Heritage Heights Subwatershed Study Phase 1: Subwatershed Characterization and Integration Report

Brampton, Ontario
Project # TP111117

Prepared for:

City of Brampton
2 Wellington Street West, Brampton, ON L6Y 4R2

6/8/2021

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2 Wellington Street West, Brampton, ON L6Y 4R2

Prepared by:

Wood Environment & Infrastructure Solutions
a Division of Wood Canada Limited
3450 Harvester Road, Suite 100
Burlington, ON L7N 3W5 Canada
T: 905-335-2353

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1.0 Introduction

The City of Brampton has initiated the secondary planning process for the Heritage Heights (HH) lands, located west of Mississauga Road, north of the Credit River valley, south of Mayfield Road and east of Winston Churchill Boulevard as illustrated on Figure 1. Heritage Heights includes lands within the West Huttonville Creek subcatchment and a number of smaller subcatchments that drain directly to the Credit River, referred to as the Credit River Tributaries. Figure 1 illustrates the boundaries of the West Huttonville Creek and Credit River Tributary (CRT) subwatersheds. A portion of the Greenbelt Plan Area exists in the southwest corner of the HH lands.

In accordance with the City's Official Plan Amendment OP93-245, the Heritage Heights Community will be planned as a complete, compact and connected community that will identify, protect and ensure a linked natural heritage system, and provide opportunities for transit-oriented, mixed use development including a variety of housing types and densities, as well as employment lands. The Heritage Heights development area is identified in the City's Official Plan as Secondary Plan Areas 52 (Huttonville North) and 53 (Mount Pleasant West). The City of Brampton is preparing one comprehensive secondary plan for these two blocks. Figure 1 illustrates the secondary plan areas referred to collectively as the Heritage Heights Community and the SWS Study Area.

The City of Brampton has structured a phased secondary planning process that includes the completion of the Heritage Heights Subwatershed Study for the West Huttonville Creek and Credit River Tributaries (HHSWS). This study is being conducted in four (4) phases. Figure 2 outlines the relationship between the HHSWS and the Credit River Water Management Strategy (CRWMS) and the key questions that will be answered at the end of each phase. The following provides a summary of each phase:

Phase 1: Subwatershed Characterization and Integration

Phase 1 documents the characterization of the resources associated with the Subwatershed by study discipline (i.e., hydrology/hydraulics, hydrogeology, water quality, stream morphology, aquatic and terrestrial ecology). Background information and supplemental field data are described within each discipline, and then across disciplines, to establish the form, function and linkages of the environmental resources. From this work, preliminary goals and objectives (targets) are developed relevant to the Subwatersheds and revisited under each subsequent phase.

Phase 2: Subwatershed Impact Assessment

Phase 2 identifies stressors (past, present and future), describes and predicts impacts, and assesses these impacts against the preliminary goals and objectives (targets) developed as part of Phase 1. Future land use scenarios are evaluated. For this study (i.e., hydrogeology, hydrology, hydraulics and water quality) computer model(s) will be used to predict changes to existing conditions. Information and analysis from CVC's Effectiveness Monitoring Study and other related studies (i.e., Integrated Watershed Monitoring Program, CRWMS, Credit River Flow Management Study) will be used to assist modelling future scenarios and calibrating existing conditions. For others (i.e., terrestrial and aquatic ecology) predictions will be largely qualitative or conceptual, based on the updated Landscape Scale Analysis, other subwatershed disciplines (i.e., hydrogeology, hydrology hydraulics and water quality models), experience elsewhere and knowledge of habitat/biota interactions. That said, some more quantitative assessments are also documented for the natural systems assessment scope.

Phase 3: Management Strategies and Implementation

Phase 3 will, based on the Impact Assessment conducted as part of Phase 2, finalize the land use concepts assessment and establish a set of preferred management solutions. These will be considered as input into the Secondary Plan process to be considered by the City to achieve the identified subwatershed goals and objectives, in addition to the recommendations of the other component studies being undertaken for the Heritage Heights Secondary Plan. The Implementation Plan will be prepared to ensure compliance by identifying specific actions in the following general areas: Planning (i.e., land use designations and form) and Policy, Rehabilitation and Retrofit, Stewardship, Monitoring, and Research and Development.

Phase 4: Long-Term Monitoring Plan

Phase 4 involves the long-term monitoring required to evaluate the effectiveness of the recommended management strategies by assessing whether the assumptions made during planning and design are appropriate and predictions made are accurate, and determining if parts of the management plan should be modified. Phase 4 will not be conducted as part of this study.

This Subwatershed Characterization and Integration Report (Phase 1 Characterization Report) provides the background information collected, field and analytical work conducted by each discipline, including specific methods and results. Due to the need to respond to comments from the Technical Advisory Committee (TAC), this report should not be considered final. The “final” Characterization will form part of the Final Subwatershed Study reporting.

1.1 Project History and Status

1.1.1 Project Timelines

The HHSWS commenced in 2011 following approval of Terms of Reference and a detailed Work Plan by the City of Brampton and Technical Advisory Committee (TAC), including the City of Brampton (City), Region of Peel (Region) and Credit Valley Conservation (CVC). The HHSWS Study Team prepared the Phase 1 Characterization Report in November 2012, followed by the Phase 2 Impact Assessment in April 2015. Agency comments were received on both the Phases 1 and 2 reports.

Subsequent to the Phase 2 Impact Assessment submission, as a result of the unknown status of the GTA West Highway, planning of the Heritage Heights lands was put on hold. At the direction of the City, the HHSWS Team commenced work on the project again in March 2017. At that time, the Team met with City and CVC to discuss a Supplemental Monitoring Plan to address field monitoring data that were over five years old. Between 2017 and the end of 2019, the HHSWS Team conducted supplemental monitoring, largely of ecological features. In late September 2019, the Province announced its technically preferred route for the GTA West Corridor, and the City of Brampton resumed the Heritage Heights Community land use planning. In late 2020, based on an updated and approved SWS Work Plan, the HHSWS Team commenced work on the Updated Phase 1 Subwatershed Characterization and Integration, building upon the more recent data collection.

As a result of the project history and timing, this Phase 1 Characterization Report contains interpretation of data collected as part of the initial Phase 1 SWS work in 2011/2012, as well as updated ecological data collected between 2017 and 2019. Where approaches to data collection and/or assessments have changed since the initial work was done, they are outlined herein.

1.1.2 Change to Secondary Plan Boundary

In 2017, the Ontario Municipal Board hearing approved two Official Plan Amendments (OPAs) to exclude lands in the northwest corner of Mississauga Road and Bovaird Drive (formerly the Osmington and Heathwood lands) from the Huttonville North Secondary Plan (Area 52) and add them to the Mount Pleasant Secondary Plan (Area 51). These lands, shown on Figure 1, are referred to as the Mount Pleasant Heights lands.

As a result of the above noted OPAs, the Heritage Heights lands, shown on Figure 1, exclude the Mount Pleasant Heights lands. However, since the HHSWS subcatchments include the West Huttonville Creek and the four Credit Valley Tributary subcatchments, and the Mount Pleasant Heights lands have been studied as part of the HHSWS in the past, the current HHSWS has included the Mount Pleasant Heights area in some of its content to provide contextual continuity in the interpretation of features and functions.

As set out in the Mount Pleasant Heights OPAs, further official plan amendments are required to designate land uses within the Mount Pleasant Heights lands. Numerous supporting background studies are underway by the Mount Pleasant Heights landowners, including an Environmental Implementation Report. Inputs from both the approved *Mount Pleasant Community Sustainable Natural Heritage System Planning Huttonville and Fletcher's Creeks Subwatershed Study* (HFSWS) and the ongoing HHSWS will inform their work. When available, the Mount Pleasant Heights landowners have indicated that they will share EIR findings with the City and the HHSWS Study Team with the intent to integrate study outcomes as appropriate.

1.1.3 Wetland Assessments

During 2020, select Heritage Heights landowners conducted further studies on several wetlands within the Heritage Heights lands and subsequently made technical submissions to the Ministry of Natural Resources and Forestry (MNRF) with the intent to update wetland characterization and their wetland evaluation status. As a result, some wetland boundaries have been updated. At the time of preparation of this Phase 1 Characterization Report, discussions with MNRF remain ongoing regarding the status of some of the remaining wetlands. As further information becomes available, the SWS will be updated where warranted to reflect MNRF review/discussions.

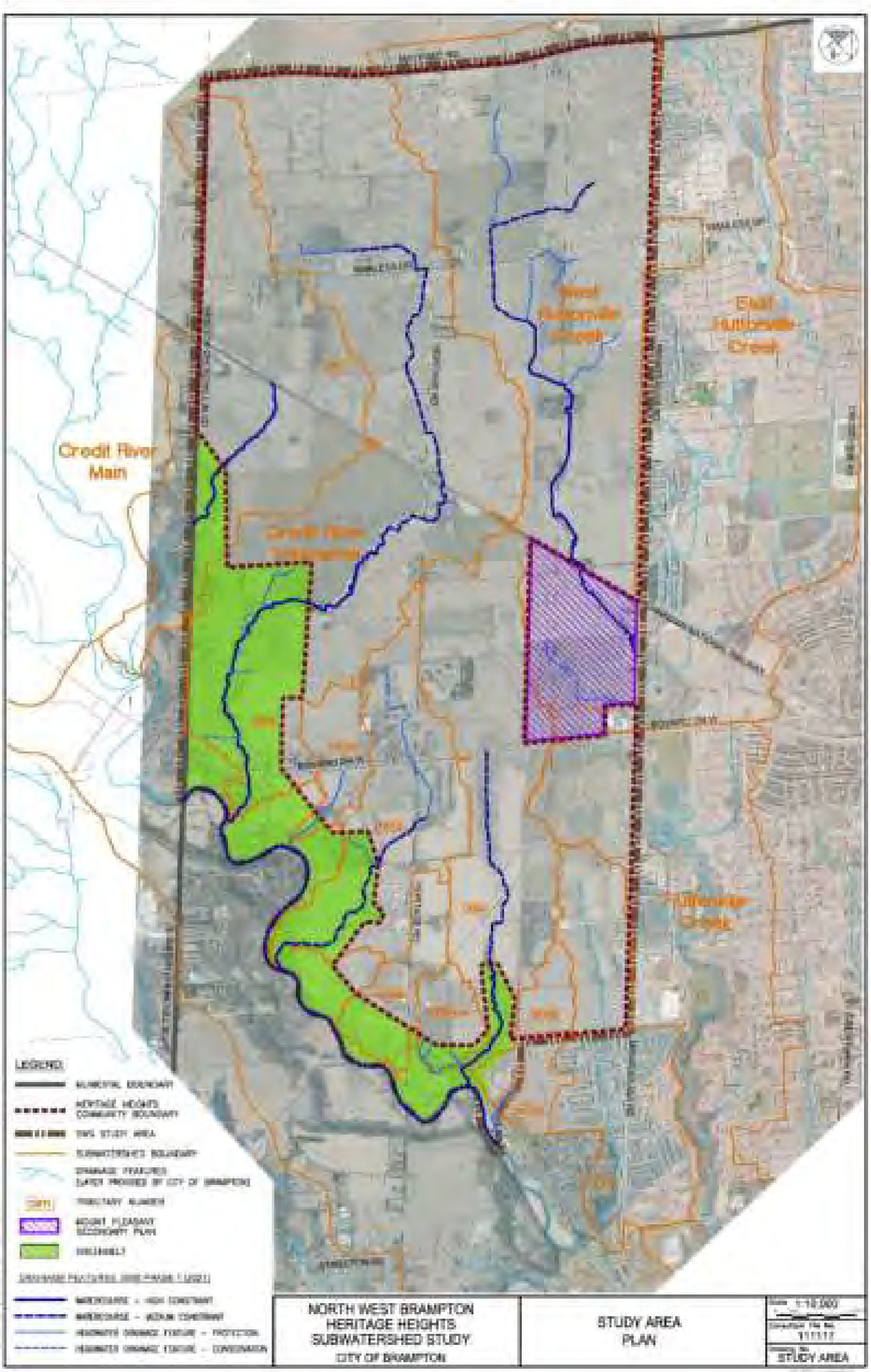
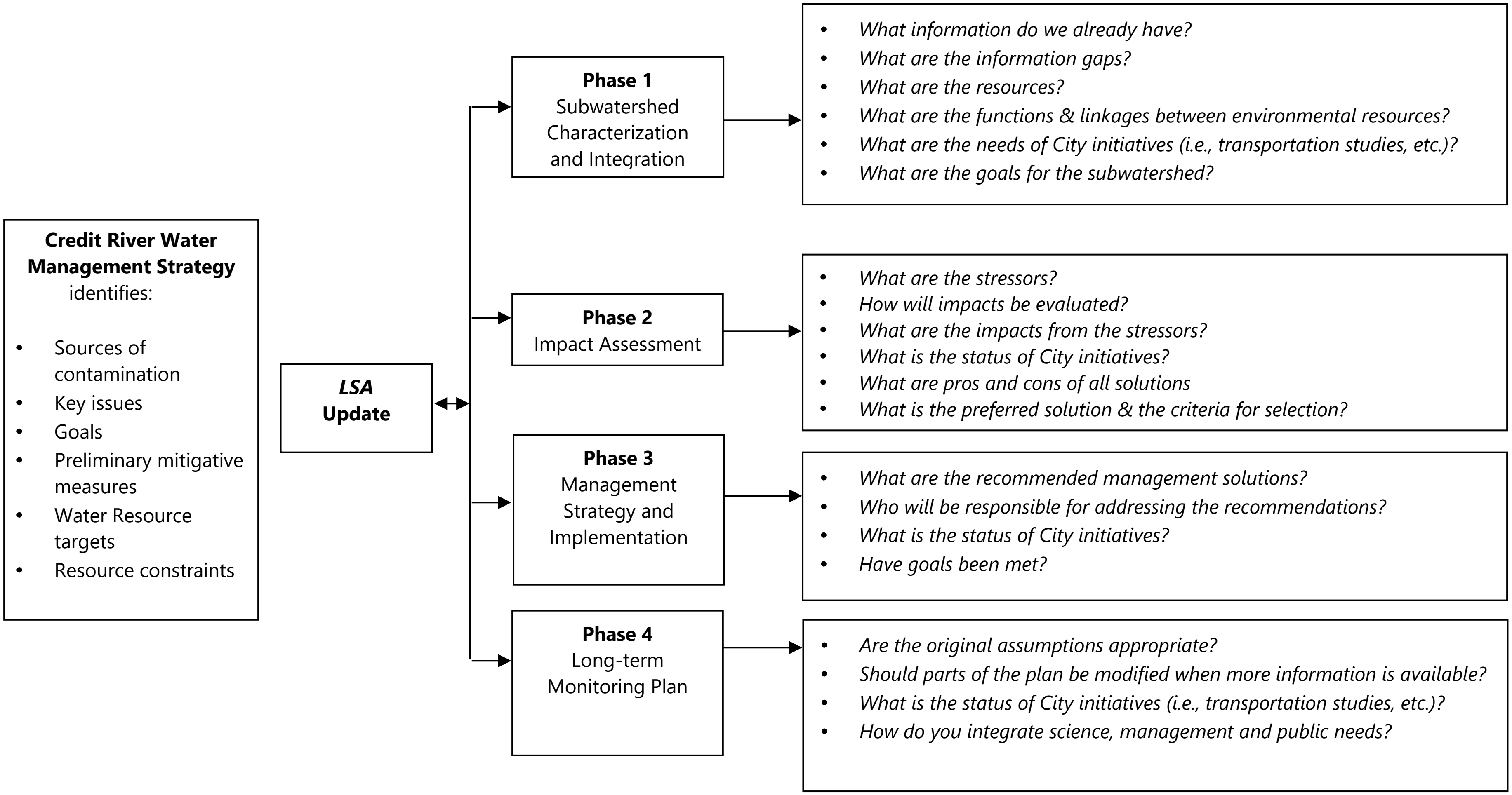


Figure 1. Study Area Plan



Credit River Water Management Strategy identifies:

- Sources of contamination
- Key issues
- Goals
- Preliminary mitigative measures
- Water Resource targets
- Resource constraints

***LSA* Update**

Phase 1 Subwatershed Characterization and Integration

- *What information do we already have?*
- *What are the information gaps?*
- *What are the resources?*
- *What are the functions & linkages between environmental resources?*
- *What are the needs of City initiatives (i.e., transportation studies, etc.)?*
- *What are the goals for the subwatershed?*

Phase 2 Impact Assessment

- *What are the stressors?*
- *How will impacts be evaluated?*
- *What are the impacts from the stressors?*
- *What is the status of City initiatives?*
- *What are pros and cons of all solutions*
- *What is the preferred solution & the criteria for selection?*

Phase 3 Management Strategy and Implementation

- *What are the recommended management solutions?*
- *Who will be responsible for addressing the recommendations?*
- *What is the status of City initiatives?*
- *Have goals been met?*

Phase 4 Long-term Monitoring Plan

- *Are the original assumptions appropriate?*
- *Should parts of the plan be modified when more information is available?*
- *What is the status of City initiatives (i.e., transportation studies, etc.)?*
- *How do you integrate science, management and public needs?*

Figure 2. Process Relationship to the Credit River Water Management Strategy

2.0 Background Information

2.1 Heritage Heights Secondary Plan Process

In 2014, a Conceptual Land Use Plan was developed for Heritage Heights. This concept was ultimately abandoned due to political uncertainty around the GTA West Corridor which resulted in a number of supporting studies also being put on hold.

In September 2019, the Ministry of Transportation announced its Technically Preferred Route ("TPR") for the GTA West Corridor. The TPR provided sufficient understanding of developable areas within the Heritage Heights area to resume planning of the area.

As part of Phase 1 of the new planning process, three (3) Charrettes were conducted to establish the vision and guiding principles, transportation structure and conceptual land use plan for the Secondary Planning Area. The following summarizes the visions and principles that will guide the planning of the community:

> *The Heritage Heights Area is planned to undergo significant change in the near future with the construction of the Heritage Heights mobility hub, Major Transit Station Areas, and The Grand Boulevard, which will be catalysts in transforming the Secondary Plan Area's landscape from mainly rural and auto-oriented uses into a mixed-use, vibrant, and transit-supported community.*
>
> *The Heritage Heights Secondary Plan establishes a vision where people, business, arts and culture thrive, and will become a choice destination within the City of Brampton, where the health and well-being of residents will be supported. Development in the Heritage Heights community will celebrate its natural setting and will be a net contributor to climate mitigation and adaptation.*

This Vision is consistent with the policies of the City of Brampton's Official Plan, October 2020 Consolidation, which outlines the City's policies, study requirements and associated timelines for implementing the expansion of the urban boundary for the North West Brampton Urban Development Area.

The resulting Plan identifies six distinct Precincts, which will accommodate a full range of housing forms, tenures and types, and uses. Urban development is intended to sensitively integrate into the surrounding neighbourhoods and will be known for its high-quality, transit-supportive built form, as well as its comfortable and attractive public realm that promotes the diversity of its residents. A network of natural areas, parks, open spaces and pedestrian amenities across the Secondary Plan Area will connect the Precincts and provide opportunities for residents to recreate and interact with one another.

Council of the City of Brampton endorsed the Conceptual Land Use Plan, vision and guiding principles for the Heritage Height Secondary Plan in July 2020. Following Council endorsement, the City commenced Phase 2 of the current planning process including the re-engagement of technical study teams to evaluate and assess the concept. This includes the preparation of the subwatershed study, transportation planning, servicing, cultural heritage, community energy planning, and shale resource review update.

As part of the technical review of the Concept Plan, the HHSWS will provide input to the land use plan on a range of ecological and engineering matters affecting NHS design and other matters such as stormwater management, low impact development measures based on the past and current SWS work. It will identify potential impacts and mitigative measures associated with surface water and groundwater resources, make recommendations for the protection, restoration and enhancement of natural features, functions and linkages, and identify compliance and long-term monitoring requirements. The 2012 HHSWS Phase 1 Characterization Report and this updated Characterization Report have informed the City's Conceptual Land Use Plan and the Heritage Heights Secondary Plan.

Phase 2 of the planning process will conclude with the preparation of a policy planning framework and community structure that highlights a Natural Heritage System that supports the objectives of the Official Plan and the HHSWS. The Phase 2 studies will provide direction and a framework plan for more detailed studies to be conducted through future planning phases at the Block Plan and site by site development stages.

2.2 Provincial Plan and Official Plan Guidance to the SWS

Several provincial and municipal planning documents provide important input to the preparation of the HHSWS. They include the Provincial Policy Statement (2020), the Greenbelt Plan (2017), the Region of Peel Official Plan (Office Consolidation December 2018) and the City of Brampton Official Plan (Office Consolidation 2020). Brief summarizes of these documents and their relevance to the HHSWS are provided below. Detailed policies in each of these documents have been reviewed during the preparation of this Phase 1 Characterization Report and will provide direction to natural heritage planning and management recommendations in subsequent stages of the Subwatershed Study.

Provincial Policy Statement

The PPS (2020) provides policy direction on matters of provincial interest related to land use planning and development in Ontario. It provides for, "… *appropriate development while protecting resources of provincial interest, public health and safety, and the quality of the natural and built environment*."

The PPS also provides the fundamental Provincial policy basis for the protection of natural heritage and water resources in Sections 2.1 and 2.2. In particular, the PPS states:

- "*natural features and areas shall be protected for the long term*" and, "*the diversity and connectivity of natural features in an area, and the long-term ecological function and biodiversity of natural heritage systems, should be maintained, restored or, where possible, improved, recognizing linkages between and among natural heritage features and areas, surface water features and ground water features.*" (PPS Section 2.1.1); and,
- *planning authorities shall protect, improve or restore the quality and quantity of water…*" (PPS Section 2.2.1).

Other policies of Sections 2.1.1 and 2.2.1 provide direction on natural heritage system planning, significant natural heritage features including significant wetlands, significant woodlands, significant valleylands, significant wildlife habitat, fish habitat and habitat of endangered species and threatened species, and the quality and quantity of water.

Greenbelt Plan

The Greenbelt Plan was prepared by the Province of Ontario in 2005 and updated in 2017. It was introduced in 2005 as, "*the cornerstone of the Greater Golden Horseshoe Growth Plan … that provides clarity and certainty about urban structure, where and how future growth should be accommodated and what must be protected for current and future generations*." The Greenbelt Plan, along with the Oak Ridges Moraine Conservation Plan and the Niagara Escarpment Plan, identifies where development should not occur to provide permanent protection to the agricultural land based and the ecological and hydrological features area and functions within Greenbelt lands.

The Greenbelt is, “a broad band of permanently protect lands which:

- Protects against the loss and fragmentation of the agricultural land base and supports agriculture as the predominant land use;
- Gives permanent protection to the natural heritage and water resource systems that sustain ecological and human health and that form the environmental framework around which major
- Provides for a diverse range of economic and social activities associated with rural communities, agriculture, tourism, recreation and resource uses; and
- Builds resilience to and mitigates climate change.”

The Greenbelt Plan area to the southwest of the Heritage Heights lands is all Natural System of Protected Countryside. Figure 1 and other plans in this SWS illustrate the location of the Greenbelt Plan Area. While the Greenbelt Plan area is part of the SWS Study Area, it is not within the City’s urban boundary. The Greenbelt Plan (2017) includes policies regarding the protection and management of these lands.

A Place to Grow, Greater Golden Horseshoe Growth Plan

A Place to Grow (2019), “together with the Greenbelt Plan, Oak Ridges Moraine Conservation Plan, and the Niagara Escarpment Plan, builds on the Provincial Policy Statement (PPS) to establish a unique land use planning framework for the GGH that supports the achievement of complete communities, a thriving economy, a clean and healthy environment, and social equity.” One of the Plan’s guiding principles is to, “protect and enhance natural heritage, hydrologic and landform systems, features and functions.” It provides for the identification of a Natural Heritage System outside of the Greenbelt Plan area and outside of settlement areas. The Plan requires the identification of water resource systems and protection of key hydrologic features and areas also outside of settlement areas. Heritage Heights is a settlement area, therefore, many of the Place to Grow Plan policies do not apply.

