension was sufficient to capture the valley floor dimension. This procedure is considered to be in accordance with applicable guidelines (TRCA 2004).

Figure 2 illustrates meander belt limits for Reach BE1A.

5. Impact Assessment and Mitigation Measures

5.1 Geomorphic Impacts

Potential impacts on channel form and function associated with the proposed widening of Warden Avenue include the following:

- Temporary disturbance to the watercourse within the limits of grading due to replacement of the crossing structure, formalization of the low flow channel and road widening activities;
- Release of sediment during and immediately following construction; and
- Modified hydraulic conditions under certain storm events due to the influence of the crossing structure on flows.

5.2 Geomorphic Mitigation Measures

The following measures should be considered to avoid and mitigate potential impacts during construction:

- Undertake in-water works during the appropriate window (July 1 – September 15);
- Minimize duration of in-water work to the greatest extent possible;
- Undertake in-water work during periods of low flow;
- Isolate work area and implement appropriate dewatering;
- Implement a phasing, sediment and erosion control plan to avoid the release of sediment or contaminants to the watercourse;
- Monitor erosion and sediment control measures during construction to ensure performance;

- Disturbed areas should be stabilized immediately to prevent erosion and/or sedimentation through re-vegetation with native species suitable for the site;
- All machinery should arrive on site in a clean condition and be maintained for the duration of the works;
- Whenever possible, machinery should be operated above the high water mark; and
- Wash, refuel and service of machinery should be undertaken in such a way as to prevent any deleterious substances from entering the water.

6. Conclusions

Beacon was retained by the Regional Municipality of York to undertake a geomorphic assessment to inform the Class EA process for the improvements to Warden Avenue from Major Mackenzie Drive (Y.R. 25) to Elgin Mills Road in the City of Markham. The Class EA Study Area is located within the North Markham FUA and captures portions of the Berczy Creek and Bruce Creek subwatersheds; both watercourses are tributaries of the Rouge River. The purpose of this geomorphic assessment was to summarize available background information and confirm existing conditions for watercourses relevant to the Warden Avenue Class EA Study Area.

The following points summarize the findings of this study:

- Available background studies including the North Markham FUA SWS and Berczy Glen and Angus Glen MESP were reviewed to summarize geomorphic information, including meander belt dimensions, in relation to watercourses within the Class EA Study Area.
- A scoped field investigation was undertaken within the Warden Avenue ROW to confirm existing geomorphic conditions. Rapid assessment results indicated that watercourse conditions generally remain consistent with those reported through background studies.
- A 55 m meander belt dimension was recommended for Reach BE1A using a desktop approach. This analysis was undertaken to address a data gap in the background studies and inform the determination of Redside Dace occupied habitat limits within the Class EA Study Area.

Should you have any questions or require any additional information please contact the undersigned.

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Appendix A

Photographic Record



Photograph 1. (Location 1)

Berczy Creek Reach BE1A

Looking downstream from Warden Avenue at scour pool formation and valley wall contact.



Photograph 2. (Location 1)

Berczy Creek Reach BE1A

Upstream view of existing Warden Avenue culvert.



Photograph 3. (Location 2)

Berczy Creek Reach BE1A

Downstream view of existing Warden Avenue culvert.



Photograph 4. (Location 2)

Berczy Creek Reach BE1A

Upstream view of abandoned concrete arch crossing structure.



Photograph 5. (Location 2)

Berczy Creek Reach BE1A

Upstream view of existing storm drainage outlet from Major Mackenzie Drive/Warden Ave intersection.



Photograph 6. (Location 3)

Berczy Creek Reach BE1A

Downstream view of Berczy Creek at abandoned crossing structure.



Photograph 7. (Location 3)

Berczy Creek Reach BE1A

Upstream view of existing storm drainage outlet from Major Mackenzie Drive.



Photograph 8. (Location3)

Berczy Creek Reach BE1A

Upstream view of Major Mackenzie Drive crossing.



Photograph 9. (Location 4)

Berczy Creek Reach BE1B

Downstream view of Major Mackenzie Drive crossing.



Photograph 10. (Location 4)

Berczy Creek Reach BE1B

Upstream view of general conditions from Major Mackenzie Drive crossing.



Photograph 11. (Location 5)

Bruce Creek Tributary Reach BRA2

Downstream view from Warden Avenue at general reach conditions.



Photograph 12. (Location 5)

Bruce Creek Tributary Reach BRA2

Upstream view of Warden Avenue twin CSP culverts.



Photograph 13. (Location 5)

Bruce Creek Tributary Reach BRA2
North facing view of ROW along east side of Warden Avenue at BRA2.



Photograph 14. (Location 5)

Bruce Creek Tributary Reach BRA2
South facing view of ROW along east side of Warden Avenue at BRA2.



Photograph 15. (Location 6)

Bruce Creek Tributary Reach BR2-H15
Downstream view of Warden Avenue twin CSP culverts.



Photograph 16. (Location 6)

Bruce Creek Tributary Reach BR2-H15
Upstream view from Warden Avenue at tile drainage feature.



Photograph 17. (Location 6)
Bruce Creek Tributary Reach BR2-H15
North facing view of ROW along western side of
Warden Avenue at BR2-H15.



Photograph 18. (Location 6)
Bruce Creek Tributary Reach BR2-H15
South facing view of ROW along western side of
Warden Avenue at BR2-H15.