Region of Peel Official Plan

The Region of Peel Official Plan (Office Consolidation, 2018) has established a Greenlands System consisting of three components, i.e., Core Areas, Natural Areas and Corridors, and Potential Natural Areas and Corridors. Core Areas contain ecological features, forms and functions that provide, “favourable conditions for uninterrupted natural systems and maximum biodiversity”. Core Areas include features with the highest importance and protection such as significant wetlands, significant woodlands, significant valleylands, significant wildlife habitat, fish habitat and habitat of endangered species and threatened species. These areas are protected in policy and are functionally supported, connected and/or buffered by Natural Area and Corridors (NAC) and Potential Natural Areas and Corridors (PNAC).

Policies in Section 2.3 of the Official Plan address each of these areas and provide direction on the types of environmental features within each designation and management requirements. The extent of the Core Areas within the Greenlands System is shown generally on Schedule “A” of the Region of Peel Official Plan B; see Appendix D.

Other policies from the Official Plan relevant to the SWS and reviewed as part of this study include:

- Section 2.2.10 – Greenbelt Plan
- Section 2.4 - Natural and Human-Made Hazards
- Section 2.5 - Restoration of the Natural Environment
- Section 3.4 - Water Resources

City of Brampton Official Plan

Guidance is provided in the City's Official Plan (Office Consolidation 2020) in Section 4.6 on Natural Heritage Systems including the protection and management of natural heritage features, valleylands and watercourse corridors, woodlands, wetlands, Environmentally Sensitive/Significant Areas, Areas of Natural and Scientific Interest, fish and wildlife habitat, environmental buffers, setbacks and linkages, and the Greenbelt Plan. Section 4.6 also provides policies relating to protection of public health and safety relating to eliminating, minimizing and mitigating the potential risks associated with natural and manmade hazards. Policies address natural hazards including Regulatory floodplains, stability hazards of valley slopes, and 100-year erosion and meander belt hazards of watercourse channels. The City's OP Schedule D, Natural Heritage Features and Areas, is provided in Appendix D. It illustrates Natural Features and Areas and notes that the review and verification of Natural Heritage Features and Areas will be undertaken through planning processes or comprehensive environmental studies such as the HHSWS.

2.3 Terrestrial Resources, Background Information

The following is a brief overview of existing information and past studies carried out on the terrestrial systems in the Heritage Heights Subwatersheds and vicinity.

The HHSWS Study Area, referred to herein as the Study Area, is located at the northern limit of the Deciduous Forest Region (Carolinian Floristic Zone (Rowe, 1972). Based on the Natural Heritage Information Center database (NHIC, 2012), no designated Environmentally Significant Areas (ESA's) or Areas of Natural and Scientific Interest (ANSI's) occur within the Study Area. The Credit River which borders the southern limit of the Study Area is identified as Core Greenland on Schedule 'A' of the Region of Peel Official Plan (2008). In addition, the majority of woodlands, plantations and wetlands have been identified as Natural Areas in the Region's Greenland mapping. Terrestrial resources in the Study Area have been reviewed and assessed at a variety of scales, primarily from studies on behalf of the City of Brampton, Credit Valley Conservation, and Ministry of Natural Resources and Forestry to a) assist in Official Plan updates for Region of Peel and City of Brampton, and b) document areas of special significance i.e., Environmentally Significant Areas, wetlands, and fisheries.

In 1978, a woodlot study for the rural portions of Brampton was completed (Ecologistics, 1978) which categorized woodlands as hardwood, coniferous or mixed, assessed soils and drainage, and assigned woodlot priority ratings to assist future planning. In 1979, the Credit River Watershed Environmentally Significant Areas study was completed (Ecologistics, 1979) which identified significant natural features meeting significance criteria; no ESAs were identified in the Study Area, however nearby ESAs include the Huttonville Valley, and Georgetown Credit River Valley ESAs. This document was more general compared to more current studies, which are based on MNRF's Ecological Land Classification system (Lee et.al., 1998).

The 1992 AgPlan Ltd. environmental inventory was completed to evaluate urban expansion options as part of an Official Plan Review, and identified all natural and successional terrestrial features in the Study Area based on an interpretation of aerial photographs and field checking of key features such as woodlands and valleylands. This study provided the first comprehensive GIS mapping of woodlands, wetlands, successional areas and hedgerows in the rural areas of Brampton. Cultural plantings such as farmyards and hamlets were also documented.

The Credit Valley Subwatershed Study and Servicing Plan was completed in 2003 (TSH et.al., 2003). The terrestrial analysis used in that study was based on the 1992 AgPlan Ltd. baseline data, converted to ELC in combination with CVC data, and scoped field study. Linkage standards outlined in that study were subsequently reflected in the Environmental Open Space Study completed by Dougan & Associates in 2005. These standards were identified as the 'Credit Valley Terrestrial Strategy', and incorporated terrestrial resources, aquatic resources, floodlines and hydrologic functions of streams to define two levels of linkage opportunity (high and moderate).

In 2000, the City of Brampton commissioned Phase 1 of the Urban Boundary Review for North West Brampton, which recommended the expansion of the urban boundary (Hemson 2002). Scoped field assessments were conducted, and general level application of the Ecological Land Classification (ELC) system based on data derived from the AgPlan 1992 environmental study, and available ELC mapping for the Credit Watershed (provided by CVC), was carried out. The Hemson study incorporated updated terrestrial natural features mapping and identified preliminary constraints based on more current policy standards, in an effort to provide a preliminary estimate of developable area.

The North West Brampton Environmental Open Space Study (EOS) was completed in 2005 by Dougan & Associates to assess whether development in the Northwest Brampton Study Area could be carried out in an environmentally sustainable manner and address the open space requirements of Policy 7.9.2.8 of the Region of Peel Official Plan. The EOS provided an ecosystem analysis of physical and biological environmental features, functions and linkages for the broader North West Brampton landscape. The EOS provided adequate information across the relevant disciplines in order to a) determine the feasibility of development in North West Brampton, and b) identify key sensitivity issues that will need to be further addressed in the subsequent subwatershed studies.

The Ministry of Natural Resources has conducted two wetland evaluations that included the Study Area and beyond, and in 2007 released an updated wetland evaluation for the Churchville-Norval Provincially Significant Wetland Complex and the Huttonville-Fletchers Provincially Significant Wetland Complex. These were subsequently revised in May of 2008. The Churchville-Norval Provincially Significant Wetland Complex includes wetlands located within the Greenbelt Plan Area in the Study Area. The Huttonville-Fletchers Provincially Significant Wetland Complex includes wetlands in the remaining portions of the Study Area and within lands to the east. The current status of wetlands is discussed in detail later in this report.

The Northwest Brampton Landscape Scale Analysis was initially prepared in 2007 to provide ecological context for the Huttonville and Fletcher’s Creeks Subwatershed Study (HFSWS), and for the Mount Pleasant Secondary Plan in the City of Brampton. The Study Area encompassed the North West Brampton Planning Area and related subwatersheds, and surrounding landscapes adjacent to these lands, including portions of the Credit River watershed, the neighbouring Etobicoke Creek watershed, and surrounding regional and local municipalities. The purpose of the LSA was to:

> *“Model through a Geographic Information Systems (GIS) analysis, the inter-relationship of ecosystem features and functions at a landscape scale, to interrelate the landscape ecology of the North West Brampton area to the surrounding landscape within the larger watershed (i.e. Credit River and Etobicoke Creek watersheds) and to provide context to the subwatershed study and municipal land use planning.”*

The LSA report was updated in May 2011 to incorporate many of the Technical Steering Committee comments and additional data and findings from Phases 2 and 3 of the HFSWS process, to summarize the outcome of the HFSWS, and to support future planning exercises (i.e. future subwatershed and secondary planning studies, regional transportation studies).

An additional LSA Update, prepared in 2013, applied the same general principles and approaches to assist with the technical studies being conducted for the Heritage Heights secondary plan area and the West Huttonville and Credit River Tributary subwatersheds.

The Landscape Scale Analysis (LSA) for Heritage Heights involved the aggregation and analysis of information at relatively broad spatial scales to provide contextual support for local-scale studies. The

LSA offered ecologically-related guidance to planning of the Heritage Heights community by presenting the ecological context of the surrounding landscape. Consistent landscape scale data resolution throughout the LSA study area allowed for: a) a valid understanding of the Heritage Heights secondary plan area, the Credit River tributaries and West Huttonville Creek subwatersheds within the LSA study area context; and b) use of the data set for future similar analyses of other developing lands in and adjacent to the LSA study area.

In 2007, the Province enacted the updated Endangered Species Act (ESA), and there have been several additions to the species listed under the ESA that are relevant to this study. The discussion in this Phase 1 report indicates the current status, and the most current status lists will form part of the basis for impact assessment criteria in Phase 2 and management strategies in Phase 3.

The HFSWS (June 2011) was completed in support of the Mount Pleasant Secondary Plan. This Subwatershed Study included the characterization of the East and West Huttonville Creek subwatersheds, and the identification of potential development impacts within these subwatersheds with particular focus to the Mount Pleasant Secondary Plan. The HFSWS provided input to the Secondary Plan including the establishment of an NHS, and a range of management strategies for its protection, uses and delineation. Hydrologic and hydraulic models were prepared for these subwatersheds and stormwater management recommendations made to address water quality and quantity controls. While the HFSWS focused on the Mount Pleasant Secondary Plan area, models were prepared and preliminary stormwater management approaches were also identified for the West Huttonville Creek within the Heritage Heights lands. These models have provided the basis for hydrologic and hydraulic assessments for portions of the Heritage Heights lands as part of the HHSWS.

The draft HHSWS Phase 1 Characterization and Report (2012) documented site specific field investigations for a range of aquatic, terrestrial, surface water and groundwater resources. Data collected and assessed as part of that study are include herein where applicable.

2.4 Other Relevant Studies

A substantial number of other plans, studies and guidelines have been referenced during the preparation of the HHSWS. A complete listing is provided in the References section of this report. Where appropriate, information on the use of data, findings, and direction from these reports has been summarized on a discipline basis in Section 4.

Municipal Class Environmental Assessments for Roads

Municipal Class Environmental Studies were completed by the Region of Peel and the City of Brampton to prepare an assessment to support planned growth in the area and provide additional road capacity, as recommended in the Long Range Transportation Plans. The Municipal Class EA process is a public process that identifies the problem "*need for additional road capacity*", identifies alternative solutions, assesses the impacts on the natural, social, economic and cultural environments, prepares alternative design concepts of the preferred solution, selects a preferred solution. These studies are documented in Environmental Study Reports (ESR) for public consultation, review and approval by government approval authorities. Municipal Class Environmental Studies, completed on the following roads in the proximity of Heritage Heights, were reviewed during the preparation of this Phase 1 Characterization Report:

- Region of Peel - Mississauga Road Class EA–Bovaird Drive West to Mayfield Road – Completed May 2013;
- Region of Peel - Bovaird Drive Class EA – Worthington Ave to 1.45 km west of Heritage Road – Completed May 2013;

- Region of Peel - Mayfield Road Class EA – Chinguacousy Road to Winston Churchill Boulevard – Completed July 2016; and
- City of Brampton - Lagerfeld Drive Extension Class EA – Creditview Road to West of Mississauga Road – Completed April 2021.

Heritage Heights Community Infrastructure Servicing Study

The draft *Heritage Heights Community Infrastructure Servicing Study* (ISS), June 2021, has been prepared by Urbantech Consulting to support the Heritage Heights Secondary Plan. The study will identify an overall servicing strategy in support of development of the Secondary Plan. More specifically, the ISS will:

- Identify and describe sanitary sewer and water servicing strategies and systems for Heritage Heights lands to confirm that the planning area may be serviced through the logical extension of existing and planned water and sanitary infrastructure;
- Identify servicing, grading, and environmental constraints and opportunities related to development of the Secondary Plan, including identification of off-site / downstream constraints, and mitigation of such constraints;
- Determine preliminary stormwater management (SWM) requirements, including:
    - approximate drainage boundary delineation;
    - preliminary locations of SWM facilities;
    - “rule of thumb” sizing of stormwater management facilities;
    - consideration of alternative / innovative SWM measures to be further addressed in future studies;
    - assessment of site grading and the need for watercourse lowering in the upstream areas of West Huttonville Creek and Credit River Tributaries 1, 2 & 3 subwatersheds where the shallow flat nature of these drainage systems may require lowering to accommodate the gravity drainage of the future roads and building foundations; and
    - comparison of Heritage Heights infrastructure servicing with previous Region of Peel infrastructure assumptions carried forward in the Water/Wastewater Master Plan and Development Charge (DC) studies.

The ISS analyses have been coordinated with ongoing HHSWS work and previous studies completed for North West Brampton including the adjacent Block 51-1 studies and designs. It will provide inputs to the HHSWS on SWM and servicing matters including channel realignment and lowering approaches to servicing the Heritage Heights lands. Equally, results from the HHSWS will provide inputs to the ISS analyses on a range of environmental matters.

Four X Lands Environmental Implementation Report (EIR) and Functional Servicing Report (FSR), January 2016

Reference will be made the EIR and FSR for the Four X lands located in the southeast corner of the Study Area immediately west of Mississauga Road. Design information from this report will influence storm drainage solutions to the north of these lands as the current development includes a SWM facility that is intended to service external drainage. This will be further reviewed through the HHSWS Phase 2 report to provide appropriate inputs to the SWS SWM analyses.

3.0 Goals, Objectives and Targets

3.1 Introduction

The purpose of this report section is to provide a starting-point and premise for establishing specific physically and environmentally-based subwatershed scale goals, objectives and targets for use in this study. Clearly there are numerous background considerations in this regard, including previous documentation at a watershed scale, historical assessments conducted on a subwatershed scale, as well as the governing Acts, Guidelines and Policy. This report section provides an overview of each of these, while laying out a course to develop more specific goals, objectives, and targets through the subwatershed study process and associated consultation with agencies and stakeholders.

3.2 Subwatershed Study Goals and Objectives

Separate from the physically-based and environmentally-founded Goals and Objectives for the respective subwatersheds of West Huttonville Creek and the Credit River Tributaries, various Goals and Objectives have been established for the Subwatershed Study itself as part of the consultation process related to the original Terms of Reference preparation.

As part of that process, it was noted that the initial preliminary subwatershed goals and objectives and targets will be derived at the conclusion of Phase 1 of the Subwatershed Studies and refined at the end of Phase 2 and Phase 3 (as required), in conjunction with the LSA Update. The following Subwatershed Study objectives were identified for completion/consideration when establishing the environmentally-based goals and objectives:

a) To integrate the information and analysis from the CVC Effectiveness Monitoring Program, Mount Pleasant Community Subwatershed Study, and other existing subwatershed studies and environmental implementation reports for Credit Valley and Fletchers Creek; Open Space Study; and the Landscape Scale Analysis Update.

b) To evaluate environmental constraints and opportunities within the North West Brampton Study Area.

c) To develop and/or estimate measurable subwatershed goals and objectives to:

- Establish natural cover targets and distribution for the achievement of sustainable ecosystem maintenance (e.g., biodiversity conservation);
- Identify key linkage points for conservation given the connected links identified in the Landscape Scale Analysis Update;
- Develop a management strategy to address surface and groundwater quantity and quality;
- Establish best management practices;

d) To provide delineation, on a reconnaissance scale, of:

- Recharge areas for regional and local groundwater systems;
- The groundwater resources potential for the area;
- Generalized groundwater flow patterns;
- Define water balance/budgets for each subwatershed and/or subcatchment.

e) Interrelate information from, and provide input to:

- The North West Brampton Community Design Study;
- Servicing Studies for Heritage Heights Community; other related undertakings.

f) To provide direction and input on mitigative measures for future studies such as EIR's, Functional Servicing Reports (FSRs), and storm water management plans (SWM plans).

g) To develop an implementation plan that includes specific implementation schemes (i.e., define areas for protection, conservation, restoration and remediation) and outlines roles and responsibilities to carry out all recommendations that result from this study.

h) To provide a monitoring plan that includes:

- A long-term plan of action and a description of the information required for assessing results of the ongoing Effectiveness Monitoring Strategy and Comprehensive Groundwater Monitoring to measure subwatershed goals and targets are being met and to implement Adaptive Environmental Management.

i) To establish recommendations for stewardship of sensitive areas.

j) To develop a Implementation Plan that includes recommendations for:

- Secondary Planning and related background components studies;
- Input into Environmental Implementation Reports as part of Block Plan stage;
- Education and Stewardship;
- Rehabilitation and Retrofit;
- Monitoring.

3.3 Governing Acts, Guidelines and Policies

As a complement to the overall process of establishing subwatershed scale goals, objectives, and targets, there also needs to be a recognition/understanding of the context of the governing legislation with respect to resource management. Various acts, guidelines, and policies exist at a federal, provincial and municipal (upper and lower tier) level to provide a framework for managing the impacts associated with land use change.

The following table has been prepared summarizing the various forms of legislation, along with their purpose.

Table 3.3.1. Summary of Acts, Guidelines, Policy

Level of Government	Name of Management Tool: Act/Regulation/Policy/Guideline/Program	Type of Tool	Purpose
Federal	Federal Fisheries Act (I)	Act	Purpose is to ensure the conservation and protection of fish and fish habitat.
	Migratory Birds Convention Act (1994)(I)	Act	Protection of migratory songbirds and their nests from disturbance or destruction
	Species at Risk Act (2003)	Act	Protection of Wildlife species at risk; recovery plans
	Canadian Environmental Protection Act (CEPA)(1999)	Act	The goal of the Canadian Environmental Protection Act (CEPA) is to contribute to sustainable development through pollution prevention and to protect the environment, human life and health from the risks associated with toxic substances.
	Canadian Environmental Assessment Act	Act	The Act requires federal departments, including Environment Canada, agencies, and crown corporations to conduct environmental assessments for proposed projects where the federal government is the proponent

Level of Government	Name of Management Tool: Act/Regulation/Policy/Guideline/Program	Type of Tool	Purpose
	Department of the Environment Act	Act	Establishes the department of the Environment and sets forth the various powers and responsibilities of the minister.
	Canadian Water Quality Guidelines for the Protection of Aquatic Life	Guideline	The Canadian Water Quality Guidelines consist of a set of recommended “safe limits” for various polluting substances in raw (untreated) drinking water, recreational water, water used for agricultural and industrial purposes, and water supporting aquatic life. They are designed to protect and enhance the quality of water in Canada. The guidelines apply only to inland surface waters and groundwater’s and not to estuarine and marine waters.
	Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses	Guideline	The Canadian Water Quality Guidelines consist of a set of recommended “safe limits” for various polluting substances in raw (untreated) drinking water, recreational water, water used for agricultural and industrial purposes, and water supporting aquatic life. They are designed to protect and enhance the quality of water in Canada. The guidelines apply only to inland surface waters and groundwater’s and not to estuarine and marine waters.
	Guidelines for Canadian Drinking Water Quality	Guideline	To provide a national guideline for the protection of drinking water.
	Guidelines for Canadian Recreational Water	Guideline	To provide a national guideline for the protection of recreational waters used for primary contact recreation such as swimming, windsurfing and water skiing and for secondary contact recreation activities including boating and fishing.
	A Framework for Guiding Habitat Rehabilitation in Great Lakes Areas of Concern (1998, EC/CWS, OMNR, OME) (D)	Policy	Initiated in 1990 as part of the federal Great Lakes Action Plan, the Cleanup Fund represents a significant part of Canada’s commitment to restore the Great Lakes Basin Ecosystem as outlined in the 1987 Protocol to the Great Lakes Water Quality Agreement between Canada and the United States (GLWQA).
Provincial	Nutrient Management Act (OMAF) (2002)	Act	As part of the Ontario government’s Clean Water Strategy, the *Nutrient Management Act* provides for province-wide standards to address the effects of agricultural practices on the environment, especially as they relate to land-applied materials containing nutrients.
	Lakes and Rivers Improvement Act (1990)	Act	The Lakes and Rivers Improvement Act gives the Ministry of Natural Resources the mandate to manage water-related activities, particularly in the areas outside the jurisdiction of Conservation Authorities.
	Provincial Planning Act (D)	Act	The purposes of this Act is to promote sustainable economic development in a healthy natural environment
	Ontario Water Resources Act	Act	The Ontario Water Resource Act deals with the powers and obligations of the Ontario Clean Water Agency, as well as an assigned provincial officer, who monitors and

Level of Government	Name of Management Tool: Act/Regulation/Policy/Guideline/Program	Type of Tool	Purpose
			investigates any potential problems with regards to water quality or supply. There are also extensive sections on Wells, Water Works, and Sewage works involving their operation, creation and other aspects.
	Environmental Protection Act	Act	The purpose of this Act is to provide for the protection and conservation of the natural environment. R.S.O.1990, c.E.19, s.3.
	Endangered Species Act (ESA) (2007)	Act	Enacts the protection of Endangered, Threatened and Special Concern species (provincial) and their habitats; regulates activities which may affect these species, and provides for development of Recovery Strategies.
	Fish and Wildlife Conservation Act (1997)	Act	*Fish and Wildlife Conservation Act* enables the Ministry of Natural Resources (MNR) to provide sound management of the province's fish and wildlife.
	Safe Drinking Water Act (MOE) (2002)	Act	Its purpose is the protection of human health through the control and regulation of drinking-water systems and drinking-water testing.
	Municipal Act	Act	The Municipal Act sets forth regulations in regard to the structuring of municipalities in Ontario.
	Ontario Regulation 242/08 under the Endangered Species Act, 2007	Regulation	This regulation allows certain activities to proceed that would affect threatened, endangered or extirpated species and that would otherwise not be allowed, provided specific conditions are followed to protect species and their habitat. O. Reg. 242/08 currently applies to all species listed on the Species at Risk in Ontario (SARO) List; it provides regulated habitat definitions.
	Guidance for Development Activities in Redside Dace Protected Habitat (MNRF, 2016)	Guideline	Guidelines provide a description of Redside Dace habitat, the protection provided to the species and their habitat under the ESA, a description of when a permit is required under the ESA and the project review and permitting process, and guidance as to best management practices for development activities to avoid or mitigate impacts on Redside Dace and their habitat.
	Ontario's New Drinking Water Protection Regulation for Smaller Waterworks Serving Designated Facilities O. Reg. 505/01	Regulation	The Regulation is Part of the New Drinking Water Regulations administered through the Ministry of the Environment.
	Ontario Drinking Water Protection Regulation	Regulation	In August 2000, the Government of Ontario announced a new *Drinking Water Protection Regulation* (Ontario Regulation 459/00) to ensure the safety of Ontario's drinking water. The regulation issued under the *Ontario Water Resources Act* was a part of the comprehensive Operation Clean Water action plan. This regulation put the Ontario Drinking Water Standards into law, updating and strengthening the Ontario Drinking Water Objectives.

Level of Government	Name of Management Tool: Act/Regulation/Policy/Guideline/Program	Type of Tool	Purpose
	Bill 127, Ontario Water Resources Amendment Act (Water Source Protection), 2002	Act	The Bill amends the *Ontario Water Resources Act* in regard to the availability and conservation of Ontario water resources. Specifically, the Bill requires the Director to consider the Ministry of Environment's statement of environmental values when making any decision under the Act. The Bill also requires that municipalities and conservation authorities are notified of applications to take water that, if granted, may affect their water sources or supplies.
	Provincial Water Quality Objectives (MOE) (1994)	Guideline	To provide objectives for the protection of aquatic life.
	Drainage Act	Act	Provides for the regulation of drainage practices in Ontario.
	Clean Water Act (2005)	Act	Purpose of the Act is to protect existing and future sources of drinking water. Act requires the preparation of Source Protection Plans across the Province to establish policies and strategies to protect the quantity and quality of municipal water supplies.
	Provincial Policy Statement (2020)	Policy	Provincial Policy Statement was issued under Section 3 of the Planning Act. It provides policy direction on matters of provincial interest related to land use planning and development in Ontario.
	Greenbelt Plan (2017)	Policy	Provides policies to permanently protect the agricultural land based and the ecological and hydrological features area and functions within Greenbelt lands.
	A Place to Grow, A Growth Plan for the Greater Golden Horseshoe (2019)	Policy	Builds on the PPS to establish a unique land use planning framework for the Greater Golden Horseshoe.
	Natural Heritage Reference Manual for the Natural Heritage Policies of the Provincial Policy Statement, 2010.	Guideline	Provides guidelines for the implementation of the PPS by planning authorities.
	Significant Wildlife Habitat Technical Guide (2000, OMNR)	Guideline	Significant Wildlife Habitat has been identified as one of the natural heritage feature areas under the Provincial Policy Statement.
	Protection and Management of Aquatic Sediment Quality in Ontario (MOE) (1993)	Guideline	The purpose of the sediment quality guideline is to protect the aquatic environment by setting safe levels for metals, nutrients and organic compounds.
	Guidelines for Evaluating Construction Activities Impacting on Water Resources (MOE) (1995)	Guideline	These guidelines were developed to protect the receiving environment according to the physical, the chemical and the biological quality of the material being dredged.
	Incorporation of the Reasonable Use concept into MOE Groundwater Management Activities (1994)	Guideline	This guideline establishes the basis for the reasonable use of groundwater on property adjacent to sources of contaminants and for determining the levels of contaminants acceptable to the ministry.
	Ontario Drinking Water Standards (MOE) (2001)	Guideline	The purpose of the standards is to protect public health through the provision of safe drinking water.
	Technical Guideline for Private Wells: Water Supply Assessment (MOE) (1996)	Guideline	Guidance manual for the development of private wells.

Level of Government	Name of Management Tool: Act/Regulation/Policy/Guideline/Program	Type of Tool	Purpose
	Technical Guideline for On-site Sewage Systems (MOE)	Guideline	Guidance manual for assessing the proposed impacts on on-site sewage systems on groundwater.
	Subwatershed Planning (MOE) (1993)	Guideline	Technical manual on conducting subwatershed planning in Ontario.
	Integrating Water Management Objectives into Municipal Planning Documents (MOE) (1993)	Policy	Policy manual on the integration of watershed management practices into municipal planning documents.
	Watershed Management on a Watershed Basis (MOE) (1993)	Guideline	Guideline manual on watershed management practices.
	Technical Definitions and Criteria for Key Natural Heritage Features in the Natural Heritage System of the Protected Countryside Area (December 7, 2012)	Guideline	Provides technical assistance to planning authorities and others on the identification and delineation of key natural heritage features in the NHS of the Protected Countryside.
	Environmental Bill of Rights (EBR)	Bill of Rights	On February 15, 1994, the Environmental Bill of Rights (EBR) took effect and the people of Ontario received an important new tool to help them protect and restore the natural environment. While the Government of Ontario retains the primary responsibility for environmental protection, the EBR provides every resident with formal rights to play a more effective role.
Regional			
	Region of Peel Official Plan (Office Consolidation, 2018)	Policy	Provides a long term plan for the management growth and development. Policies direct how Peel will grow and develop while protecting the environment, managing resources and setting a structure for growth.
	Peel-Caledon Significant Woodlands and Significant Wildlife Study (2009)	Study	Provides a comprehensive analysis of criteria and thresholds for identifying significant woodlands and significant wildlife habitat in the Region and the Town of Caledon.
Municipal	City of Brampton Official Plan (Office Consolidation 2020)	Policy	Municipal planning strategies, and associated land use bylaws, are the primary tools used by municipalities for land use planning. As a statement of Council's policies and priorities, a strategy establishes a framework for addressing how a community will respond to opportunities and challenges for orderly growth and development. And while opinions on municipal planning strategies are many and varied, most would agree they are necessary.
	City of Brampton Tree Preservation Bylaw	Bylaw	Protects City's trees by regulating and prohibiting destruction of trees on private property.
	City of Brampton Woodlot Conservation Bylaw	Bylaw	Conserves and protects woodlots in Brampton
	Municipal EIS Guidelines (D)	Guideline	Purpose is to set forth guidelines for conducting Environmental Impact Study as

Level of Government	Name of Management Tool: Act/Regulation/Policy/Guideline/Program	Type of Tool	Purpose
			part of the review of social, economic and environmental impacts of proposed projects in order to protect natural heritage features.
	Functional Servicing Study Terms of Reference and Environmental Implementation Report Terms of Reference	Guideline	Provides terms of reference for completion of studies noted.
Conservation Authority	Conservation Authorities Act	Act	Conservation Authorities, created in 1946 by an Act of the Provincial Legislature, are mandated to ensure the conservation, restoration and responsible management of Ontario's water, land and natural habitats through programs that balance human, environmental and economic needs.
	Ontario Regulation 160/06, CVC Regulation of Development, Interference with Wetlands and Alterations to Shorelines and Watercourses (2006)	Regulation	Regulation to prohibit or regulate development in or adjacent to Shorelines, wetlands, floodplains, watercourses, valleys, dynamic beaches and hazard lands.
	Credit Valley Conservation Watershed Planning and Regulation Policies (April 2010)	Policy	Provides CVC's watershed planning and regulation policies. These policies provide the parameters against which CVC administers Ontario Regulation 160/06 under Section 28 of the Conservation Authorities Act and guide CVC's review of official plans, zoning bylaws and planning applications under the Planning Act, including other legislation.
	Credit Valley Conservation Stormwater Management Criteria (August 2012)	Guideline	Provides guidance in the planning and design of stormwater management infrastructure and outlines the processes and infrastructure needed to address flooding, water quality, erosion, water balance, and natural heritage.

3.4 Credit River Water Management Strategy Update Study

The Credit River Water Management Strategy (CRWMS) provides high-level guidance to local municipalities on a broad range of environmental matters generally illustrated in the figure below:

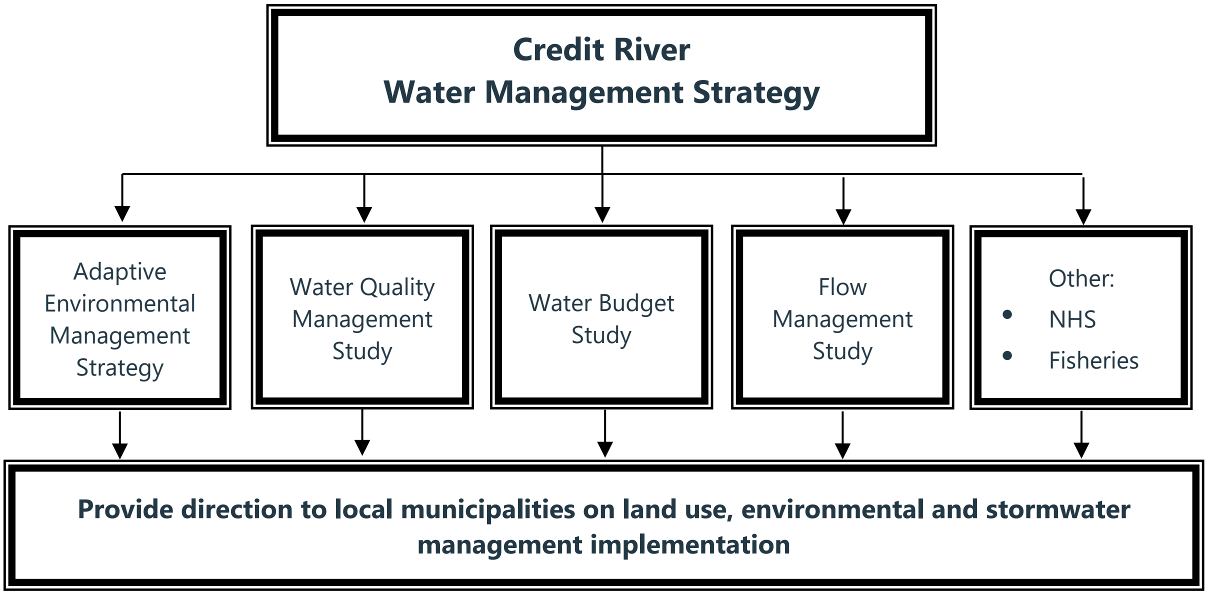


Figure 3. Relationship of CRWMS to CVC Technical Studies

The CRWMS Update Study was released in 2007. The report documents both Watershed Scale and Subwatershed Scale, Objectives, Indicators and Targets. Insofar as the latter, the report identifies the need to refine/establish Subwatershed Scale Targets during the course of subwatershed studies.

Table 3.3.2 provides a summary of relevant CRWMS Objectives to this Subwatershed Study. Each of these have an indicator and measurable parameter (related to the indicator). Through the approved HFSWS, 2011 numerous discussions were held with the City, CVC, MNR and landowners regarding appropriate objectives, indicators, measurable parameters and targets. Table 3.4.2 reflects the outcomes of these discussions including only specific relevant objectives from the CRWMS as well as several new objectives not identified in the CRWMS. The outcomes from these detailed discussions are expected to be applicable to this Subwatershed Study and provide the starting point for subwatershed analyses and refinements through future study phases. .

Table 3.3.2 also provides the 'Source-Pathways-Receptors Linkage' as determined within Phase 2 of the HFSWS, 2011 to document the integration of the targets. As such, the level of importance and the benefit/impact of meeting or not meeting each target can be viewed on a system basis.

Table 3.3.2. Target Summary

Objective	Indicator	Measurable Parameter	Target	System Integration Source – Pathways – Receptors Linkage
Surface Water				
4c	Flow Time Series	Ratio of a Flow Time Series (Q2;Q5;Q10;Q25;Q50 m3/s)Compared to Historic Time Series	Should generally be less than 1.5 times the comparable historic value.	Linked impact pathways: • Stable Bed Sediment Regime (5c) • Low Flow Function (NEW 4)
5b	Instream Erosion Potential 2	Erosion Threshold (shear stress or other variable)	To be determined for each subwatershed. The target to be developed based on monitoring	Linked impact pathways: • Stable Bed Sediment Regime (5c) • Low Flow Function (NEW4)
9d-k	Contaminants of Concern	Copper - 75 percentile Iron - 75 percentile Zinc - 75 percentile Total Phosphorus - 75 percentile Nitrate-Nitrogen - 75 percentile Suspended Solids - 75 percentile Chlorides - 75 percentile	Move towards volume of: Cooper - 0.005 mg/L Iron - 0.3 mg/L *(+/-)* Zinc - 0.02 mg/L *(+/-)* Total Phosphorus - 0.03 mg/L *(+/-)* Nitrate – Nitrogen - 2.9 mg/L *(+/-)* Suspended Solids - <25 mg/L *(+/-)* (dry) Chlorides - <250 mg/L *(+/-)*	Linked impact receptors • Fish Communities (16a) • Fish Productive Capacity (16b) • Species at Risk (aquatic) (16c) • Benthic Invertebrate Community New13)
7a	Protection of Life and Property	Regulatory Peak Flood Flow	To be calculated for each subwatershed. The target is no increase or a net reduction in the regulatory flood flow.	Linked impact pathways: • Flow Time Series (4C) • Natural Corridors and Linkages (NEW6)
NEW 1	Protection of Life and Property (2 to 100 year Peak flows)	2 to 100 year Peak Flood Flow	No increases in return period peak flows	Linked impact pathways: • Flow Time Series (4C)
Ground Water				
8b	Groundwater Discharge	Existing Stream Baseflow	Groundwater Discharge functions to be maintained. To be determined on a subwatershed basis (or other functionally related area).	Linked impact receptors: • Fish Communities (16a) • Fish Productive Capacity (16b) • Species at Risk (aquatic) (16c) • Benthic Invertebrate Community (New 13)
8c	Recharge Areas	Average Recharge on a Subwatershed Basis	Groundwater Recharge functions to be maintained. To be determined on a subwatershed basis (or other functionally related area).	Linked impact receptors: • Fish Communities (16a) • Fish Productive Capacity (16b) • Species at Risk (aquatic) (16c) • Vegetation Communities (16d)

Objective	Indicator	Measurable Parameter	Target	System Integration Source – Pathways – Receptors Linkage
				• Benthic Invertebrate Community (New 13)
8d	Water Table Elevations	Average Water Table Elevation	Groundwater discharge function to be maintained. To be determined on a subwatershed basis (or other functionally related basis).	Provides hydraulic gradients for linkages noted above as well as terrestrial community components, and maintains water levels for local domestic wells.
Fisheries				
16c	Species at Risk (Redside Dace)	Number of Special Status Species Present and Amount of Species At Risk Recovery Habitat Present	Watershed target to be established through monitoring.	Linked impact pathways: • Flow Time Series (4c) • Instream Erosion Potential 2 (5b) • Stable Bed Sediment Regime (5c) • Low Flow Function (NEW 4) • Contaminants of Concern (5d-k) • Groundwater Discharge (8b) • Recharge Areas (8c) • Maintenance of drainage density (NEW 2) • Protection of Property and Structures (meander belt) • Riparian Cover 1 (15a) • Riparian Cover 2 (15b)
NEW 13	Benthic Invertebrate Community	Hillsenhoff Biotic Index	No significant deterioration in HBI	Linked impact pathways: • Flow Time Series (4c) • Instream Erosion Potential 2 (5b) • Stable Bed Sediment Regime (5c) • Low Flow Function (NEW 4) • Contaminants of Concern (5d-k) • Groundwater Discharge (8b) • Recharge Areas (8c) • Maintenance of drainage density (NEW 2) • Protection of Property and Structures (meander belt) • Riparian Cover 1 (15a) • Riparian Cover 2 (15b) Linked impact receptors: • Fish Communities (16a) • Fish Productive Capacity (16b) • Species at Risk (aquatic) (16c)
Geomorphology				
NEW 2	Maintenance of Drainage Density	Channel Length/Catchment Area	Maintain open channel length within similar natural systems of	Linked impact pathways: • Natural Corridors & Linkages (NEW 6 & 7)

Objective	Indicator	Measurable Parameter	Target	System Integration Source – Pathways – Receptors Linkage
			similar Regional subwatershed samples	
5c	Stable Bed Sediment Regime	Particle Size Distribution and Mean Particle Size of Bed Sediments (D_{50}; D_{85} particle size)	To be determined for each subwatershed. Targets to be developed based on monitoring.	Linked impact receptors: • Other fluvial targets • Riparian cover (15a and 15b) • Fish Communities (16a) • Fish Productive Capacity (16b) • Species at Risk (aquatic) (16c) • Benthic Invertebrate Community (New 13)
6a	Protection of Property and Structures	Risk to Structures within Areas Prone to Erosion (the number of affected structures under a Q_5 event)	To be determined on a subwatershed basis. Target is no increase or a net decrease in number of affected structures.	Linked impact pathways: • Natural Area Protection (NEW 5)
NEW 3	Flushing Flow (sediment mobility)	Using a target flow for flushing fines from riffles. Used as a check to ensure post-development flow regime will maintain sediment movement	To be modeled for each modeling catchment	Linked impact receptors: • Fish Communities (16a) • Fish Productive Capacity (16b) • Species at Risk (aquatic) (16c) • Benthic Invertebrate Community (New 13)
NEW 4	Low Flow Function	Test of minimum width/depth ratio (thalweg) to check on channel connectivity at low flows	To be modeled for each modeling catchment.	Linked pathways: • Stable bed sediment regime (5c)
Terrestrial Ecology				
15a	Riparian Cover 1	Width of the Riparian Buffer	15 m back from each streambank (warmwater) 30 m back from each stream (coldwater)	Linked pathways: • Riparian cover (15b) • Forest Cover (15c) • Wetland Cover (15d) • Interior Forest (15e) • Natural Area Protection (NEW 5) • Natural Corridor & Linkages (NEW 6)
15b	Riparian Cover 2	Percent of Stream Length Buffered	75% of stream length in natural vegetation	Linked pathways: • Riparian cover (15a) • Forest Cover (15c) • Wetland Cover (15d) • Interior Forest (15e) • Natural Area Protection (NEW 5) • Natural Corridor & Linkages (NEW 6)
15c	Forest Cover	Percent of the Subwatershed Forested	To be calculated on a subwatershed basis.	Linked pathways: • Wetland Cover (15d) • Interior Forest (15e) • Natural Area Protection (NEW 5)

Objective	Indicator	Measurable Parameter	Target	System Integration Source – Pathways – Receptors Linkage
				• Natural Corridor & Linkages (NEW 6) • Multi-Functional Supporting Linkage (NEW 7)
15d	Wetland Cover	Percent of the Subwatershed in Wetlands	To be calculated on a subwatershed basis.	Linked pathways: • Forest Cover (15c) • Interior Forest (15e) • Natural Area Protection (NEW 5) • Natural Corridor & Linkages (NEW 6) • Multi-Functional Supporting Linkage (NEW7)
15e	Interior Forest/Core Habitat	Percent of the Subwatershed in Wetlands	To be calculated on a subwatershed basis.	Linked pathways • Natural Area Protection (NEW 5) • Natural Corridor & Linkages (NEW 6) • Multi-Functional Supporting Linkage (NEW 7)
16c	Species At Risk and Special Status Species	Number of Special Status Species Present and Amount of Species At Risk Recovery Habitat Present	Watershed target to be established through monitoring. Address SAR species habitat in manner compatible with Provincial requirements.	Linked pathways: • Forest Cover (15c) • Wetland Cover (15d) • Natural Area Protection (NEW 5) • Natural Corridor & Linkages (NEW 6)
16d	Vegetation Communities	Average Number of Different ELC Community Types per Vegetation Patch	The average number of ELC communities/unit natural area is to be determined through monitoring on a subwatershed basis. Target is a net gain on a subwatershed basis	Linked pathways: • Riparian cover (15a/15b) • Forest Cover (15c) • Wetland Cover (15d) • Natural Area Protection (NEW 5) • Natural Corridor & Linkages (NEW 6) • Multi-Functional Supporting Linkage (NEW 7)
NEW 5	Natural Area Protection	Development Setback	To be determined through Subwatershed Study .	Linked pathways: • Riparian cover (15a/15b) • Forest Cover (15c) • Wetland Cover (15d) • Natural Corridor & Linkages (NEW 6) • Multi-Functional Supporting Linkage (NEW 7)
NEW 6	Natural Corridors and Linkages	Corridor component width, efficient linkage of significant natural features	Widths and extent to reflect policies and regulations, NH system needs, and other plan component needs.	Linked pathways: • Riparian cover (15a/15b) • Forest Cover (15c) • Wetland Cover (15d) • Natural Area Protection (NEW 5) • Multi-Functional Supporting Linkage (NEW 7)
NEW 7	Corridor Type 2 Multi-Functional Supporting Linkage	Corridor width; efficient linkage of significant natural features (parameters to be developed in design charette)	Widths and extent to reflect policies and regulations, NH system needs, and other plan component needs.	Linked pathways: • Riparian cover (15a/15b) • Forest Cover (15c) • Wetland Cover (15d)

Objective	Indicator	Measurable Parameter	Target	System Integration Source – Pathways – Receptors Linkage
				• Natural Area Protection (NEW 5) • Natural Corridor & Linkages (NEW 6)
NEW 10	Significant Woodlands	Significant Criteria	Apply draft Region of Peel criteria for Significant Woodland identification in area municipalities	Linked pathways: • Riparian cover (15a/15b) • Forest Cover (15c) • Wetland Cover (15d) • Natural Area Protection (NEW 5) • Natural Corridor & Linkages (NEW 6)

3.5 Previous Subwatershed Studies

The Huttonville Creek and Credit River Tributaries subwatersheds have been the subject of previous studies; the most current subwatershed undertakings in this regard include:

- *"Mount Pleasant Community Sustainable Natural Heritage System Planning Huttonville and Fletcher's Creeks Subwatershed Study", AMEC et al., 2011*

i) "Credit Valley Subwatershed Study", Totten Simms Hubicki, 2003

Each of these efforts established various Goals, Objectives, and Targets; specific relevant excerpts from each study have been compiled and summarized into Appendix 'H' for the West Huttonville Creek Subwatershed.

3.6 Other Considerations

Endangered Species Act and Regulations

As of April 1, 2019, the Endangered Species Act (ESA, 2007) is regulated through the Ministry of Environment, Conservation and Parks (MECP). 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;
- Threatened - a species that is at risk of becoming endangered in Ontario if limiting factors are not reversed; and
- Special Concern (formerly Vulnerable) - a species that is not endangered or threatened, but may become so due to a combination of biological characteristics and identified threats.

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. Species of Special Concern require management plans from the MECP but are not directly protected under the ESA. Species of Special Concern are considered Species of Conservation Concern and may be protected through the identification of Significant Wildlife Habitat.

Ontario Regulation 242/08 provides definitions of regulated habitats.

With respect to Redside Dace, an endangered fish species, the Provincial document entitled, *Guidance for Activities in Redside Dace Protected Habitat* (MNRF, March 2016) provides guidance to the SWS on matters relevant to works in Redside Dace habitat including best management practices for development activities to avoid or mitigate impacts on Redside Dace and their habitat.

Clean Water Act

The Clean Water Act required the preparation of Source Protection Plans across the Province to establish policies and strategies to protect the quantity and quality of municipal water supplies. The Province approved the Source Protection Plan applicable to the City entitled the Credit Valley-Toronto and Region-Central Lake Ontario Source Protection Plan in July 2015, and was amended in March 2019. Source protection policies have been in force and effect since December 31, 2015. The Source Protection Plan identified four types of vulnerable areas where certain land uses or activities have the potential to negatively affect drinking water supplies (quantity or quality), and contains policies to direct works in and near these aeras - Wellhead Protection Areas (WHPAs), Highly Vulnerable Aquifers (HVAs), Significant Groundwater Recharge Areas (SGRAs) and surface water Intake Protection Zones (IPZs).

Provincial Water Quality Objectives

In addition to the current guidance related to the respective environmental factors, other criteria need to be considered, such as the Provincial Water Quality Objectives (PWQO)) and the ESA regulations with respect to Redside Dace (i.e. water quality and stormwater management criteria) that have the potential to influence targets. In regard to potential water quality targets, issues associated with "Existing" versus "Interim" status will need to be rationalized as referenced in **Table 3.6.1**.

Table 3.6.1. Summary of Contaminants for Which Provincial Water Quality Criteria are Available

Contaminant	Existing PWQO	Interim PWQO	Comments
Aluminum (Al)		X	PWQO varies with pH
Arsenic (As)	X	X	
E.coli	X		PWQO limit to be compared with geometric mean of at least five samples
Beryllium (Be)	X		PWQO varies with Hardness as $CaCO_3$
Boron (B)		X	
Cadmium (Cd)	X	X	Interim PWQO varies with Hardness as $CaCO_3$
Cobalt (Co)	X		
Copper (Cu)	X	X	Interim PWQO varies with Hardness as $CaCO_3$
Dissolved Oxygen	X		PWQO varies with Temperature as deg. C
Chromium (Cr)	X		PWQO provide for Cr III and Cr VI only
Iron (Fe)	X		
Lead (Pb)	X	X	Existing PWQO varies with Alkalinity as $CaCO_3$; Interim PWQO varies with Hardness as $CaCO_3$
Molybdenum (Mo)		X	
Nickel (Ni)	X		
pH	X		
Total Phosphorus (Total P)		X	PWQO states "Current scientific evidence is insufficient to develop a firm objective at this time". General PWQO guidelines depend upon "site-specific status".
Selenium (Se)	X		
Silver (Ag)	X		
Water Temperature (deg. C)	X		PWQO varies by location (i.e., edge of mixing zone versus within receiving water body)
Thallium (Tl)		X	
Tungsten (W)		X	
Uranium (U)		X	
Vanadium (V)		X	
Zinc (Zn)	X	X	
Zirconium (Zr)		X	
Antimony (Sb)		X	

4.0 Baseline Inventory

This report section describes the activities associated with each discipline involved in developing a better understanding of the conditions prevalent in the Heritage Heights Study Area. Specifically, this report section outlines the importance of each discipline, associated background information of relevance, the methods used to define and assess the respective subwatersheds, including field and analytic procedures, along with an interpretation, leading ultimately to a characterization of the system and its resources. While each discipline has been presented individually, information is provided within each discipline's presentation which outlines how one discipline would relate to others by way of interactions associated with features, functions, or form. This initial integration, which offers a framework from which to define the value of existing and future resources, as well as their potential sensitivity to change as a result of changing land uses and associated stressors, is further elaborated upon in Section 5.

4.1 Climate

4.1.1 Importance/Purpose

Climate data are critical to developing the hydrologic and hydrogeologic/groundwater system modeling for characterization of the surface water conditions, as well as surface and groundwater interactions for both West Huttonville Creek and Credit River Tributaries. Long-term meteorological data sets have been developed within and adjacent to the Credit River Watershed and in close proximity to the West Huttonville Creek and Credit River Tributaries subwatersheds for use in multi-seasonal, multi-year assessments.

4.1.2 Background Information

As part of the Credit River Flow Management Study, meteorological data sets pertinent to the Credit River Watershed were evaluated and subsequently used in developing the flow regime for the Watershed. In order to account for the meteorological conditions across the watershed, various meteorological data sets from Environment Canada's Atmospheric Environment Service (AES) stations were used in order to account for the variable meteorologic conditions (rainfall, temperature) across the watershed. As the Heritage Heights Study Area is not as extensive as the Credit River Watershed, spatially variable meteorological data sets are not required.

As per Section 1.1.1 of the PPS (2020) managing and directing land use to achieve efficient and resilient development and land use patterns includes preparing for the regional and local impacts of a changing climate. Specifically, climate change trends are also relevant to the long term maintenance and management of terrestrial/vegetation communities, particularly with regard to defining water balance/budgets, vegetation communities and habitat changes i.e. invasive species.

4.1.3 Methods

Field

For the current subwatershed study, no rainfall data have been collected, as calibration to local stream flow gauges has not been required based on the availability of previous hydrologic modelling calibration and consultation with CVC.

The Subwatershed Study Team collected local rainfall data for the HFSWS, 2011, during 2006 and 2007 by using a tipping bucket rainfall gauge located on Heritage Road (ref. Appendix 'C', Figure Hydrology 1). Complementing the Subwatershed Study Team's rainfall gauge, the CVC as part of the Effectiveness Monitoring Program (EMP) has two local rainfall gauges located at the Fire Station on Creditview Road and at the CVC administration office. Rainfall data were collected weekly from the Subwatershed Study Team gauge, and following significant storm events.

In addition to rainfall data, local continuous air temperature data are collected by the CVC, as part of EMP at Creditview Road Fire Station and CVC administration office.

Analytic

The Toronto Pearson Airport is the closest AES rainfall gauge to the Heritage Heights Study Area and the meteorological data from this gauge had been used for the Credit River Flow Management Study. The meteorological data from Toronto Pearson Airport that was used in the Credit River Flow Management Study are summarized in **Table 4.1.1**. The Source column within **Table 4.1.1** indicates the various hydrologic model meteorological data sets developed by the CVC.

Table 4.1.1. Toronto Pearson Airport (6158733) – Meteorologic Data

Meteorologic Data	Source	Period of Record	Format
Rainfall	HSP-F (CVC)	Jan. 1996 – Aug. 2001	Daily Rainfall (mm)
	HSP-F (CVC)	Jan. 1991 – Dec. 2001	Hourly Rainfall (mm)
	GAWSER (CVC)	Jan. 1960 – Dec. 1997	Hourly Rainfall (mm)
Temperature	HSP-F (CVC)	Jan. 1996 – Dec. 2000	Daily Min./Max. Temperature (°C)
	HSP-F (CVC)	Jan. 1991 – Aug. 2001	Daily Min./Max. Temperature (°C)
	HSP-F (CVC)	Jan. 1960 – Dec. 2000	Hourly Temperature (°C)
	GAWSER (CVC)	Jan. 1960 – Jul. 1998	Average Daily Temperature (°C)
Wind	HSP-F (CVC)	Jan. 1996 – Dec. 2000	Hourly Wind (km/hr)
Dew Point Temperature	HSP-F (CVC)	Jan. 1996 – Dec. 2000	Hourly Dew Point Temperature (°C)

In addition to the Toronto Pearson Airport gauge, the Credit River GAWSER hydrologic model has also incorporated the following meteorological data sets:

Table 4.1.2. Orangeville (Gauge b – 6155790) – Meteorologic Data

Meteorologic Data	Source	Period of Record	Format
Rainfall	HSP-F (CVC)	Jan. 1991 – Aug. 2001	Daily Rainfall (mm)
	GAWSER (CVC)	Jan. 1960 – Dec. 1999	Hourly Rainfall (mm)
Temperature	HSP-F (CVC)	Jan. 1991 – Aug. 2001	Daily Min./Max. Temperature (°C)
	GAWSER (CVC)	Jan. 1960 – Dec. 1999	Average Daily Temperature (°C)

Table 4.1.3. Georgetown (6152695) – Meteorologic Data

Meteorologic Data	Source	Period of Record	Format
Rainfall	GAWSER (CVC)	Jan. 1950 – Dec. 2005	Hourly Rainfall (mm)
Temperature	GAWSER (CVC)	Jan. 1960 – Dec. 1999	Average Daily Temperature (°C)

Further discussion of the meteorological data used in this study has been provided in Section 4.3.3.2.

Integration

The data from the AES gauges at Toronto Pearson Airport have been incorporated into the Huttonville Creek HSP-F hydrologic model. The Toronto Pearson Airport/ Orangeville and Georgetown gauge data have been used within the Credit River Tributaries GAWSER hydrologic modelling. The long-term AES data have been used to develop a long-term flow record for the purpose of developing frequency flows. The climate data collected and used for this study serve as input to the modelling, which describes the water cycle and allows for interpretation of the significance of certain components of the system.

4.1.4 Interpretation

The HHSWS Study Area is in the Lower Credit River Watershed area and is at the interface of the Lower and Middle Watersheds and generally cover the lands coincident with the Niagara Escarpment as well as the Greenbelt Plan area. From the perspective of climate, the Study Area is in southern Ontario and is generally south of, or below, the Niagara Escarpment within the South Slope, the physiographic area south of the Niagara Escarpment. The climate for most of southern Ontario is characterized by mild winters and hot summers, with each of the four seasons incurring different precipitation patterns.

Mean annual precipitation for the Study Area is approximately 793 mm, based on the 30 year climate data collected at Toronto Lester B. Pearson Airport. The driest months of the year are usually January through to March (42.6 to 57.1 mm/month), with the wettest months typically being May through to September (72.5 to 79.6 mm/month). Based on the 30 year record, precipitation occurs, on average, 146 days of the year and approximately 11 to 13 days per month. High runoff conditions may occur during the months of November, December, February and March, when the ground is saturated or frozen and precipitation occurs as rainfall.

It is recognized that precipitation patterns are evolving with climatic changes. Southern Ontario in the last several years has seen a number of '100 year storm events'. The frequency of the larger storm events, such as a 100 year storm, appears to be increasing and meteorological data collected prior to the year 2000 may not provide an accurate basis of the precipitation trends to come.

Precipitation may also be impacted by changes in daily temperatures. Southern Ontario appears to be heading to milder winters (ref. The Canada Country Study, Climate Impacts and Adaptation, Environment Canada, 1998). The results of milder temperatures will be reduced snow pack depths, higher runoff events when precipitation occurs as rainfall during 'winter' and a reduced spring freshet.

4.2 Hydrogeology

4.2.1 Importance/Purpose

It is important to understand the interrelationship between the hydrogeologic conditions, the use of groundwater for anthropogenic needs and the subwatershed ecosystem in order to assess and develop targets and controls for potential impacts from land use changes and to enhance the linkages where appropriate.

4.2.2 Background Information

The reports and maps that were reviewed, along with the results from other disciplines in the current study have been documented in Section 2.3.

In order to present a more convenient flow of technical material for the reader, this background section includes graphical material created specifically for this study dealing with geological cross-sections, overburden thickness, bedrock topography and water well capacities. This graphical material was generated using a well log database. The York, Peel, Durham, Toronto (YPDT) – Conservation Authorities

Moraine Coalition (CAMC) Groundwater Study has undertaken a number of technical studies that include the Northwest Brampton Study Area inclusive of Heritage Heights. One key product of this study has been the development of the "YPDT Database" that stores the geologic and hydrogeologic information from all study partners. The database is structured around the Ministry of the Environment (MOE) Water Well Information System (WWIS) which includes the location of all drilled wells and associated geology, well construction, water level, and well capacity information. Using information available from study partners, well locations have been assessed and assigned a quality code providing information on the confidence in the well location. Additionally geologic descriptions have been standardized using a rule-based method developed by the Geological Survey of Canada (MOE, 2001) to aid in geologic interpretation and correlation between wells.

In the Heritage Heights Study Area, higher quality information on geology and groundwater levels is provided by 13 exploration wells drilled as part of work completed by the Interim Waste Authority (IWA) in 1993. Other high quality subsurface data gathered specifically within the Heritage Heights Subwatershed Study Area include:

- 9 monitoring wells drilled at 8 locations (includes 1 nest) and 23 piezometers installed at 18 locations (includes 4 nests) across the Study Area; and, 10 boreholes drilled for a hydrogeological study of the proposed Norval Quarry site in the area just north of Bovaird Drive West and east of Winston Churchill Boulevard (Golder, 2010); and,
- numerous shallow boreholes drilled for geotechnical studies on various properties in the area.

Additional high-quality subsurface data are available in and around the Study Area from the Subwatershed Study completed for the adjacent Mount Pleasant Community Lands and the Sub-Area 51-1 EIR studies. These data include geology and groundwater information from 32 monitoring wells installed in 23 locations (i.e., includes 9 'nested' locations of 2 boreholes); 24 piezometers installed in 12 locations (includes 12 nests) and numerous shallow boreholes drilled for various geotechnical studies in the area.

All of this information was added to well and borehole data from the YPDT database for use in this study. Domestic water well and monitoring well locations are shown on Figure GW-1; additional geotechnical borehole locations are included on Figure GW-2.

Study Area

The extent of the study area for the hydrogeological component varies. To put the groundwater flow system within a more regional context, the majority of the mapping represents an area beyond the Heritage Heights Subwatershed Study Area.

Physiography and Geology

The physiographic description of an area commonly includes summaries of topography, landform, drainage and the occurrence of surface soils types along with an overview of the depositional and erosional history that created the landform. Geologic descriptions commonly detail the overburden and bedrock composition and form below the surface as well as the relationship of the geology to the physiography of that area. Together these two descriptions are used to characterize the physical setting of a study area and form the basis of any groundwater interpretation. Within the study area, the physiography and geology are so very closely related that for the purposes of this study, the physical setting overview is a synthesis of both overall characteristics.

The physiography and Quaternary geology of the general area is detailed in Chapman and Putnam (1984) and Karrow (1991), respectively. More study-specific detailed assessments and descriptions were presented in the North West Brampton Shale Resources Study, 2002 (MacNaughton Hermson Britton

Clarkson), the Credit Valley Subwatershed Study, July, 2003 (Totten Sims Hubicki Associates, ESG International, Parish Geomorphic Ltd. Bill Blackport, Schroeter and Associates) and the Golder Associates IWA Landfill Site Search Peel Region – Step 6 Hydrogeological Reports (Dec.1993). The IWA studies investigated, in substantial detail, the geology and hydrogeology of 3 candidate landfill sites located within and adjacent to the Study Area including 2 sites at the north-western and south-western corner of Heritage Road and Wanless Drive, and one site immediately south of Bovaird Drive West between Mississauga Road and Creditview Road.

The Study Area lies within the general physiographic regions known as the Peel Plain and South Slope. The shape of the bedrock surface as well as the occurrence of the overburden units, which make up the above region, is a result of the repeated glacial advances and retreats which have occurred in southern Ontario. The most recent glacial advance and retreat formed much of the land surface and geology present in the area today. This event is referred to as the Wisconsin Glaciation, and was accompanied by various meltwater lakes and channels. The last glacial retreat ended between 10,000 and 20,000 years ago, blanketing the area in glacial till sediments. Most of the study area is flat or has gently rolling topography except where the Credit River or its tributaries have cut through the glacial till plain, in some cases to the underlying bedrock. The tributaries are more deeply incised towards their downstream reaches. The regional slope of the upland Peel Plain is south to south-eastward. The direction of glacial movement has formed parallel topographic features which tend to control the surface drainage features. The topographic elevation varies from approximately 270 masl in the north to 180 masl in the south.

Surficial Deposits

The surficial (Quaternary) geology map shown in Figure GW-3 shows the distribution of these units within the Study Area. Surficial geology differs from soil maps in that it represents the upper 2 m of material whereas the soils maps represent the material at surface. The surficial geology was mapped by Karrow (1991) at a scale of 1:50,000 within the CVC watershed. In the area outside the watershed, 1:100,000 scale provincial mapping (OGS, 2000) is used. Previous periods of glaciation such as the Illinoian, 135,000 years ago, have not formally been identified in the Credit River watershed, however, remnants of York Till have been identified east of the Study Area (Karrow, 1989) and potentially exist at the base of deep buried bedrock valleys in the watershed.

In the Study Area, several glacial depositional processes resulted in various overburden deposits. As the glacier advanced, the bedrock was eroded and "till" units were deposited. These consist of a mixture of materials; usually including a significant fine grained component (silt and clay of the Halton Till) as well as sand, gravel and/or larger stones. The texture and reddish brown colour of the Halton Till reflects in part the erosional material from the underlying Queenston shale during glaciation. As meltwater flowed away from the glacier (or temporary lakes), some stream channels were eroded and sand and gravel was left behind as older alluvium. Within glacial lakes, silt and clay were laid down as lakebed material, known as (glacio)lacustrine deposits. The geological interpretation will be presented in more detail below.

The Halton Till overlies the Queenston shale bedrock over the majority of the area. Isolated sand or gravel units may occur at or near bedrock. The plain is relatively flat in the upper Study Area and slopes to the southeast in the lower reaches. Along portions of the Credit River and tributaries in the southwest and west central portion of the Study Area, erosion through both the glaciolacustrine and Halton Till deposits has exposed the shale bedrock within the stream valleys. Minor bedrock valleys associated with these stream reaches occasionally contain sand and gravel infill deposits. More significant deposits of sand and gravel may infill the lower reaches of these creeks as they enter the Credit River valley.

Halton Till

The IWA (1993) studies provided extensive characterization of the overburden in support of assessing the potential for a landfill site. Where the overburden had sufficient thickness, the overburden was subdivided into four stratigraphic units to establish a certain level of confidence in the hydrostratigraphic correlation for hydrogeologic impact assessment.

These units included:

Upper Till Unit – this correlates with the Halton Till. This unit is described as sandy silty clay to clayey silt with sand. Small amounts of gravel and cobbles were noted. The till was described as massive and generally weathered through its entire thickness (up to 5 m). Vertical fractures were noted extending beyond the base of the unit.

Middle Till Complex – up to 13 m of individual, poorly correlated massive till layers with interbeds of stratified silt to sand and gravel. The layers and interbeds, generally in the range of 0.1 to 3.3 m thick, are interpreted to be discontinuous but may extend tens to hundreds of metres. Weathering, to varying extents, occurs within the Middle Till.

Glaciolacustrine Deposits – layers of fine grained glaciolacustrine clayey silts and silty clays were encountered at the base of the Middle Till. Although these layers were generally less than 1 m, varved (rhythmically layered) sequences were found up to 8.4 m in thickness.

Lower Till Complex – this till is similar to the Middle Till but not as variable. Gravel was observed in all till samples and shale fragments were more common closer to the bedrock surface. Sand and gravel at the bedrock contact was common but not consistent.

Geologic Interpretation

The geological interpretation presented in the IWA reports is excellent and is re-presented below.

The surficial deposits beneath the site, including the Upper Till Unit, Middle Till Complex, Lower Till Complex and Glaciolacustrine Deposits, are predominately ice-contact deposits associated with the last glaciation of the area. The depositional events beginning with the basal Lower Till Complex and proceeding to the Upper Till Unit are discussed below.

The Lower Till Complex represents basal deposition from an initial advance of glacial ice moving across the area likely in direct contact with the bedrock surface. The Lower Till Complex is overlain by glaciolacustrine deposits consisting of silt and laminated clay. The glaciolacustrine deposits drape over the underlying Lower Till Complex and the topography formed by the basal till likely influenced the deposition and thickness of the glaciolacustrine deposition. The deposition of the glaciolacustrine deposits is considered to reflect a retreat of the glacier associated with the Lower Till from the vicinity of the site. The retreat was also associated with the inundation of the area by a pro-glacial lake, likely confined between the Niagara Escarpment upland and the ice lobe that occupied Lake Ontario through-out much of the late Wisconsin period. The deposition of these deposits was likely quite laterally extensive and as such they provide significant stratigraphic marker horizons unless removed by subsequent glacial advances. These deposits are also locally associated with layers of stratified sands and gravels, deposited during periods when the glacial ice was more proximal to the site or when rates of melt water runoff and associated sedimentation increased.

The Middle Till Complex represents a period preceding the deposition of the Upper Till Unit. The complex was associated with highly variable deposition of relatively thin layers of till interbedded with glaciolacustrine clay, silt, sand, sand and gravel. This "Middle period" may represent successive advances and retreats of a glacier front over comparatively short periods of time. Alternatively, it may also represent the deposition of till as inter-fingered lobes of material originating as debris slides into a glaciolacustrine environment from either a stagnant or moving glacier front. Regardless, the highly interbedded nature of the deposits encountered within the Middle Till Complex, which represent the bulk of the soil beneath the site, reflects a very complicated and highly variable environment of depositions.

The clayey Upper Till Unit represents the last ice-contact glacial deposits underlying the site. This till correlates with the Halton Till recognized throughout the area (Karrow, 1987). The more `clayey' nature of the till may reflect incorporation of earlier glaciolacustrine deposits. The upper portion of the till may also be glaciolacustrine till deposited in a pro-glacial pond during the retreating stages of the Halton ice. No clear evidence of such was encountered during drilling, although Ontario Geological Survey mapping within the area (Karrow, 1987) has indicated the local occurrence of glaciolacustrine silts and clays overlying the till at the ground surface.

Overburden Thickness

A map of overburden thickness is depicted in Figure GW-4. The map was created using the ground surface topography from the 5 m digital elevation model (DEM) provided by CVC and the bedrock surface developed using borehole logs and water well records as described in the previous section. The bedrock surface elevation map was subtracted from the ground surface elevation map (DEM) to compute the thickness of unconsolidated material (overburden) that overlies bedrock. Within the Heritage Heights Subwatershed Study Area, the thickness of the overburden ranges from 0 m southeast of the intersection of Heritage Road and Bovaird Drive and in the incised stream valleys to over 30 m in places along the buried bedrock valleys beneath the Credit River and through the northern portion of the Study Area along Wanless Drive.

Bedrock

The IWA geologic description and interpretation for the Queenston shale bedrock is detailed and re-presented below. The Queenston shale is the surficial bedrock unit for the entire Study Area.

The Queenston Formation shale is an Upper Ordovician age sequence that was deposited in a sub-aerial, marine-deltaic environment. The Queenston delta encroached westward from the ancient Appalachian Mountain source area into the marine water that occupied the area during ancient geological times. The surface of the delta was exposed to the atmosphere which accounts for the red, oxidized condition of the material. The bulk of the detrital material comprising the deposit is illitic clay and quartz mineral derived from mature weathering of the sedimentary source area. However, some marine material including calcite (calcium carbonate), gypsum (calcium sulphate) and traces of intergranular halite (sodium chloride) also occur within the shale.

The total depositional thickness of the Queenston Formation within the area was approximately 120 m based on records of deep petroleum exploration drilling in the adjacent Niagara Escarpment area near Milton. Subsequent erosion both previous to, and during the Pleistocene Epoch has removed the upper portion of the formation within the site area based on the geological mapping within the area (Bond and Telford, 1976).

The present bedrock surface was developed during the last glaciation of the area.

The weathering profile that has developed within the bedrock surface may reflect both pre-glacial as well as post-glacial weathering. Portions of the pre-glacial weathered layer may have been removed by the glaciers considering the relatively soft nature of the material, accounting for the variability in the thickness of the weathered zone encountered in the boreholes.

The fracturing that occurs within the shale is largely due to both structural fracturing, such as the more vertical fractures, and weathering of bedding planes. Bedding planes associated with gypsiferous coatings are most susceptible to weathering due to circulating groundwater.

The bedrock topography is influenced by a number of factors including the lithology, weathering, glacial-fluvial erosion and direct glacial erosion. Figure GW-5 presents a map of the bedrock topography determined by interpolating bedrock surface elevations contained within the borehole database. This bedrock surface was updated as part of this study using the high quality data previously outlined and the June 2006 version of the YPDT database. The surface was created using wells that intersected bedrock and overburden wells were used to constrain the minimum depth of the bedrock surface elsewhere.

A large bedrock valley is interpreted to underlie the southern portion of the Study Area beneath the main branch of the Credit River. A smaller, less continuous bedrock valley is interpreted to cross through the northern portion of the Study Area beneath Wanless Drive (Figure GW-5).

Geologic Cross-Sections

The geologic units described above are readily seen on schematic cross-sections prepared for the Study Area. The locations of these cross-sections can be found on Figure GW-2 and in Appendix B-1 (Figure B1). Eight (8) geologic cross-sections are presented in Appendix B-1 (Figures B2-B9). The sections were developed by projecting the subsurface logs for the high-quality monitoring wells and drive-point piezometers, as well as the water wells in the YPDT database along each cross-section line to enable interpretation of subsurface features. Wells were selected for projection onto each section by preferentially selecting high-quality (e.g., IWA) wells and deep wells which provide the most complete information on the subsurface. Wells were excluded to avoid visual overlap of well logs on the sections. The static water levels, screen or open well sections, surface water features and cross-section intersection points were annotated on the logs. The ground surface (5m DEM) is also displayed on the sections. The lithologic names and colours used to represent the geology reflect the standardized GSC_code names (MOE, 2001).

The cross-sections reflect the stratigraphic description presented above and, of particular note, illustrate:

- The variable thickness of the till overburden layer.
- The inclusions of discontinuous sand and gravel lenses within the till overburden.
- Sand and gravel lenses at the bedrock contact particularly within bedrock depressional areas.
- The general bedrock topography and localized depressions and valleys.

The cross-sections also present the static water levels at the time of well installation.

Hydrogeologic Setting

Hydraulic Conductivity

Water level response tests were carried out at all the IWA sites to determine the hydraulic conductivity of the various units. Although these numbers may vary across the study area, they likely reflect the general and relative permeabilities of the various units. The average hydraulic conductivity of the massive tills was on the order 3 x 10^{-6} cm/sec. The stratified units were interpreted to act as one hydraulic unit with a representative hydraulic conductivity on the order of 5 x 10^{-5} cm/sec. The permeable overburden deposits at the bedrock contact, below the till, had an averaged hydraulic conductivity of 1 x 10^{-4} cm/sec. Hydraulic conductivity measurements in the overburden for the Norval Quarry had a geometric mean of 4 x 10^{-5} cm/sec for the falling and rising head tests and 5 x 10^{-6} cm/sec for the Hazen analyses. Hydraulic conductivities measured in the overburden for the Mount Pleasant Community Sub-Area 51-1 study were in the range of 10^{-5} to 10^{-7} cm/sec depending on the overburden characteristics. Hydraulic conductivities for the overburden in the Fletchers Creek study were in the range 3 x 10^{-5} to 5 x 10^{-7} cm/sec. The Shale

Resources Review reported an average bulk hydraulic conductivity for the till of 1 x 10^{-4} cm/sec. It is important to note that water level response tests may not accurately represent the increased hydraulic connection that may occur within fractured tills as borehole drilling may smear and disrupt fracture networks.

In the IWA study, the shallow highly fractured bedrock had a representative hydraulic conductivity of 1 x 10^{-3} cm/sec, the intermediate bedrock (within the top 10 m) had a representative hydraulic conductivity on the order of 4 x 10^{-5} cm/sec, and the deep bedrock (> 10 m) had a representative hydraulic conductivity of 1 x 10^{-6} cm/sec. The hydraulic conductivity measurements in the bedrock for the Norval Quarry showed a geometric mean of 5 x 10^{-5} cm/sec for the shallow bedrock and 5 x 10^{-7} cm/sec for the deeper bedrock. The general trend of decreasing hydraulic conductivity with depth in the bedrock reflects the trend to less fracturing.

Groundwater Levels

The 1993 monitoring of groundwater levels at the three IWA sites showed seasonal variations of between 1 and 2 m, reflecting seasonal recharge. The site south of Bovaird Drive showed less of a seasonal variation which could be a result of the site being situated further down in the groundwater flow system. The water level trends within the surficial deposits and the bedrock were similar and this was interpreted to indicate a strong degree of hydraulic connection between the surficial overburden and the bedrock. The vertical gradients between the overburden wells and the bedrock varied within and amongst the sites. There were minor upward gradients at a few wells, neutral gradients at the majority of wells and minor to strong downward gradients at a number of wells. The vertical hydraulic gradients within the bedrock were consistently downward.

At the Norval Quarry site, the following trends in groundwater levels were noted:

- Water levels in the overburden and shallow bedrock were near ground surface;
- Water levels in these wells generally respond similarly to seasonal precipitation events; and,
- Slight to moderate downward gradients exist in the majority of the onsite wells.

Similar trends in water levels were noted for the Mount Pleasant Community Sub-Area 51-1 study with groundwater levels ranging from about 2.7 m below grade to more than 2 m above ground (artesian pressures). The water levels are influenced by the topographically driven groundwater flow systems; water levels in wells in the upland areas are generally below grade and water levels in the topographically lower areas are at or above grade.

Groundwater Recharge and Flow

Infiltration/recharge rates are governed to a large extent by the surficial geology and associated hydraulic conductivity. Other factors include vegetative cover, topography, hydraulic gradient, spatial and temporal distribution of precipitation events and temperature. A long-term variation in frequency of the low intensity precipitation events may affect the overall infiltration/recharge. Groundwater flow in the overburden, as has been previously noted, is primarily driven by local topography and the spatial variations in hydraulic conductivity.

The horizontal flow within the overburden and shallow bedrock at the IWA sites generally followed the topography and basically the same gradient as the topography, approximately 0.4 to 0.7 per cent. Groundwater balances were calculated for each site. Darcy fluxes were calculated using the representative hydraulic conductivities, the cross-sectional flow through area of the proposed site property and the horizontal gradients across the property. Horizontal fluxes were on the order of 0.5 to 1.4 L/min. This did not include flows in the most upper fractured till. It was presented that the recharge at these sites would be on the order of 10% to 20% of the annual precipitation or 80 mm to 160 mm per year. The basis for these numbers was not presented in the IWA report. It was further reported that on a site basis (approximately 125 ha), this equated to approximately 190 to 380 L/min. It was then proposed that the two orders of magnitude difference between the expected recharge and the potential horizontal groundwater flux indicates that the majority of groundwater beneath the site is derived from local recharge and migrates horizontally over relatively short flow paths to points of surface discharge. It was also interpreted that the shallow flow within the site is likely significantly influenced by soil fracturing within the weathered zone of the Upper Till Unit and by more permeable stratified soil lenses or layers that occur beneath it.

Within the Norval Quarry study area, groundwater level contours in the overburden and shallow bedrock are influenced by local topography with groundwater flow directions towards the main tributary (CRT2) bisecting the quarry property. Seasonal variations in the groundwater levels do not alter the groundwater flow directions. Within the quarry catchment area, a recharge rate of 58 mm/year was determined (Golder, 2010).

Within the Mount Pleasant Community Sub-Area 51-1, the following general flow conditions were noted:

- The groundwater elevation contours suggest that the groundwater elevations, in both the overburden and shallow bedrock, generally reflect the topography and, as such, the groundwater flow patterns closely follow the surface water flow patterns. The groundwater elevations also suggest that there is a high degree of hydraulic continuity between the overburden and bedrock and that the bedrock topography influences the groundwater flow conditions (just as the bedrock topography influences the ground surface topography).
- The local movement of shallow flow responds quickly to precipitation conditions and explains why the shallow hydraulic gradients in some areas are variable and often reverse from discharge to recharge conditions.
- There appears to be very little water moving through the local flow systems due to the relatively tight soil conditions. Even with upward gradients along the watercourse, the actual volume of groundwater that discharges tends to be insufficient to sustain visible seepage or groundwater baseflow.
- In the Study Area, local, intermediate and more regional flow systems are evident. The overall regional groundwater system moves generally towards the south. Recharge occurs in the topographically higher areas of the northwest and east (within and external to the Study Area). The deep groundwater flow paths are interpreted to generally converge through the buried bedrock valley, flowing through deep sand layers that infill portions of the valley and through the upper fractured layer of shale. They continue to flow south towards the lower reaches of East Huttonville Creek and the more deeply-incised valleylands of the Main Huttonville Creek, south of Bovaird Drive. The downstream reaches, where the stream bottom intercepts the sand and/or shale, are the areas where groundwater discharge provides perennial baseflow to the streams.

In the Fletchers Creek Subwatershed Study (Paragon, 1996), infiltration rates were approximated by correlating to a baseflow range of 50 to 150 mm year over the basin. The Shale Resources Review (MHBC, ESG -2002) reported an infiltration rate of 80 to 100 mm/year. An estimated infiltration rate of 50 mm/year was reported by Funk (1979) for a watershed underlain by the Halton Till. By way of example, a stormwater management study carried out within a subcatchment area in the upper reaches of the Red Hill Creek in Hamilton Ontario estimated an infiltration rate of 150 to 200 mm/year in a highly fractured Halton Till directly connected to highly fractured bedrock (Guther, Scheckenberger, Blackport, 1997). The Credit Valley Subwatershed Study & Servicing Plan (Final Draft, 2003) used potential infiltration rates of 100 to 150 mm/year for the Halton Till.

Groundwater Quality

Overburden

The IWA overburden water quality was further divided into the stratified unit (i.e., units described above within the Middle Till) and the massive tills. The water in the stratified unit is typically hard (up to 490 mg/L $CaCO_3$) and slightly alkaline with concentrations of Total Dissolved Solids (TDS) up to 810 mg/L. Major ions are calcium, magnesium, sodium and bicarbonate. There were minor concentrations of sulphate and sodium. Water quality within the sand lenses in the basal till had relatively high concentrations of TDS, principally from sodium and chloride reflecting the mixing of more saline water from the underlying bedrock. The water quality within the Upper and Middle Till units is similar to the water quality within the stratified unit. The Lower Till unit had relatively higher values for TDS, chloride, sodium and sulphate. Again, this is interpreted to reflect mixing with more saline water within the upper bedrock. The level of mixing would depend on the consistency of upward gradients flux of fresher water horizontally or from above to the basal unit.

In the Mount Pleasant Community Sub-Area 51-1 EIR, sampling results indicate the groundwater is hard and mineralized, with reported hardness in the 200 mg/L to 335 mg/L range and TDS reported from about 250 mg/L to 540 mg/L. The chloride concentrations ranged from 9.5 mg/L to 38.8 mg/L, sulphate concentrations were highly variable, ranging from 15.9 mg/L to 200 mg/L, and nitrate was detected in all four groundwater samples. In three of the groundwater samples, the reported nitrate concentration was less than 1 mg/L with the fourth being 11.3 mg/L. The metal concentrations were generally low and within the PWQO, although there are occasional levels of various metals including aluminum, copper, iron, lead, molybdenum and uranium that were reported above the method detection limits (considered to be naturally sourced from the soils).

Bedrock

The IWA water quality in the upper 6 m of bedrock demonstrated both saline and relatively fresh water. The difference likely reflects varying fluxes to the upper bedrock of fresh recharge water and the residence time of water within the bedrock. The upper fractured bedrock, although assumed to be continually fractured and hydraulically connected, may not be locally. This can result from local portions of the pre-glacial fractured bedrock being removed during the latest glaciation. Again the dominant ions are calcium, sulphate, sodium and chloride. Bromide appears to be a tracer as well for the more saline waters. Deeper in the bedrock, the water becomes more saline due mainly to a longer residence time (i.e., much slower moving water as the deeper bedrock is not as hydraulically connected). Nitrate values appear in a number of overburden and bedrock samples, along with elevated ammonia. The nitrate values vary from non-detect to 21ppm and are generally higher in the shallow bedrock/overburden contact or within the more permeable stratified silt/sand/gravel unit.

In the Mount Pleasant Community Sub-Area 51-1 EIR, groundwater samples collected from the Queenston Formation shale showed the water typically has high TDS and somewhat elevated chloride, sodium, and sulphate concentrations.

Groundwater Use

Groundwater use in this context refers to anthropogenic use. Permeable geologic materials, through which groundwater moves in sufficient volumes to be relatively easily extracted, are referred to as ‘aquifers’. The less permeable units are known as aquitards, and although water can move through these units, it moves slowly and it is difficult to extract water from these units.

In the study area, there are no high-yielding or extensive groundwater supply aquifers reflecting the lack of continuous coarse-grained sand and gravel layers and the relatively thin, glacial till overburden as previously described. The low hydraulic conductivity till and shale materials that characterize the local geology are generally considered to be relatively poor aquifers. Wells within the overburden are generally dug or bored and tend to be completed within the water bearing sand lenses. The drilled wells are completed within the shale or at the bedrock/overburden contact where the overburden contact is more permeable material.

The Ministry of the Environment (MOE) issues Permits to Take Water (PTTW) that allow the owner to withdraw a large volume of surface water and/or groundwater. These permits are contained within a database that identifies the location, source of water, maximum permitted volume and pumping rate, number of days of extraction, and expiry date of the permit. They are completed for both surface water and groundwater withdrawals that have a pumping rate of greater than 50,000 litres per day (LPD). CVC was provided a copy of the PTTW database by MOE in May 2005 and this database was updated to reflect known expired permits. CVC provided a copy of the PTTW database from the MOE dated March 31, 2012. This database shows a single active permit within the Study Area on the Credit River. This surface water permit indicates that it is used for agriculture. The MOE water wells and the locations of all PTTW (active or historical) in the Study Area are presented on Figure GW-5.

The specific capacities of the water wells, a reflection of the ability of the well to produce water, are generally provided in the MOE Water Well Database. Recorded capacities have been plotted for overburden wells (ref. Figure GW-6) and bedrock wells (ref. Figure GW-7). Low to moderate yields in the wells generally reflect the range of hydraulic conductivity values previously described. Higher capacity wells in the overburden may indicate larger more extensive sand lenses. Higher well capacities in the bedrock likely reflect the shallow highly fractured rock.

Water well survey questionnaires were developed and sent to landowners for the IWA study (1993), the HFSWS, 2011, and the Environmental Implementation Report (EIR) for Mount Pleasant Community Secondary Plan, Block 51-1, 2011. The surveys were carried out to determine the characteristics of wells, water usage, the current status of the quantity and quality of well water and any related concerns.

The IWA water well survey carried out in 1993 at, and within 500 m of the 3 potential landfill sites had 67 responses. The water well survey indicated 42 dug or bored wells and 25 drilled wells. There were only three concerns with water quantity and most responded that the quality of water was good.

For the HFSWS, 2011, a total of 119 well survey questionnaires were sent out. Eight surveys were sent back address unknown. Of the remaining 111 surveys, 17 were completed and returned (15%). The properties contained a total of 26 wells. Six properties had two or more wells. Of the 26 wells, 6 were drilled wells, 7 were dug wells, 11 were bored and 2 were of unknown construction. The majority of wells were used for basic domestic purposes (15 wells), one well for a daycare (60+ persons), one well at the police centre (10+ persons), one well for a dairy operation (120 head) and 8 were not being used. Water shortages were reported in 5 of the wells, 3 of those wells had poor recovery and two of the wells were drilled deep wells. Of the remainder of the wells reporting recovery rates, 5 were satisfactory and 16 wells had good recovery. The high use wells for the police centre, the daycare and the dairy operation reported no shortages and good recovery.

The EIR well survey program included 56 surveys delivered to local residents with a total of thirteen (24%) being returned. The well surveys requested information relating to water supply quantity, quality and usage. The survey results confirmed the relatively low well yields reported in the MOE well records. Residents generally reported sufficient water volumes for basic household uses (showers, laundry, car washing, etc.), but insufficient water for lawn watering and irrigation. Most reported that their water quality is generally acceptable for household use, i.e., clear, sand free, and without odour, but the water is hard and contains iron that stains fixtures. Many reported the use of water softeners and about 50% of the respondents also reported that they use carbon filters and/or UV treatment for the water. Some do

not drink the water (they purchase water for drinking), and one reported using reverse osmosis treatment for drinking water. These data highlight the hardness of the local groundwater and the somewhat salty nature of the groundwater that is obtained from the shale bedrock.Methods and Results
Additional field data were and will continue to be collected in order to:

- further characterize the hydrogeologic setting;
- provide a more detailed conceptual model to form the basis for the computer model; and,
- obtain more detailed data to provide for a preliminary sensitivity analysis (i.e., calibration) of the computer model.

These data will be used to refine the understanding of potential groundwater flow pathways, groundwater discharge zones and to provide additional input into the groundwater balance.

Scope of Field Work

The scope of the hydrogeological field monitoring included the completion of site-specific investigations as described below:

1. Drilling and installation of groundwater monitoring wells across the Study Area: A total of 9 monitoring wells were installed at 8 locations (i.e., one location has 2 wells to form a 'well nest') to investigate the site-specific soil and groundwater conditions. The locations of the monitoring wells (MW) are shown on Figure GW-8 and monitoring well construction details are provided on the borehole logs in Appendix B-2
2. Drive-point piezometer installations: 23 drive-point piezometers were installed at 18 locations (4 nests) to investigate the site-specific shallow groundwater conditions near wetlands and watercourses. The locations of the piezometers (PZ) are shown on Figure GW-8.
3. Review of grain-size analyses: Analyses were completed on representative soil samples obtained during the drilling investigations. These grain-size data were reviewed to characterize the surficial sediments and estimate the hydraulic conductivity of the soils encountered. Copies of the soil grain-size analyses are provided in Appendix B-3.
4. Hydraulic conductivity testing: Single well response tests were completed in 6 groundwater monitoring wells (MW1, MW2, MW4, MW7s, MW7d and MW8) to assess the in-situ hydraulic conductivity of the surficial soils. The hydraulic conductivity field testing results are provided in Appendix B-4.
5. Infiltration Testing: Infiltration tests were conducted using a double ring infiltrometer at 6 locations (IF) across the subject lands to assess the surficial infiltration potential (Figure GW-9). The infiltration testing results are provided in Appendix B-4.
6. Monitoring of groundwater levels: Monitoring has been completed to measure the depth to the water table and assess the horizontal and vertical groundwater flow conditions. Groundwater level measurements have been obtained in the site monitoring wells and piezometers since June 2010. Automatic water level recorders (dataloggers) were installed in each of the on-site monitoring wells and 6 of the drivepoint piezometers in order to record continuous water level fluctuations. The groundwater monitoring data and hydrographs are provided in Appendix B-5.
7. Monitoring of surface water: Surface water spot-flow measurements have been obtained since June 2010 at 26 locations along the tributaries to the Credit River and West Huttonville Creek (Figure GW-9). Flow was estimated using a stream area-velocity method. Spot flow measurements were carried out from June, 2010 – November 2014 and from July 2017 – November 2017. The surface water monitoring data are summarized in Appendix B-6.

8. Water quality testing: Groundwater and surface water samples were collected to characterize the baseline water quality across the Study Area. The water samples were submitted to a qualified laboratory for analysis of general quality indicators (e.g., pH, hardness, and conductivity), basic ions (including chloride and nitrate) and selected metals. These testing results are provided in Appendix B-7.

Drilling Investigations Results

Six boreholes were drilled across the study lands in June 2010 to determine the shallow soil conditions (MW1 to MW6; Figure GW8). Monitoring wells were installed in each of these boreholes to characterize the shallow groundwater conditions. Three additional boreholes were drilled in April 2012 to confirm the location of a potential bedrock valley. A monitoring well nest (i.e., two monitoring wells installed beside each other at different depths) was installed at one of these locations (MW7s/d) and a single monitoring well was installed at MW8. The borehole logs, including monitoring well installation details are provided in Appendix B-2.

The results of the drilling indicate that the surficial soils vary across the site. Glacial till deposits were encountered at surface or immediately below the soils re-worked from farming activities at MW1, MW3, MW4 and MW5. Clayey silt or silty clay soils were encountered at surface at MW6 and MW7, located in the southwestern portion of the study area. Sand and silty sand soils were encountered at surface at MW2, located in the north central portion of the study area and MW8, located in the southeast. Each of the boreholes encountered varying layers of glacial till and sand with the exception of MW1, MW6 and MW8, where clayey silt till (in MW1), clayey silt (in MW6) or sand (MW8) extended to the shale bedrock.

Shale bedrock was encountered in MW1, MW6, MW7 and MW8 at depths ranging from 1.1 m below ground surface at MW6 to 17.8 m below ground surface at MW7.

Soil Hydraulic Conductivity and Testing Results

There are various methods that can be used to assess soil hydraulic conductivity, (i.e., the ability of the soil to transmit groundwater). Grain-size data and soil characteristics can be used to provide a general estimate of hydraulic conductivity. There are also field testing methods to assess in-situ conditions. These include single well response tests in groundwater observation wells to assess the lateral hydraulic conductivity and infiltrometer tests to assess the ability of the surficial soils to infiltrate water. Each of these methods was used to estimate the soil hydraulic conductivity and infiltration potential as discussed below.

During the drilling investigations, representative samples were collected and analysed for grain-size distribution (Appendix B-3). The grain-size analyses were conducted on various soil types found across the property. The hydraulic conductivities estimated from the grain size analyses, using the Hazen estimation method, range from 1×10^{-2} to 5.8×10^{-6} cm/sec. The higher values are for fine to medium sand and the lower values are for sandy silt.

To assess the in-situ hydraulic conductivity of the shallow soils, single well response tests were completed at 6 locations: MW1, MW2, MW4, MW7s, MW7d and MW8. The test results are provided in Appendix B-4 and are consistent with the hydraulic conductivity values provided in Section 4.2.2.3.

MW1 is screened in weathered shale. The results of the test at this location suggest a low hydraulic conductivity of 2.5×10^{-5} cm/sec.

MW2 and MW7s are screened in silty sand till. The results of the test at this location suggest a more moderate hydraulic conductivity of 2.5×10^{-4} cm/sec.

MW8 is screened in sand and the test at this location indicates a hydraulic conductivity of 9.5 x 10^{-4} cm/sec. MW4 is screened in a layer of gravel and sand, and MW7d is screened across alternating layers of sand and gravel. The tests at these locations indicate hydraulic conductivities of 2.1 x 10^{4} cm/sec and 3.1 x 10^{-4} cm/sec, respectively. These values are lower than would be expected for these soils types and suggests that the silt and/or clay content in these layers or surrounding these lenses has a significant impact on the hydraulic conductivity of the soil.

As previously discussed, the groundwater movement in the surficial layers of soils may be increased where thin sand or silt layers, weathering, fracturing and ecological and biological factors can increase the effective hydraulic conductivity of the material. To assess surficial infiltration potential, a series of tests using a Turf-Tec^{TM} double ring infiltrometer were completed at selected locations across the site (Figure GW-8). The tests were completed by removing the topsoil in the test area and installing the infiltrometer in the underlying sediments. Both rings of the infiltrometer were then filled with water and the time for the water level in the inner ring to fall 10 mm was recorded. This was repeated until consistent readings were recorded for at least three consecutive intervals.

Six infiltrometer tests were completed across the subject lands in early July 2012 at the locations shown on Figure GW-8. The results of these tests were plotted and are provided in Appendix B-4. One of these tests (IF5) was completed in silty sand soils. The results of this test indicate an infiltration rate of 610 mm/hr. IF1, IF3, IF4 and IF6 were completed in silty clay and clayey silt soils and the results of the tests suggest infiltration rates ranging from 7 mm/hr to 125 mm/hr. IF2 was also completed in clayey silt soils, however a larger sand component was noted in this soil. The results of the infiltration test at this location indicate an infiltration rate of 400 mm/hr, suggesting the sand content at this location has a significant impact on the infiltration rate. There are many different factors beside the soil composition that affect the tests and the surficial infiltration properties. The weathering, fracturing, disturbance, roots, soil compaction, humidity, etc. are all factors that may affect the infiltration rates. You can get the same value for different type of soils or different values for the same type of soil. The higher infiltration rate of 125 mm/hr observed at two locations occurs appear to be in areas that are sandy silt and cobbly

Water Level Monitoring Results

Groundwater level monitoring was conducted on a monthly basis between June 2010 and May 2011, on a bi-monthly basis between July 2011 and November 2011 and on a quarterly basis from 2012 through 2015 and monthly from July 2017 – December 2017. The groundwater level monitoring includes all of the monitoring wells installed during the drilling investigations, as well as drive-point piezometers that were installed at 18 locations to monitor the shallow groundwater conditions in wetlands and watercourses. Piezometers at 10 locations were installed in June 2010 and at a further 8 locations in June 2012. The groundwater monitoring data for the property are summarized in Appendix B-5.

An automatic water level recorder was installed in MW1 to MW6, PZ2, PZ3 and PZ4 in June 2010 to record continuous water levels. Additional automatic water level recorders were installed in MW7s, MW7d, MW8, PZ1d, PZ16 and PZ18 in July 2012. Water levels over time for each monitoring location are provided in Appendix B-5.

The groundwater monitoring data show the following (refer to Figure GW-8 for the monitoring locations and the data tables and hydrographs in Appendix B-5):

- The depth to the water table is typically related to the topography, with relatively shallow groundwater levels in the lower lying areas and deeper groundwater levels in the topographically higher areas. Groundwater levels were found at or above ground surface in MW2 and MW5), approximately 1 to 2 m below ground surface at MW1, MW3, MW6 and MW7s/d and approximately 4 m below ground surface at MW4 and 8 m below ground surface for MW8. The groundwater levels in the monitoring wells typically fluctuate by approximately 1.5 m to 2 m seasonally with the trend being quite consistent.

- The detailed water levels over time provided by the dataloggers show how the water table responds to precipitation events). Following large rainfall events, the groundwater level has been observed to rapidly rise by almost 1 m in some wells. The hydrographs for MW1 – MW8 show an extended water level decline through the summer of 2016 reflecting the lower annual precipitation in 2015 (675 mm) and 2016 (631 mm) compared to an 18 year average (2000-2017) of 791 mm at Toronto-Pearson.
- A well nest was installed at the northwest corner of Bovaird Drive and Mississauga Road (MW7s/d; Figure GW-8). The water levels measured at these locations show that the water level in the deeper well (MW7d) is higher than the water level in the shallower well (MW7s) indicating an upward hydraulic gradient, i.e., potential groundwater discharge conditions.
- Nested piezometers were installed in the wetland located north and east of Wanless Drive and Winston Churchill Boulevard (PZ1s/i/d, Figure GW-8). The groundwater levels in the shallow piezometer are typically higher than the groundwater levels in the intermediate and deeper piezometers, indicating groundwater recharge conditions.
- Nested piezometers were installed along the tributary to the Credit River crossing Heritage Road south of the railway (PZ8s/d, Figure GW-8). The groundwater levels in the deeper piezometer at this location are typically higher than the groundwater levels in the shallow piezometer, indicating potential groundwater discharge conditions.
- The groundwater levels in the single piezometers PZ2, PZ4 and PZ5 are typically above ground surface, indicating potential groundwater discharge conditions in these locations .
- The groundwater levels in the piezometers PZ3 and PZ9 are above ground surface during the spring and fall months, indicating there may be potential for seasonal groundwater discharge at these locations.
- The groundwater levels in PZ6, PZ7 and PZ10 are consistently below ground surface, suggesting these may be areas of groundwater recharge.

Streamflow Monitoring Results

Surface water monitoring was conducted on a monthly basis between June 2010 and May 2011, on a bi-monthly basis between July 2011 and November 2011 and on a quarterly basis from 2012 through November 2014 and monthly July 2017 through November 2017. A total of 26 stations were established across the subject lands. Ten (10) of the surface water stations are located along the Credit River tributaries and 16 are located along West Huttonville Creek (Figure GW-8). The monitoring consisted of spot flow measurements using a stream area-velocity method and, when flow was present, measurement of field chemistry parameters, including pH, conductivity, temperature, salinity, dissolved oxygen and total dissolved solids. No flows were measured at the downstream locations on the Credit River Tributaries (i.e., where the tributaries converge with the Credit River) as these locations are monitored by Credit Valley Conservation (CVC). The CVC monitoring stations are shown on Figure GW-8 and the results are presented in Appendix B-6..

The results of the flow monitoring show the following.

Credit River Tributaries

- Four flow stations were established on the CRT1 (WIN1, WIN2, RL2 and RL3). These watercourses were found to be dry during the summer months and had flow ranging from 0 L/s to 90 L/s. with a median of 0 L/s. Higher flows were measured during snow melt or within a day of rainfall.
- Two flow stations were established on the CRT2 (WAN3 and HER1). The reaches associated with these stations were found to be dry during the summer months. The measured flows at WAN3 ranged

from 0 L/s to 46 L/s with a median of 0 L/s and the measured flows at HER1 ranged from 0 L/s to 110 L/s with a median of 0 L/s. Higher flows were measured during snow melt or within a day of rainfall.
- One flow station was established on CRT3 (BOV3). This watercourse was found to have no flow or be dry during the summer months and flows from 0 L/s to 4 L/s. with a median of 0 L/s..
- One flow station was established on CRT4 (BOV2). This watercourse was found to be dry during the summer months and flows ranging from 0 L/s to 20 L/s. with a median of 0 L/s and the 20 L/s flow occurring during snowmelt.
- Two additional flow stations were established along tributaries to the Credit River, BOV4, which is located on a small tributary between CRT2 and CRT3, and MIS9, which is located on a tributary south of CRT4. BOV4 was found to be dry or have no flow during the summer and fall months and flows ranging from 0 L/s to 2 L/s with a median of 0 L/s. MIS9 was found to be dry during the majority of the summer months with flows ranging from 0 L/s to 9 L/s with a median of 0.5 L/s.

West Huttonville Creek

- Three stations along West Huttonville Creek (MIS5, MIS7and QST1; Figure GW-8) were found to have flow during all but 3 of the 87 measurements , suggesting this is a perennial watercourse. For MIS5 the flows from 0 L/s to 125 L/s with a median of 2 L/s. For MIS7 the flows ranged from 0 L/s to 254 L/s. with a median of 14 L/s and for QST1 the flows ranged from 0 L/s to 378 L/s. with a median of 54 L/s.

- The remaining flow stations contributing to West Huttonville Creek (MIS1, MIS2, MIS3, MIS4, MIS6, MIS8, MIS9) were found to be dry in the summer months, and had flows, when present, typically ranging from 0 L/s to 30 L/s with medians of) with one high flow measured during the spring melt in March 201.

Water Quality Results

Water quality sampling was conducted at 6 monitoring well locations (MW1, MW1, MW4, MW7s, MW7d and MW8 (Figure GW-8); and 4 surface water locations (MIS5 and QST1 along West Huttonville Creek, and CRT2 and CRT4 along the Credit River Tributaries (Figure GW-8); in July 2012 to determine the background water quality in the area. The samples were submitted to a qualified laboratory (AGAT Laboratories) for analysis of general quality indicators (e.g., pH, hardness, and conductivity), basic ions (including chloride and nitrate) and selected metals. The water quality results are provided in Appendix B-7.

The results of the groundwater quality testing were compared to the Ontario Drinking Water Quality Standards (ODWQS) and show the following:

- Nitrate was not detected in 4 of the wells (MW1, MW2, MW7s and MW7d). A nitrate concentration of 14.0 mg/L was reported for MW4, which exceeds the ODWQS of 10.0 mg/L. A nitrate concentration of 7.12 mg/L was reported for MW8 which, although does not exceed the ODWQS standard, is considered relatively high. The higher nitrate concentrations suggest the shallow groundwater in these areas has been impacted by the surrounding agricultural uses.
- Sodium and chloride concentrations were generally low (<30 mg/L and <175 mg/L, respectively) in all wells with the exception of MW1, which had a sodium concentration of 681 mg/L and a chloride concentration of 3,270 mg/L. This well is located at the corner of Winston Churchill Boulevard and Mayfield Road and is very near the roadway. The high sodium and chloride concentrations at this location are likely due to the usage of road salt.
- The groundwater in this area is considered hard, and the total hardness in each of the samples obtained exceeded the ODWQS of 80 mg/L to 100 mg/L with concentrations ranging from 263 mg/L to 2,910 mg/L.

The results of the surface water quality testing were compared to the Provincial Water Quality Objectives (PWQO) and show the following:

- Total phosphorus concentrations were reported above the PWQO of 0.03 mg/L at all sampling locations, with concentrations ranging from 0.06 mg/L to 0.14 mg/L.
- Nitrate was reported at all sampling locations. The concentrations ranged from 0.42 mg/L at CRT4 to 5.07 mg/L at QST1. The presence of nitrate in these watercourses is likely the result of agricultural activities on the surrounding lands.

Slightly elevated sodium and chloride levels were reported at MIS5 and QST1 (ranging from 61.8 mg/L to 88.3 mg/L and 139 mg/L to 183 mg/L, respectively), which are both located along roadways. Usage of road salt (sodium chloride) typically affects the runoff quality along paved roads; the water samples were collected in July, higher concentrations of chloride and sodium would be expected during spring conditions.

The chemistry of groundwater samples collected at these spot baseflow sites is consistent with the detailed groundwater chemistry in the overburden monitoring wells and the chemistry presented in the IWA reports for the overburden/shallow bedrock system.

It is proposed that the deeper system is not contributing to the local discharge as the highly saline groundwater quality at this depth has not been observed in surface water quality, and the permeability of the deeper unit is significantly lower.

4.2.3 Conceptual Groundwater Flow

Water from precipitation percolates or infiltrates into the ground until it reaches the water table. Areas where water moves downward from the water table are known as recharge areas. These areas are generally in areas of topographically high relief. Areas where groundwater moves upward to the water table are known as discharge areas. These generally occur in areas of topographically low relief, such as stream valleys. Groundwater that discharges to streams is the water that maintains the baseflow of the stream. Wetlands may be fed by groundwater discharge.

There are different types and rates of recharge and discharge. Water percolating into the ground at a specific location may discharge to a small stream a short distance away. This is local recharge and local discharge. Some water may recharge in a certain area and discharge to a larger river basin a long way from the source of recharge. This is known as regional recharge and regional discharge.

Permeable geologic materials through which groundwater moves are known as aquifers. Aquifers are "water bearing" formations meaning that water can be easily extracted from these units. The less permeable units are known as aquitards, and although water can move through these units, it moves slowly and it is difficult to extract water from these units. How these aquifers are connected within a hydrogeologic setting is what controls much of the movement of groundwater.

A delineation of the flow system(s) in this way will identify where groundwater originates, where it discharges and the most prominent paths it travels between these points (e.g., the aquifer pathways or more permeable hydrostratigraphic units). Having done this, one can assess the relative sensitivity of the linkage from the groundwater system to the aquatic or terrestrial systems. Knowing the level of sensitivity of the receptor, the impacts of particular types and scales of land uses or land use changes on the groundwater flow system and other linked ecosystem components can be assessed. Best management practices can then be developed to prevent unacceptable impacts from occurring.

The map of shallow water levels (Figure GW-10) representing the shallow equipotential surface (water table) was developed by interpolating static groundwater levels reported for each high-quality monitoring well and drive-point piezometer, as well as the water wells in the YPDT database that have a total borehole depth of 15 m or less (725 water level measurements). No surface water points were added to control the water table elevations. The distribution of wells was sufficient to represent the character of the water table including the connection with surface water features. The contour interval for the map is 2 m.

The map of deep water levels (Figure GW-11) representing the deep groundwater equipotential surface was developed by interpolating static groundwater levels reported for each high-quality monitoring well as well as the water wells in the YPDT database that have a total borehole depth greater than 15 m (1012 water level measurements). No surface water points were added to control the water elevations. The distribution of wells was sufficient to represent the character of the deep equipotential surface. The contour interval for the map is 5 m.

General Groundwater Flow

The detailed geological and hydrogeological background information presented Section 4.2.2 gives rise to the following major hydrogeologic units:

- The surficial organic sediments within the forested areas,
- The glaciolacustrine surficial units,
- The fractured shallow till;
- The permeable discontinuous stratified units within the till;
- Vertical fractures within the till where the till is sufficiently thin to develop fractures to the bedrock (approximately 6 m);
- The highly fractured upper bedrock (approximately the upper 5 m).

The general direction of horizontal groundwater flow within the shallow overburden/shale system (Figure GW-9) tends to follow the surficial and bedrock topography (Figure GW-5). The flow trends from the north to the south-east and south towards the main Credit River, but tends to follow the tributaries as well. On a more local scale, there is convergence of flow in the vicinity of PZ8, MW4, PZ4 and PZ5 where there are observed upward gradients. This convergence continues downstream of these sites and is consistent with observed flows in CRT2 west of Heritage Road (Section 4.7.4) and historic CVC flow data at Bovaird Drive.

The deeper groundwater flow (Figure GW-10) shows a similar regional trend but shows a convergence of flow north of the rail line in the vicinity of the shallow bedrock valley (Figure GW-5).

Groundwater Flow in the Till

The horizontal component of groundwater flow, particularly within the overburden, will be weak due to the low hydraulic conductivity of the silt/clay sediments as discussed in Section 4.2.2.2. The upper fractured till is expected to transmit more significant quantities of water but on a more local scale. A significant amount of research has focused on the hydrogeology of fractured glacial tills. A literature review was carried out for the HFSWS, 2011, and documented the following hydrogeologic factors that relate to the till in the Study Area:

- Frequency and depth of fractures can depend on the clay/silt/sand content, average precipitation and temperature;
- Fractures can occur up to 6 m but they are likely more prevalent with the upper 2 to 3 m (Upper Fractured Till);
- The lateral connection within the Upper Fractured Till can be relatively significant;
- Horizontal flow patterns in the Upper Fractured Till will be controlled by local depressional topography and restricted by underlying more massive and less permeable till;

- Vertical groundwater flow below the Upper Fractured Till is generally low unless more permeable, interconnected lenses exist;
- Evapotranspiration will significantly reduce water levels in the Upper Fractured Till;
- Lateral flow and vertical flow in the Upper Fractured Till reduces more quickly as the water levels drop due to less fracture with depth; and
- Gradients can be reversed within the underlying massive till (downward to upward) as water levels in the Upper Fractured Till lower thereby reducing recharge to depth.

It was presented that the Upper Fractured Till is a more active groundwater flow zone mainly due to the expected hydraulic conductivity contrast (2 to 3 orders of magnitude) between it and the underlying more massive till. It is currently interpreted that lateral flow in the Upper Fractured Till will be directed locally by the subtle topography to the depressional features. Where water levels in the Upper Fractured Till are high enough and the depressional features are connected at surface (i.e., a ridge/swale system), groundwater discharge and overland flow may occur. The extent and distance of overland flow will vary. This flow may be more dominant immediately following a precipitation event and may only last for a short period of time. It is more common for the water to exist as shallow ponding within these depressions or for the water table to be closer to ground surface within the depressional areas as the depth of the depressional features is on the order of the thickness of the Upper Fractured Till layer. This more common scenario would lead to greater evapotranspiration within the depressional features. In this setting, although precipitation would infiltrate to the water table and be considered recharge, local shallow flow would deliver it to depressional areas where it could be considered groundwater discharge but would be lost to evapotranspiration and not manifest as overland flow or flow to the deeper groundwater flow system. Additionally, this shallow flow could occur on a local scale, both spatial and temporally (i.e., event based) as interflow within the unsaturated zone where local contrasts in shallow hydraulic conductivity occur.

Where the underlying till is thick enough and is massive, both vertical and horizontal groundwater flow is restricted. The vertical hydraulic gradients are generally quite higher than the horizontal gradients. Some level of fracturing may occur in the more massive till as well as interconnected more permeable layers which may transmit more groundwater to depth. In areas where the overburden thickness is on the order of 6 m (Figure GW-4), it is expected that there is an increased potential for groundwater flux to the bedrock. Where the overburden thickness is on the order of 2 to 3 m (Figure GW-4), it is expected that there is a much more direct connection from ground surface to the upper bedrock.

Some questions concerning the extent of the hydraulic connection of vertical flow in the till arise. Basic Darcy fluxes calculated in the IWA study do not allow for a significant flow to the bedrock or to recharge the more permeable stratified layers within the till, yet domestic wells do not appear to have quantity problems and water trends in the shallow bedrock correlate with trends in the till. The extent of vertical fracturing and interconnection of inter-fingered permeable units within the till may account for the apparent inconsistency or this may be simply a transmission of hydraulic head.

Groundwater flow within the discontinuous sand lenses may also be significant on a local scale where these sand lenses intercept surface water features. It was presented in the IWA study that some of these sand lenses may be on the order of 100 m in areal extent. These lenses could provide discharge for extended periods of time during the drier seasons. The potential presence of sand and gravel lenses are shown on the geologic cross-sections provided in Appendix B-1. The area in the vicinity of the West Huttonville Creek from Bovaird Drive upstream to Wanless Drive may demonstrate the potential hydraulic connection as upward gradients are observed in a number of monitoring wells

The question as to whether standing pools in some stream reaches were areas of groundwater discharge was raised in the Credit Valley Subwatershed Study and Servicing Plan, July 2003 and the following assessment was presented to the CVC:

'Although the data varies there is an indication that groundwater is discharging to the ponds during periods of both low and non-flow. A positive gradient reflects upward flow. Zero values may reflect a horizontal gradient or a poor seal between the piezometer and the bed. The positive gradient and expected groundwater discharge that is occurring during the non-flow events is likely being lost to a combination of lateral subsurface flow or evapotranspiration.'

Groundwater Flow in the Bedrock

Groundwater flow, generally a more dominant horizontal flow, is expected to be greater in the upper fractured shale (and where it contacts overlying permeable sand and gravel lenses) due to the contrast between the higher hydraulic conductivity of this unit and the lower hydraulic conductivity of the overlying silt/clay unit and the underlying more competent shale unit. This hydrogeologic unit is also considered to be the most continuous although there may be local areas that where the upper fractured shale was eroded from prior glacial activity. Where stream reaches intercept the shale or basal sand and gravel units, there is a likelihood of groundwater discharge, particularly further down in the groundwater flow system. Examples of this occur at the lower ends of CRT 3 and CRT 4, and West Huttonville Creek immediately north of Bovaird Drive. The seasonal trends in perennial baseflow quantities indicate that the flow likely originates from a more intermediate system as local systems would dry up and more regional systems would be more resilient.

Terrestrial Features

The groundwater connection to the local terrestrial features has generated much technical discussion. As discussed, given the low hydraulic conductivity of the Halton Till and expected lower hydraulic conductivity of the glaciolacustrine sediments, the actual groundwater flux potential is very low compared to more permeable sand and gravel. The potential vertical and lateral flux within the weathered till can be relatively higher if fracturing occurs. It is expected that this groundwater flux will be small compared to overall water balance.

In the HFSWS, 2011, AMEC et al., a basic approximation of lateral flux within any portion of the study area was determined by considering the general horizontal gradient (on the order .005 regionally) and a conservative horizontal hydraulic conductivity (on the order of 7 x 10 $^{-4}$ cm/sec). Assuming an areal feature of 100 m x 100 m, a lateral flux flow through depth of 1 m and an average annual precipitation of 850 mm, the groundwater flux corresponds to 1.3% of the total water balance. Calculations carried out in the Sub-Area 51-1 EIR study showed similar results. The general horizontal hydraulic gradient in the upland areas of the Heritage Heights Subwatershed Study Area is on the order of 0.006 and the highest measured hydraulic conductivity in the till is 2.5 x 10^{-4} cm/sec which gives a groundwater flux of 0.6% of 850 mm, total annual precipitation. It must be emphasized that exact flux quantification is challenging due to the inherent variations in K and local gradients and only would be expected to provide a range of possible groundwater fluxes.

The organic sediments within the forested areas could provide significant storage of water on a local scale which could provide local recharge to the upper fractured till or could drain slowly to local reaches.

The pocket of surficial glaciolacustrine clays located north of Wanless (Figure GW-3) may behave differently with respect to storage and retention of groundwater (greater disconnected pore space) for greater lengths of time that has infiltrated from direct precipitation of overland flow

The following discussion from the Sub-Area 51-1 EIR study gives a characterization which is expected to be consistent with the features in Heritage Heights:

There is generally only standing water in the features in the spring when surface water contributions are highest. The water table is seasonally high in many of the wetland areas and discharge gradients also occur in several wetlands. The high spring water table below the wetlands is important to the soil conditions in the root zone; however, the low permeability of the till and clay sediments limits the actual groundwater flux *(volume of flow) that moves through the subsurface soils. This limits the potential for significant seepage or direct groundwater contributions to maintain any standing water in the wetland features. Throughout the summer months as the vegetation grows, the evapotranspiration requirements use up the available standing water supply and the wetlands dry out. As the seasonal water table declines in the summer months, any direct precipitation that ponds in the wetlands can infiltrate into the soils. This recharge helps to maintain the water table and soil saturation conditions beneath the features to continue to support wetland vegetation.*

The groundwater contributions have been calculated to range from zero to less than 2% of the total water supplies to the features. It is concluded that although the high water table conditions are important for the wetland soil conditions and vegetation, the groundwater movement is insufficient to sustain the wetland features, and as such, they rely on direct precipitation and surface water inputs for their existence. The precipitation and surface water inputs are also important for maintaining the water table and soil conditions in the features.

4.2.4 Groundwater Modelling

Groundwater Modelling Objectives

The objective of the modelling effort for Phase 1 of the HHSWS is to confirm that the current version of the CVC watershed-scale FEFLOW groundwater model, and the conceptual model it represents, reflects observed groundwater flow within the Heritage Heights study area. In Phase 2 (Impact Assessment), modelling will use the conceptual three-dimensional groundwater flow model within the MIKE SHE integrated model to study groundwater and surface water interactions.

The watershed-scale FEFLOW groundwater model was developed by CVC and reported in the CVC Tier Two Integrated Water Budget Report (AquaResource, 2009a). It was updated and used as the groundwater model for the Mount Pleasant Community Subwatershed Study (AMEC, 2011). That study and the associated surface water and groundwater models provide a general conceptual understanding or framework characterizing the hydrogeology of the Study Area. This understanding helps to focus efforts in the current study, where the main objective is to assess the existing local function of groundwater as it relates to watercourses and wetland features, and to evaluate the efficacy of alternative management scenarios under future conditions (Phases 2 and 3).

The MIKE SHE model will be developed in Phase 2 to study shallow groundwater conditions and provide further insight on:

- The transient nature of the groundwater flow system, including the seasonal variation in depth to the water table, and interactions with streams and wetlands;
- The water balance for typical wetland areas including an evaluation of their function and hydro-period to aid in setting targets for subwatershed-scale management;
- The range of potential recharge rates that is consistent with the available water level and groundwater discharge observation data; and
- The impact of various land use scenarios on surface water and groundwater and the performance of mitigation measures.

CVC Watershed Scale FEFLOW Model Update

CVC's three-dimensional regional groundwater flow model, developed using the finite-element code FEFLOW (WASY, 2007), encompasses the Credit River watershed and parts of the surrounding areas. The Heritage Heights study area lies within the watershed and covers portions of subwatersheds 9 (Norval to Port Credit) and 7 (Huttonville Creek). The model integrates the available information of the hydrogeologic system of the Credit River watershed and has been shown by the CVC to be a valuable tool for understanding existing three-dimensional groundwater flow and discharge, and evaluating potential impacts of future development or climate change. This model has been used by CVC and its member municipalities for over 12 years to understand and manage the groundwater function in the watershed ecosystem, and as the basis for wellhead protection and future land use development studies.

AquaResource recently updated the FEFLOW model to reflect model application studies completed since 2006, including incorporating the updates done for the HFSWS, 2011. The recent update incorporated local-scale refinements from numerous subwatershed-scale studies including: the bedrock topography and the delineation of buried bedrock valleys; the distribution of unconsolidated materials (sand, gravel and tills); the characteristics of bedrock units; and the incorporation of additional water levels and spot flow measurements for local calibration. Although these updates are important for representing local conditions, they did not fundamentally change the simulated regional flow, groundwater discharge, and water budget for the CVC subwatersheds (AquaResource, 2011).

Methodology

The updated CVC groundwater flow model was examined to confirm its consistency with new field data collected as part of the HHSWS. Nine groundwater monitoring wells and 18 drive-point piezometers were installed across the subject lands to investigate the subsurface and groundwater conditions. Available data from these monitoring locations were used to update the conceptual hydrogeologic model for this study (described above in Section 4.2.3) and to check the hydraulic head prediction of the existing CVC groundwater model against the new data. Of the 18 drive-point piezometers, eight were recently installed and thus only 10 have sufficient monitoring data that can be used for this verification exercise at this time. Additionally, 43 groundwater monitoring points reported in a number of previous studies were added to the observation dataset and used to verify the model's level of calibration. The average water level was calculated for wells having multiple readings.

Surface water spot flow measurements have also been collected at 26 locations within the study area along the tributaries of the Credit River and West Huttonville Creek. These measurements were compared against the groundwater discharge predicted by the current CVC FEFLOW model to help confirm the ability of the groundwater flow model to represent the subwatershed-scale hydrogeologic conditions.

FEFLOW Model Results

Overall the regional CVC model is consistent with the observed data for both hydraulic head and spot baseflow estimates. Although the average water levels are slightly under-predicted by the model, they are within seasonal variations. The FEFLOW model has been calibrated to steady-state, annual-average conditions and thus does not capture the transient seasonal variations. The model-predicted groundwater discharge also matches the observed spot baseflow data under average, steady-state conditions.

Based on the agreement between field data and simulated results, it is concluded that the existing FEFLOW model acceptably represents the groundwater flow system in the study area and can be used within the MIKE SHE integrated model in Phase 2. This new model will be used to further study the transient, near-surface groundwater flow conditions that influence wetland function on the Halton Till within the study area.

The forthcoming subwatershed-scale MIKE SHE model includes sufficient resolution to evaluate the function of the wetlands at the subwatershed scale and the hydro-period of typical wetlands in the study area. This integrated simulation, including both surface and groundwater processes, can be used to provide appropriate insight into the role of surface water and groundwater in a wetland's water balance.

Further details documenting the FEFLOW modeling can be found in Appendix B-7.

4.3 Hydrology and Hydraulics

4.3.1 Importance/Purpose

The purpose of developing hydrologic and hydraulic models for urbanizing subwatersheds is to provide a better understanding of the operative factors which influence the amount and movement of water in the system. By developing representative models, which reasonably predict seasonal and storm-based runoff response, the impacts of urbanization can be better quantified and thereby managed more effectively in the future, as part of fully integrated management plans.

4.3.2 Background Information

Background information for both hydrology and hydraulics has been provided by the City of Brampton, CVC and from the land owners. The reports and maps that were reviewed, along with the results from other disciplines in the current study, have been documented in Section 2.3, and are considered integral to the development of the hydrology and hydraulics characterization.

Reports

The reports which have been reviewed having direct relevance to Heritage Heights for the Subwatershed Characterization include:

- *Four X Lands Environmental Implementation Report (EIR) and Functional Servicing Report (FSR), January 2016, Beacon Environmental et al.*

The EIR/ FSR provides the stormwater management for the Four X lands. Stormwater management is to be provided by two (2) stormwater management facilities located at the south end of the development. The report also provides the development staging.

- *Mount Pleasant Community Sustainable Natural Heritage System Planning Huttonville and Fletcher's Creeks Subwatershed Study, June 2011, AMEC et al.*

The subwatershed study established the environmental requirements, the Natural Heritage System (NHS) and stormwater management requirements for the Mount Pleasant Community, west of Mississauga Road. The characterization process, impact analysis and recommended mitigation measures are a guideline for the Heritage Heights subwatershed study.

- *Mount Pleasant Block 51-1 FSR, October 2011, Urbantech Consulting.*

The FSR incorporates the servicing requirements and recommendations of the Mount Pleasant Subwatershed Study into a more detailed land use framework. The report established the proposed grading, road network, water, sanitary and stormwater management infrastructure at a functional level for Block 51-1.

- *Bluegrass Helport Property CVSP Sub-Area 1 Stormwater Management Report Pond H1 Design Report, February 2011, Schaeffers Consulting Engineers*

The report provides design details for the H1 Stormwater Management facility located south of Bovaird Drive, north of Williams Parkway within the Credit Valley Secondary Plan area. The stormwater management facility has been designed as a wet pond providing an Enhanced level of water quality treatment, erosion control and 2 to 100 year storm event quantity controls for 37.31 ha of development. The stormwater management facility has also been designed to address Redside dace habitat criteria for stormwater management facilities.

Maps

The following mapping of the Heritage Heights Study Area has been provided to the Study Team in the form of GIS database, AutoCAD^{TM} files and raw data:

- 2009 contours (AutoCAD^{TM} file)
- 2011 LIDAR topographic mapping - 0.25 m increment
- GIS database (.dbf) and shape (.shp) files for 2001 land use conditions within the Huttonville Creek and Credit River Tributaries Subwatersheds.
- GIS database (.dbf) and shape (.shp) files for surficial soils and geology within the Huttonville Creek and Credit River Tributaries Subwatersheds.
- 2009 aerial photography for the Credit River and Huttonville Creek Subwatersheds.
- 2009 shapefiles for roads, property fabric, parks, paths and culverts

In addition, drainage and stormwater management reports have been included among the various reports for the on-going development south of Bovaird Drive. The 2011 Functional Servicing Report for Block 51-1 has provided detailed drainage boundaries for the area north of Bovaird Drive and east of Mississauga Road. The reports have been used to update the existing conditions for hydrologic modelling of the Mount Pleasant Community.

Models

The following hydrologic models have been provided to the Subwatershed Study Team for use in the Subwatershed Study:

- GAWSER hydrologic model for the Credit River Adaptive Management Study, CVC 2003.
- HSP-F hydrologic model for the Credit River Tributaries for Credit River Water Quality Study, CVC 2006.

The Subwatershed Team has used and updated the modelling from the Mount Pleasant Community Sustainable Natural Heritage System Planning Huttonville and Fletcher's Creeks Subwatershed Study including:

- HSP-F hydrologic model of the Huttonville Creek Subwatershed
- HSP-F hydrologic model for the Huttonville Creek
- HEC-RAS hydraulic model for Huttonville Creek

4.3.3 Methods

Hydrology Field Methods

Huttonville Creek

As per the HHSWS Terms of Reference, field work specific to streamflow data calibration for either the Credit River Tributaries and West Huttonville Creek is not required based on discussions with CVC. The HSP-F hydrologic model for the Huttonville Creek Subwatershed had been previously calibrated using an extensive field monitoring program for the HFSWS (ref. Appendix C). That field program included rainfall and streamflow data collection as outlined in **Table 4.3.1** and explained in more detail in the subsequent text.

Table 4.3.1. Water Quantity Field Sampling Program Details

Creek	Sampling Location	Location Description	Sampling Requirements
Fletcher's Creek	No. 1	Upper Fletchers Creek at Wanless Drive (field verify)	• Continuous flow gauge • Six samples per rainfall event
	No. 2	Mid-Fletchers Creek at Highway 7 (SW4 CVC's Fletcher Creek Monitoring Station)	• Continuous flow gauge • Temperature readings
Huttonville Creek	No. 1	Upper Huttonville Creek at Wanless Drive (field verify)	• Continuous flow gauge • Temperature readings
	No. 2	Mid-Huttonville Creek (downstream of City Park)	• Continuous flow gauge
	No. 3	Lower-Huttonville Creek (Queen Street) (CVC's EMS Monitoring Station EM9)	• Continuous flow gauge
Area-wide			• Regional continuous tipping bucket rain gauge

Rainfall Gauge

The rainfall gauge for the HFSWS, 2011 was located at 10378 Heritage Road. In addition to that rainfall gauge, the CVC also provided rainfall data from the CVC's Firehall Station rainfall gauge and the CVC Administration Office rainfall gauge.

Flow Monitoring

Continuous stream flow monitoring was completed at four locations within the Huttonville Creek Subwatershed for the purpose of calibrating the HSP-F hydrologic model (ref. Sites H1, H2, H3, and H5 of Figure Hydrology 1, Appendix C). The flow gauges at all of the four sites for continuous monitoring provided recorded flow depths. Velocity measurements taken within the channel during both dry and wet weather events were used to establish velocities at various depths. The observed instantaneous flow rates were compared with theoretical values in order to validate the observed data. Rating curves for each flow monitoring site were established based on both the observed and theoretical flow data (ref. Appendix C).

Credit River Tributaries

The CVC has been conducting flow monitoring upstream of Bovaird Drive on Credit River Tributary 2 from 2007 to 2011 The CVC has had issues with the flow monitoring site for CRT 2, in that the tributary thalweg has been migrating at the flow monitoring location, thus making it difficult to develop an accurate depth/ flow rating curve. The CVC has assessed the flow data collected from the gauge and has determined that the flow data should not be used for calibrating the Heritage Heights GAWSER hydrologic model (ref. Appendix ‘C’).

Through discussions with CVC and Dr. Harold Schroeter in 2012, it has been concluded by CVC that no additional field work (streamflow/rainfall) is required to calibrate the Credit River Tributaries GAWSER hydrologic model, as the model does not need additional calibration (ref. Appendix ‘C’, March 7, 2012 Meeting Minutes).

Comments received from CVC and Dr. Harold Schroeter dated April 8, 2013, indicated that the refined and more discretized GAWSER hydrologic model, needed to be revised, to reduce the model discretization, adjust the FTB parameter (Overland flow basetime factor) and to reduce determined peak flows. The parent GAWSER model had one (1) catchment for each CRT, and the level of discretization was not considered adequate for assessing the CRTs. As such the Heritage Heights model discretization was maintained. To further understand the CRT’s hydrology and to refine the Heritage Heights GAWSER hydrologic model, the City agreed to a flow monitoring program with two (2) locations in 2017, which was extended for 2019 to provide additional observed flow data.

Rainfall Gauge

The rainfall gauge used to determine rainfall data during the 2017 and 2019 flow monitoring program was the CVC’s Norval gauge, located adjacent to the Credit River in the Community of Norval, located less than 500 m from the west limit of the HHSPA.

Flow Monitoring

The 2017 flow monitoring program used two (2) locations, one (1) each on CRT 2 and CRT 3 (ref. Appendix C, Drawing Hydrology 2). The 2017 flow monitoring program did not yield runoff events at the CRT 3 monitoring location, even though the flow gauge was located at the downstream limit of CRT 3. The 2017 CRT 2 monitoring location did provide limited baseflow information, although again there was no reliable runoff events recorded.

To supplement the 2017 observed flow data, and to understand the influence of the infiltrative soils within the CRT’s ravines it was determined to use the original CRT 2 monitoring location just upstream of Bovaird Drive and to add a second monitoring location upstream of the CRT 2 ravine and downstream of Heritage Road (ref. Appendix C, Drawing Hydrology 2). The 2019 CRT 2 observed flows provided more useable flow data, although again it was limited to approximately four (4) rainfall events, which were used during model calibration. The flow monitoring hydrographs have been provided in Appendix C.

Hydrologic Analytic Methods

Two hydrologic modelling platforms have been used to determine the Huttonville and Credit River Tributaries subwatersheds’ precipitation responses as required by CVC. The Credit River Tributaries have been modelled using the Credit River Water Management Strategy (CRWMS) GAWSER hydrologic model. The GAWSER hydrologic catchments for the Credit River Tributaries have been refined as discussed herein.

The West Huttonville Creek has been modelled using the parent HSP-F hydrologic model developed for the HFSWS, 2011. The Huttonville Creek HSP-F hydrologic model has been further refined for the purposes of this study.

Huttonville Creek

The hydrologic analytic characterization has been facilitated by updating the HFSWS, 2011, HSP-F hydrologic model to provide an indication of subwatershed response to rainfall and snowmelt. HSP-F is both an event based and continuous hydrologic model, although it is more commonly used for continuous modelling. HSP-F incorporates meteorological data, such as precipitation data, air temperature, evapotranspiration, solar radiation, wind, and dew-point temperature. The HSP-F hydrologic model provides a continuous flow time series for use in characterization of surface runoff, baseflows and surface and groundwater interaction.

The following provides a summary of the hydrologic conditions within the Huttonville Creek Subwatershed:

Soils

Soils data within the Huttonville Creek Subwatershed had been provided by CVC for the HFSWS, 2011 in the form of a GIS database (.dbf) and graphical (.shp) files, two of which pertain to the surficial soils within the Mount Pleasant and Heritage Heights Study Areas. The SCS classifications of the surficial soils also include the specific soil types. The information provided in October 2006 has been used in the current study, since it represents the most current database for the Heritage Heights Study Area, and is also consistent with the information in the Ontario Ministry of Agriculture, Food, and Rural Affairs (OMAFRA) soils database.

The surficial soils within the Heritage Heights Study Area are depicted in Drawing Hydro 4. The surficial soils are primarily Chinguacousy clay loam, which is classified as SCS Soil Type 'C' (i.e. exhibits moderate to low infiltration rates), with small pockets of Jeddo Clay Loam which is classified as SCS Soil Type 'D' (i.e., exhibits low infiltration rates).

Huttonville Creek is located over Halton Till. The Halton Till overlies Queenston shale bedrock over the majority of the area. There are isolated sand or gravel units which may occur at or near bedrock. The Halton Till plain is considered to be flat in the headwater areas and is more sloping in vicinity of the Credit River. Within the sloping area near the Credit River valley associated with Huttonville Creek, the area may contain sand and gravel deposits.

Slopes

Slopes for the HFSWS, 2011 had been characterized using 2011 LiDAR mapping. For the Heritage Heights Study Area, slopes have been characterized as typically low, with only the creek and valley features having slopes that are steeper using the following ranges:

- Low (0.00 – 3.0%)
- High (3.0% or higher)

Huttonville Creek has an average slope of approximately 0.5%, which increases to 0.65% +/- towards the Credit River.

Land Use Conditions

Land use for the HFSWS, 2011, was based on the 2001 land use data and 2005 air photo to identify the existing land use conditions within the Huttonville Creek Subwatershed. For the current study, the existing land use condition has been revised to reflect the approved Block 51-1 development, (i.e., the future land use condition east of Mississauga Road). The Subwatershed Team has used the October 2011 Functional Servicing Report for Mount Pleasant Sub Area Block 51-1 for this update. The report has been used to refine drainage area boundaries and stormwater management facilities sizing for the approved development area.

South of Bovaird Drive, the existing land use represents the Credit Valley Secondary Plan. Development of the area located between Bovaird Drive and Queen Street West is still on-going, with the area north of Williams Parkway partially developed as of April 2021.

West of Mississauga Road, land use has been based on the 2011 air photo provided by the City of Brampton. The existing land use west of Mississauga Road has not changed from the Mount Pleasant Community Subwatershed Study, 2011 (ref. Drawing Hutt LU2).

Existing/Approved Stormwater Management Facilities

Five (5) stormwater management facilities (HE-1 to HE-5) have been proposed and constructed within the Block 51-1 Secondary Planning Area in the Huttonville Creek Subwatershed to provide water quality, erosion and stormwater quantity control for that development. The storage-discharge relationships for the stormwater management facilities within Block 51-1 have been provided within the 2011 Block 51-1 Functional Servicing Report (FSR). The rating curves within the have been based on the stormwater management criteria for Block 51-1 developed within the HFSWS, 2011 (ref. Appendix C).

Stormwater management requirements for East Huttonville Creek are as follows:

- Erosion Control: Storage 200 (m^3/imp. ha), Critical Erosion Flow Rate 0.00052 (m^3/s/ha)
- 25 Year Control: Storage 550 (m^3/imp. ha), Unitary Discharge Rate 0.0068 (m^3/s/ha)
- 100 Year Control: Storage 975 (m^3/imp. ha), Unitary Discharge Rate 0.0025 (m^3/s/ha)

In addition to the 2 to 100 year storm event quantity control, Regional Storm control was required at 841 m^3/imp. ha, with East Huttonville Creek requiring approximately 125,000 m^3 of total storage at the Mount Pleasant Community outlet. The Regional Storm storage is provided upstream of the CNR tracks with flows at the CNR crossing not to exceed 28.4 m^3/s as per the Mount Pleasant Community Subwatershed Study, 2011.

South of Bovaird Drive within the Credit Valley Secondary Plan, there are six (6) stormwater management facilities that provide Enhanced Level of water quality control, erosion control based on the Distributed Runoff Control (DRC) and post to pre-development flow controls for the 2 to 100 year storm events.

Previous Hydrologic Modelling

Hydrologic analyses of the Credit River Watershed had been completed as part of the 2007 Credit River Watershed Flow Management Study. In addition, under a separate CVC initiative, a Water Quality model has been developed using the Hydrologic Simulation Program Fortran (HSP-F) hydrologic model. The objective of that study had focused on assessing land use impacts and evaluating Best Management Practices (BMP's) for water quality management within the Credit River Watershed; as such, that model was developed using a different philosophy and methodology compared to conventional hydrologic modelling practices. Nevertheless, that model was developed using the most current information within the CVC database for land use, soil types, and slopes, and was (according to the authors), calibrated for observed monthly and seasonal flow rates. The urban response function (URF) methodology which was developed for that model, had been considered unsuitable for the HFSWS, 2011, as it related to peak flow management, due to the focus on weekly, monthly and seasonal hydrologic response rather than instantaneous flood conditions. It had therefore been recommended, through consultation with CVC and Steering Committee members, that a "new" conventional HSP-F hydrologic model be developed for the HFSWS, 2011, with a focus on flood impact assessment and management, however to use the Water Quality model data as a base for building the conventional HSP-F hydrologic model. Using the conventional HSP-F hydrologic model, hydrologic analyses for the Huttonville Creek Subwatershed was completed in 2011 as part of the HFSWS, 2011.

Hydrologic modelling has been conducted for south of Bovaird Drive in the Credit Valley Secondary Planning Area for various developments. The development land use and stormwater management information for this area has been updated from the HFSWS, 2011.

Hydraulic Routing

Routing elements within Huttonville Creek exist in the form of surface drainage features such as creeks, ditches roads, and on-line stormwater management facilities. These elements influence flow rates through reductions in peak flow rates and modifications to hydrograph shape (stormwater management facilities more so than watercourses), and lagging effects (i.e. shifts in the occurrence of time-to-peak). These elements are incorporated into the HSP-F hydrologic model in the form of rating curves, which define the storage-discharge relationship of the specific element.

The routing elements for the watercourses had been determined using a HEC-RAS hydraulic model which had been developed for the hydraulic analyses within the Huttonville Creek Subwatershed within the HFSWS, 2011.

The storage-discharge relationships for the existing and approved stormwater management facilities have been integrated into the model, based upon the most current information received, including the governing Functional Servicing Reports.

Parameterization

The parameterization for the Heritage Heights HSP-F hydrologic model has remained the same as per the parent model from the HFSWS, 2011, apart from minor refinements due to drainage area boundary revisions. The HFSWS, 2011, HSP-F hydrologic modelling parameterization process has been summarized here, and provided in more detail in Appendix C.

The CVC's 2006 HSP-F Water Quality model had been developed for the evaluation of BMP's within the Credit River Watershed, rather than for the conventional purpose of hydrologic analysis for flood and erosion assessment. As such, the format of the current HSP-F hydrologic model, and the manner in which the analyses have been completed, is considered unique to the intended purpose of water quality analysis and varies from the conventional format of a flood management tool. As such, it was agreed with the Steering Committee for the HFSWS, 2011, that the HSP-F Water Quality model be converted to a format which is more consistent with conventional hydrologic modeling for flood prediction and management.

The conversion methodology had been entirely based upon the parameters provided for the generic landforms in the Water Quality HSP-F model. The variations in elevation across the subwatersheds and surface length (i.e., drainage density) within each subcatchment are typically calculated based upon a review and measurement of topographic mapping; however, the application of the conversion methodology described above does not provide a method for determining the values for these parameters which is consistent with the more conventional approach. As such, drainage density has been determined using the LiDAR mapping for Huttonville Creek.

Each geographic subcatchment within the Water Quality model is represented as a routing element (i.e., a RCHRES), which receives the hydrographs from each generic landform. The hydrographs corresponding to each generic landform are scaled according to the respective area of each generic landform within the subcatchment. As the Water Quality model database contained land use information representing the 2001 condition land use data, it was updated for development approved south of Bovaird Drive within Huttonville Creek and by using the 2005 aerial photography provided by the City of Brampton. As discussed, the existing land use for 2012 has been based on the approved development east of Mississauga Road using the future land use condition from the HFSWS, 2011 and updates based on approved FSRs.

The subcatchment boundary and subsequently the model schematic have been developed based upon review of background reports, the 2011 LiDAR mapping, 2011 aerial photography and field verification. The Huttonville Creek HSP-F hydrologic model schematic is presented in Figure Hydro 3.

Meteorological Time Series Assembly

To account for the variable meteorologic conditions across the Credit River watershed, the rainfall and temperature data, the Credit River Flow Management Study used for Zones of Uniform Meteorology (ZUM's) for rainfall and temperature (ref. Table 4.3.2).

The Toronto Pearson Airport rainfall data has been used herein as the gauge is the closest to the Huttonville Creek subwatershed, thereby providing rainfall data for a 40 year continuous simulation.

Table 4.3.2. Toronto Pearson Airport (Gauge A) – Meteorologic Data

Meteorologic Data	Source	Period of Record	Format
Rainfall	HSP-F (CVC)	Jan. 1996 – Aug. 2001	Daily Rainfall (mm)
	HSP-F (CVC)	Jan. 1991 – Dec. 2001	Hourly Rainfall (mm)
	GAWSER (CVC)	Jan. 1960 – Dec. 1997	Hourly Rainfall (mm)
Temperature	HSP-F (CVC)	Jan. 1996 – Dec. 2000	Daily Min./Max. Temperature (°C)
	HSP-F (CVC)	Jan. 1991 – Aug. 2001	Daily Min./Max. Temperature (°C)
	HSP-F (CVC)	Jan. 1960 – Dec. 2000	Hourly Temperature (°C)
	GAWSER (CVC)	Jan. 1960 – Jul. 1998	Average Daily Temperature (°C)
Wind	HSP-F (CVC)	Jan. 1996 – Dec. 2000	Hourly Wind (km/hr)
Dew Point Temperature	HSP-F (CVC)	Jan. 1996 – Dec. 2000	Hourly Dew Point Temperature (°C)

The temperature data provided at each location encompasses the same period of record, however is only available in the form of daily maximum and minimum temperatures; thus the hourly temperature data for the Pearson gauge has been applied, in order to facilitate a more representative simulation for snow accumulation and melt processes within the subwatershed (i.e. spring freshet).

The HSP-F hydrologic model requires that data be provided for solar radiation, wind movement, evaporation, and dew point temperature. These datasets have been obtained for the period of record based upon nearest available data for the period of record as per the HFSWS, 2011 (i.e., Royal Botanical Gardens in Burlington, as the data at this location represented the longest record currently available for each of the requisite datasets). Although this dataset is not within proximity of the Huttonville Creek subwatershed, the information had been compared with the data at the Guelph/Turfgrass Institute, and it had been verified that the trends for each dataset (i.e., the monthly and seasonal maxima and minima) at the Royal Botanical Gardens are comparable to the trends observed for the Guelph/Turfgrass Institute. Therefore the data currently available for the Royal Botanical Gardens is considered suitable for the current study as it was for the HFSWS.

Calibration/Validation

The Huttonville Creek existing land use conditions HSP-F hydrologic model had undergone a significant calibration process using the 2006 to 2007 field monitoring rainfall and flow data within the HFSWS, 2011. As discussed with CVC, the HSP-F hydrologic model for Heritage Heights has not been calibrated further, but has been validated using the results from the HFSWS, 2011. A summary of the calibration process conducted in the previous study has been provided.

Calibration of the HSP-F hydrologic model had been completed in order to adjust the model parameterization to "best" simulate runoff response to meteorologic events based on observed flows within the subwatershed. Flow data has been available from the flow monitoring sites H1, H2, H3 and H5.

2006 and 2007 rainfall data had been provided by the study rainfall gauge located on Heritage Road with CVC's Firehall gauge on Creditview Road providing data during 2006 to fill in data gaps from the study gauge. Calibration had been conducted based on rainfall event peak flows and peak daily flows. The total number of calibration events which have been used for the calibration of the HSP-F model are summarized in Table 4.3.4. The parameter adjustments for the calibration of the hydrologic model are summarized in Table 4.3.3.

Table 4.3.3. Final Calibration Parameter Adjustment Summary

Parameter	Description	Calibrated Adjustment From Original Values
Snowmelt Parameters for Pervious Land Segments		
COVIND	Maximum snowpack at which the entire land segment would be covered by snow (mm)	Calibrated values within range of Credit River Flow Management Study (CRFMS), values which vary by subcatchment; permissible values are above 0.25 mm with no maximum limit; calibrated values adjusted to less than 500 mm in response to CVC comments and subsequent assessment of proposed revisions.
RDCSN	Relative density of cold new snow relative to water	Calibrated value of 0.12 as per CRFMS; permissible values are between 0.01 and 1.0
TSNOW	Air temperature below which precipitation occurs as snow	Calibrated value of 1.0°C as per CRFMS; permissible values are between –1.0°C and 5.0°C
SNOEVP	Parameter which adapts snow evaporation (sublimation) to field conditions	Calibrated value of 0.0 as per CRFMS; permissible values are between 0.0 and 1.0
CCFACT	Factor which adapts snow condensation/convection equation to field conditions	Calibrated value of 2.0 as per CRFMS; permissible values are between 0.0 and 10.0
MWATER	Maximum water content of the snowpack (mm water/mm water)	Calibrated value of 0.99 as per CRFMS; permissible values are between 0.0 and 1.0; value subsequently adjusted to 0.25 in response to CVC comments and subsequent assessment of proposed revisions..
MGMELT	Maximum rate of snowmelt by ground heat (mm water/day)	Calibrated value of 0.0 as per CRFMS; permissible values are between 0.0 and 25.0
Soil Parameters for Pervious Land Segment		
LZSN	Nominal lower zone storage (mm)	Calibrated values vary by subcatchment; permissible values are between 0.25 and 2500
INFILT	Index to the infiltration capacity of the soil (mm/hr)	Calibrated values vary by subcatchment; permissible values are between 0.0025 and 2500
UZSN	Upper zone nominal storage (mm)	Calibrated values vary by subcatchment; permissible values are between 0.25 and 250
INTFW	Interflow inflow parameter	Calibrated values vary by subcatchment; permissible values are greater than 0.0 with no maximum limit
FZG	Parameter that adjusts for the effects of ice on infiltration (1/mm)	Calibrated value of 1.0 as per CRFMS; calibrated value corresponds to default
FZGL	The lower limit of INFFAC (an infiltration factor) as adjusted by ice in the snowpack	Calibrated value of 0.3 as per CRFMS; permissible values are between 0.0001 and 1.0
Parameters for Impervious Land Segments		
COVIND	Maximum snowpack at which the entire land segment would be covered by snow	Calibrated value set to 1000 as per CRFMS; permissible values are above 0.25 mm with no maximum limit

Parameter	Description	Calibrated Adjustment From Original Values
RDCSN	Relative density of cold new snow relative to water	Calibrated value of 0.12 as per CRFMS; permissible values are between 0.01 and 1.0
TSNOW	Air temperature below which precipitation occurs as snow	Calibrated value of 1.0°C as per CRFMS; permissible values are between –1.0°C and 5.0°C
SNOEVP	Parameter which adapts snow evaporation (sublimation) to field conditions	Calibrated value of 0.0 as per CRFMS ; permissible values are between 0.0 and 1.0
CCFACT	Factor which adapts snow condensation/convection equation to field conditions	Calibrated value of 2.0 as per CRFMS; permissible values are between 0.0 and 10.0
MWATER	Maximum water content of the snowpack	Calibrated value of 0.99 as per CRFMS; permissible values are between 0.0 and 1.0
MGMELT	Maximum rate of snowmelt by ground heat	Calibrated value of 0.0 as per CRFMS; permissible values are between 0.0 and 25.0

The observed and simulated hydrographs had been compared graphically, and analyses have been completed for the observed and simulated peak flow rates for the respective events; additional analyses were completed for the observed daily flow rates in order to verify that the simulated runoff volumes are comparable to those which were observed.

In order to address concerns raised by CVC and EBNFLO Environmental, its consultant in 2010, the model parameterization had been revised in order to comply with the values and ranges specified by the Authority and its consultant, specifically:

- MWATER = 0.25 (maximum water content of the snowpack)
- COVIND < 500 (index to the depth of snow cover at which the entire land segment would be covered with snow)
- IRC < 0.2 (index to the infiltration capacity of the soil)
- INTFW ~ 3.0 (interflow recession constant)
- AGWRC = 0.99 (Water Quality Model) (groundwater recession constant)

Statistical analyses had been completed for this final calibrated model in order to confirm that the model satisfactorily reproduces observed peak flows and runoff volumes, and is therefore appropriate for use in this study. The results of this assessment from the HFSWS, 2011, are as follows.

Table 4.3.4. Calibration Summary for Huttonville Creek

Event Date	H1 Peak Flow (m^3/s)		H2 Peak Flow (m^3/s)		H3 Peak Flow (m^3/s)		Rainfall (mm)
	Observe	Simulate	Observe	Simulate	Observe	Simulated	
10-Jul/06	0.29	0.709	0.148	0.181	0.285	0.266	42.25
12-Jul/06	0.696	0.859	0.445	0.304	0.504	0.563	39.25
28-Jul/06	0.123	0.042	0.028	0.0107	0.111	0.0203	22
19-Sep/06	0.065	0.078	0	0.025	0.023	0.0436	14.3
4-Oct/06	0	0.146	0.046	0.0469	0.075	0.0834	17
11-Oct/06	0.215	0.132	0.059	0.0443	0.11	0.0784	21.2
17-Oct/06	0.632	0.701	0.264	0.242	0.513	0.453	31.6
16-Nov/06	0.7	0.905	0.272	0.32	0.508	0.594	33.2
1-Dec/06	0.812	1.19	0.433	0.417	0.637	0.779	51.7

The observed and simulated instantaneous peak flow rates for the calibration events, as well as the observed and simulated runoff volumes (daily average flow rates) had been compared as part of the calibration process.

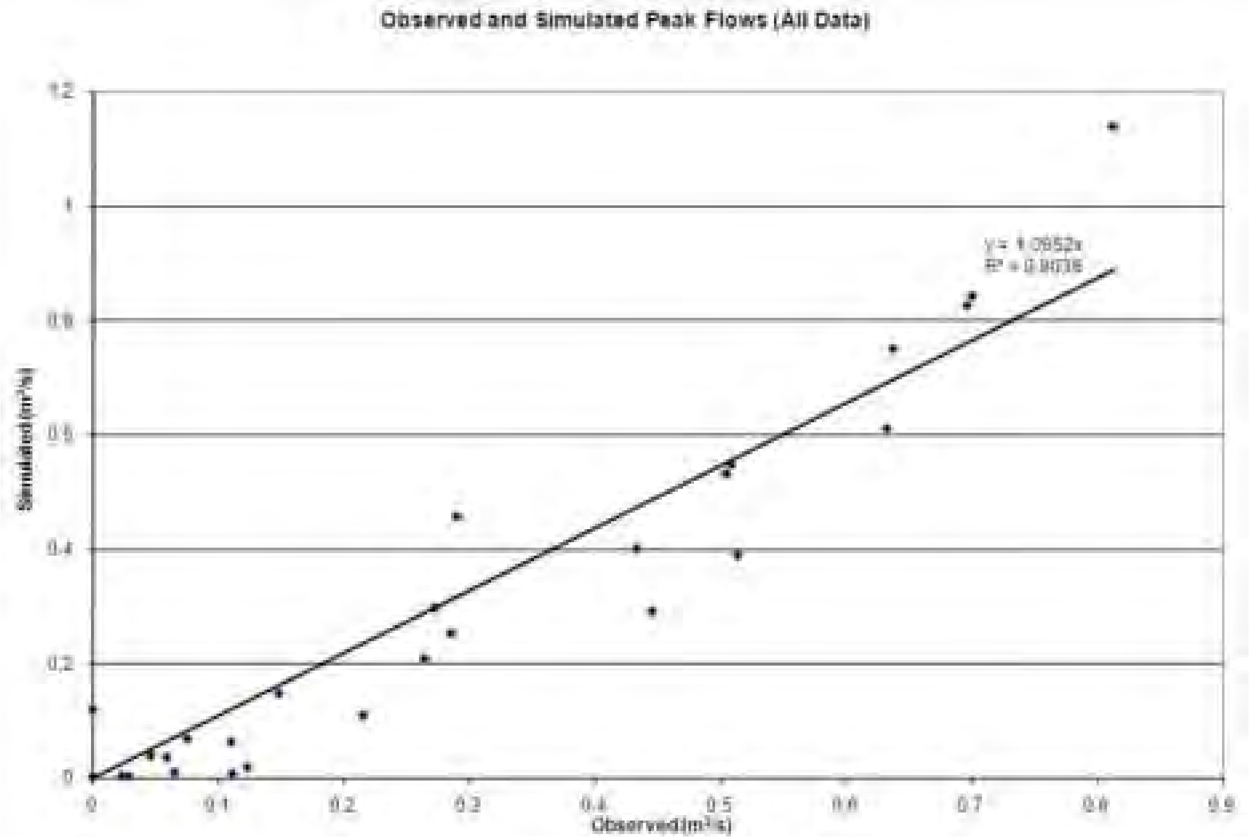


Chart 4.3.1. Huttonville Creek Comparison of Observed Versus Simulated Peak Flows

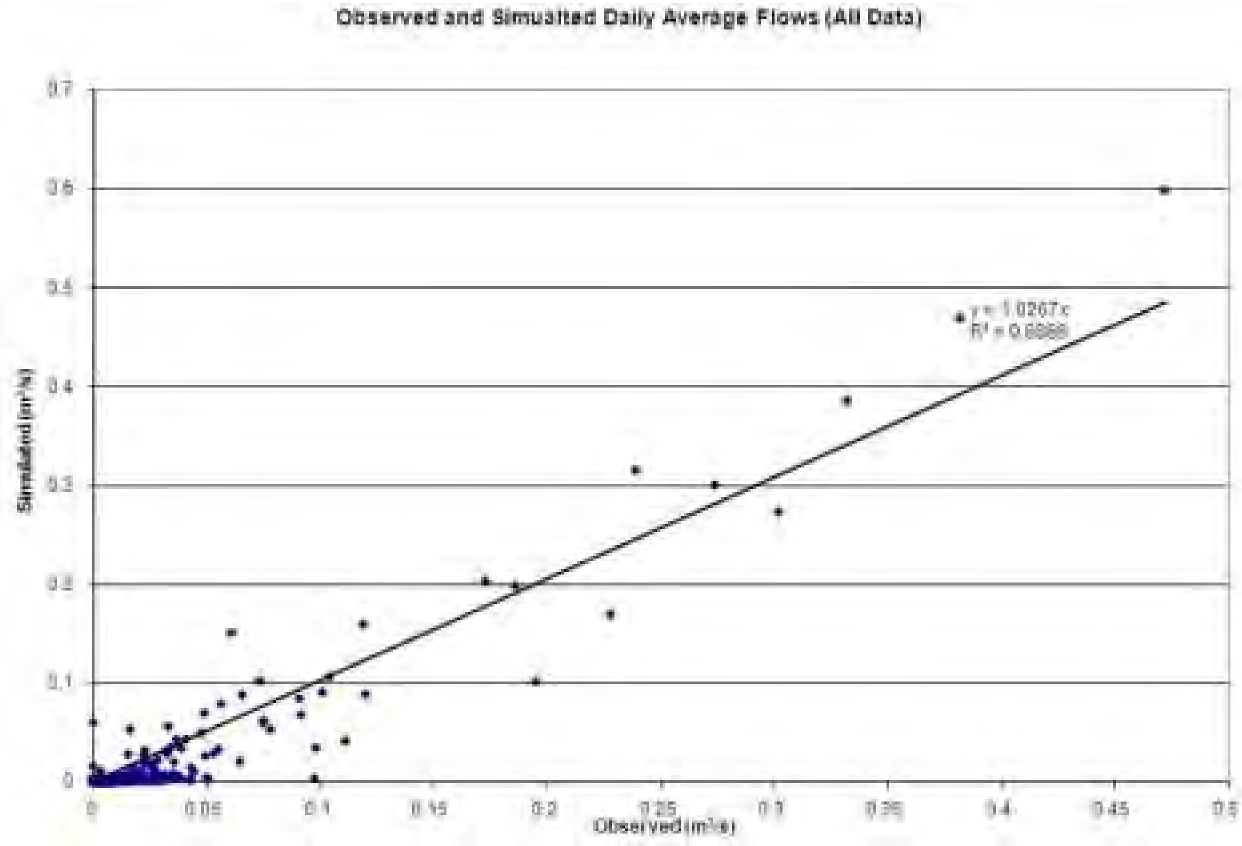


Chart 4.3.2. **Huttonville Creek Comparison of Observed Versus Simulated Daily Average Flows**

Discussion of the validation of the updated existing land use HSP-F hydrologic model has been provided in Section 4.3.4.

Credit River Tributaries (CRTs)

The CRTs have been previously modelled for CVC by Dr. Harold Schroeter using the GAWSER hydrologic modelling platform developed in 2004. The GAWSER hydrologic model for the Credit River includes the CRTs as Subwatershed 9. Each of the five (5) CRTs has been modelled as single catchments (ref. Appendix C). For the purpose of this study, the CRT catchments have been further discretized to establish flows at key locations such road crossings and confluences.

The GAWSER hydrologic model for the Credit River has been prepared using nine (9) hydrologic response units (HRUs). The GAWSER HRU's have been established to represent different land uses and soil types. The first HRU represents impervious coverage with the remaining eight (8) HRUs representing pervious land use conditions. The 9 HRUs have been developed for Subwatershed 9 by Dr. Schroeter by grouping 75 combinations of land use coverage and soil types as provided within CVC's soil and land use GIS mapping. For Subwatershed 9, CVC provided soil and Ecological Land Classification (ELC) mapping with over 4,000 polygons of land uses and soil groupings. The 75 soil and land use classifications have been reduced to 53 combinations by organizing land use and soil grouping into more consistent soil groups.

The last step in developing the nine (9) HRUs has been to group similar land uses and soil groups together and add certain classifications with small areas to other classifications (e.g. silty soils have been added to silty-clay soils). Table 4.3.5 provides descriptions of the nine (9) HRUs.

Table 4.3.5. Hydrologic Response Unit Descriptions

Hydrologic Response Unit (HRU)	Description (vegetation/soil type)
1	Impervious Surfaces
2	Direct lake, pond or open water contributions
3	Wetland areas (contribute to SS)
Low Vegetative Cover (includes pasture and row crops)	
4	Clay (includes peat & muck, and bedrock areas) (contributes to SS)
5	Silty clays (Contributes to Subsurface)
6	Sand (contributes to Groundwater)
7	Gravel (contributes to Groundwater)
High Vegetative Cover (Forests)	
8	Low infiltration soils (includes RU 4 and 5) (Contributes to Groundwater)
9	High infiltration soils (includes RU 6 and 7) (Contributes to Groundwater)

Wood has determined the HRU's applicable for each catchment by applying the more discretized catchment boundary layer to the CVC HRU mapping as provided within Appendix C. AMEC has made one change to the HRUs as applied to Subwatershed 9 CRTs, as it was apparent that the CVC GAWSER hydrologic model applied HRUs from Subwatershed 10 to catchment 901. For the CVC Catchment 901 area within Wood's model, the HRUs for Subwatershed 9 have been applied.

Soils

The CRTs are located over Halton Till, the same as the Huttonville Creek subwatershed, as such soils for the CRT subwatersheds are similar to soils found in the Huttonville Creek subwatershed. Soils in the CRT subwatersheds are primarily Chinguacousy clay loam, with small areas of Jeddo Clay Loam, which exhibit medium and low infiltration rates. The CRT ravines contain sand and gravel deposits.

Slopes

The 2011 LiDAR data has been used to establish a Digital Elevation Model with 0.25 m topographic contours. Slopes for the CRT subwatersheds have been determined using the DEM. The CRT slopes have been characterized as low (0.00 to 3.00%). Average slope for the CRTs is approximately 0.5%, apart from the ravines which are 3% or higher.

Land Use Conditions

The existing land use for the CRT subwatersheds has been determined using the CVC HRU mapping and the catchment layer. Verification of the HRU land use mapping has been conducted using the City of Brampton's aerial photography. The existing land use within the CRT subwatersheds is predominantly agricultural with limited woodlot areas.

Table ***4.3.6*** summarizes the land use for each of the five (5) tributary subwatersheds.

Table 4.3.6. Credit River Tributaries Land Use (ha)

Land Use	CRT1	CRT2	CRT2A	CRT3	CRT4	CRT4A-e	CRT4A	CRT4B	CRT5B	CRT5
Agriculture	172.93	373.19	15.57	74.40	133.47	18.07	5.64	20.31	15.65	46.87
Aquatic	0.02	0.04	0.03	0.02	0.00	0.01	2.90	0.01	-	2.26
Employment	6.06	5.54	0.68	1.06	2.35	-	-	-	-	-
Forest	22.67	26.09	1.77	16.16	12.49	2.41	0.10	1.63	1.07	3.91
Open Space, Managed	-	0.73	5.74	11.08	4.93	-	-	-	-	2.20
Open Space, Unmanaged	31.09	45.92	2.31	6.38	1.82	-	-	-	-	2.94
Residential	13.67	14.50	2.11	8.86	-	1.05	13.40	2.80	-	24.00
Wetland	-	-	-	2.19	0.03	-	-	0.40	-	-
Total	**246.43**	**466.01**	**28.21**	**120.16**	**155.09**	**21.54**	**22.04**	**25.15**	**16.72**	**82.18**

Existing/Approved Stormwater Management Facilities

Within the CRT subwatersheds, there are three (3) existing stormwater management facilities. The first stormwater management facility (to be confirmed if it is a stormwater management facility or a pond) is located at the City of Brampton property (2719 Bovaird Drive West), and receives drainage from the office and associated lands and discharges to Credit River Tributary 2. The facility/ pond has an overflow concrete weir which is in disrepair, which is a minimum of 6 to 7 m in length and 1.5 m height. The stormwater management facility discharges to a CSP culvert-lined channel that discharges to the natural channel within the ravine.

The second and third stormwater management facilities are located within the Four X Development and discharge to CRT 5 and CRT 4A.

Previous Hydrologic Modelling

Previous hydrologic modelling has only included the CVC Credit River GAWSER modelling that has been used as the basis for the refined GAWSER modelling for this study (ref. Appendix 'C', December 16, 2011 Modelling Subwatershed 9 to Highway 401 – Result Summary, Schroeter and Associates).

Hydraulic Routing

The hydraulic routing of flows through catchments within the CRT subwatersheds has been established using cross-sections that represent the reach. To determine cross-sections, the LiDAR topographic data has been used. Creek reach length and slopes have also been determined using the LiDAR data.

Parameterization

CRT catchment limits have been established using the LiDAR topographic mapping, CVC's stream layer, City of Brampton's road layer and hydraulic crossing location information provided by land owners complemented by additional survey by Wood Catchment drainage boundaries have been established at main hydraulic crossings, confluences and locations where erosion assessments have been conducted. Catchment areas, slopes and lengths have been determined using the GIS tool ArcGIS 9.3.1.

For the CRT subwatersheds, catchment length has been determined as per the methodology used in Lesson 7 of the GAWSER Training Guide. For catchments with multiple tributaries, the length (L) of the longest tributary has been used. Catchment width has been determined based on the maximum of either:

Width = Area/ Length or Width = Area/ Length1 where Length1 is based on total tributaries length.

Initial parameterization for each catchment has used the HRU characteristics for Subwatershed Nine (9) as originally provided in Table 8.2 from Watt et al (1989) as provided within **Table 4.3.7**.

Table 4.3.7. Initial Hydrologic Response Unit Drainage Characteristics for Subwatershed 9

Symbol	Description	Units	Imp	Direct Open Lakes	Wet Lands	Low Veg. Clay, Peat, Muck	Low Veg. Silty Clays	Low Veg. Sand	Low Veg. Gravel	High Veg. Slow Infilt. Soils	High Veg. Fast Infilt. Soils
	Response Unit Number		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
DS	Maximum depth of depression Storage	(mm)	2	0	60	5	6	5	5	15	15
KEFF	Infiltration into 1st soil layer	(mm/h)	0	0	0.2	2.0	5.0	16	30	16	50
CS	Infiltration into 2nd soil layer	(mm/h)	0	0.1	0.2	1.5	3.8	12	23	12	38
D	Infiltration out of 2nd layer	(mm/h)	0	0.1	0.2	0.1	0.1	0.8	1.5	0.8	2.5
SAV	Average suction at the wetting front	(mm)	0	200	200	200	200	250	250	200	250
	First Soil Layer										
HI	Soil layer thickness	(mm)	0	1	1	100	150	150	150	200	200
SMCI	Saturated soil-water content (porosity)	(vol/vol)	0	0.56	0.56	0.56	0.54	0.40	0.40	0.50	0.40
IMCI	Initial soil-water content	(vol/vol)	0	0.46	0.46	0.46	0.40	0.10	0.10	0.32	0.10
FCAPI	Field capacity soil-water content	(vol/vol)	0	0.46	0.46	0.46	0.40	0.10	0.10	0.32	0.10
WILTI	Wilting point soil-water content	(vol/vol)	0	0.27	0.27	0.27	0.19	0.04	0.04	0.13	0.04
	Second Soil Layer										
HII	Soil layer thickness	(mm)	0	1	1	150	300	600	600	500	600
SMCII	Saturated soil-water content (porosity)	(vol/vol)	0	0.56	0.56	0.56	0.54	0.40	0.40	0.50	0.40
IMCII	Initial soil-water content	(vol/vol)	0	0.46	0.46	0.46	0.40	0.10	0.10	0.32	0.10
FACPII	Field capacity soil-water content	(vol/vol)	0	0.46	0.46	0.46	0.40	0.10	0.10	0.32	0.10
WILTII	Wilting point soil-water content	(vol/vol)	0	0.27	0.27	0.27	0.19	0.04	0.04	0.13	0.04
	Groundwater Contribution Indicator:										
X	1=SS, 0=GW		0	1	1	1	1	0	0	0	0
FATR	Groundwater Fraction (not used in this model, set=1)		1	1	1	1	1	1	1	1	1
INC	Maximum depth of interception storage	(mm)	0	0	3.0	1.0	0.5	0.5	0.5	3.0	3.0

The CVC GAWSER hydrologic model URF impervious coverages are based on the following:

Residential:	Low Density: 25 to 30% Medium Density: 30% to 35% High Density: 35% to 40%
Employment:	Low Density: 80% Medium Density: 85% High Density: 90%

To be consistent with impervious coverages used for Huttonville Creek within the HSP-F hydrologic model and to have impervious coverages for more than just residential and employment land uses, the impervious coverages listed in **Table 4.3.8** have been used.

Table 4.3.8. Impervious Coverage by Land Use

Land Use	Directly Connected Imperviousness (%)
Aggregate Extraction	0
Agricultural (Intensive and Non-Intensive)	0
Commercial Big Box	96
Strip Commercial	96
Small Institutional	32
Open Spaces/Parks/Corridors (Managed)	10
Valley Lands (Managed)	3
Golf Courses	0
Forest	0
Industrial Big Box	93
Prestige Industrial	80
Unmanaged Open Space	0
Rural Estate Residential	0
High Density Residential	65
High Rise Residential	50
Low Density Residential	30
Medium Density Residential	50
Transportation Corridor	60
Wetland	0

Parameterization of catchments in GAWSER has also included establishing the catchment *main* and *off* channels. The main channel travel time (TMC) and off-channel travel time (TOC) have to be determined based on establishing *reference flows* for both the main channel QRMC and the off-channel QROC. The reference flows are related to the channel bankfull conditions. Representative channel cross-sections have been developed for both the main and off channels to establish travel times.

The main channel cross–section within Subwatershed 9 in the CVC GAWSER hydrologic model has been based on stream geomorphic relationships as follows:

Q_B *(Channel bankfull flow m3/s) = 0.52 ** $A_D^{0.75}$ *(Creek Reach Drainage Area)*
W_B *(Bankfull width) = 3.71 8* $Q_B^{0.49}$
$W_B = 2.69\ Q_B^{0.49}$

Based on a review of the main channel reference flows, it has been determined that a linear relationship of Flow = 0.402 * Drainage Area +0.1033 applies with an R^2 of 0.999 for the rural catchments, as such the relationship has been used to determine main channel reference flows.

(Ref. Memorandum: Modelling Subwatershed 9 to Highway 401 – Results Summary, December 16, 2011, Dr. Harold Schroeter)

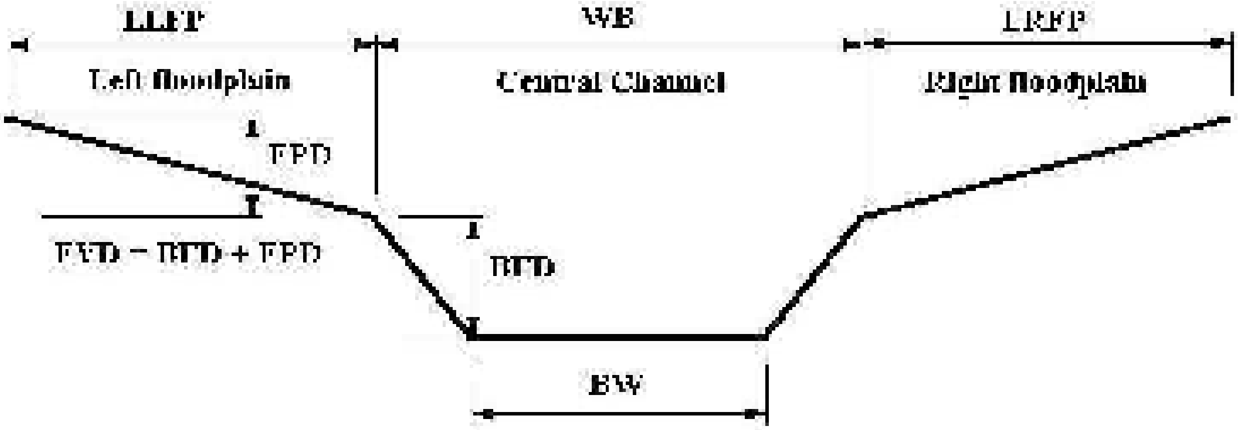


Figure Hydro 1. Channel Cross-Sections Definitions used for Cross-Sections
(Ref. Memorandum: Modelling Subwatershed 9 to Highway 401 –
Results Summary, December 16, 2011, Dr. Harold Schroeter)

The following has been used for the channel cross-section geometry as per the December 16, 2011 memorandum provided by Dr. Schroeter:

$ABF = 0.5*(TW + BW) * BFD$

- The bankfull area is represented by ABF, where the channel top widths (TW) have been set to 25% Greater than the channel bottom width (BW).
- Channel width to flow ratio (TW/BFD) have been set to a value of 8,
- The lengths of the left floodplain (LLFP) and the right floodplain (LRFP) have been set as a multiple of the top width (TW). Typically, the floodplains (LLFP and LRFP) have been set to 10 times the specified top width.
- To finish the cross-section development work, an approximate slope of the ground surface across the floodplain (the LRFP or LLFP) has been assumed. Slopes for the CRTs have been set at 4%. The slope has been set assuming that the floodplain depth (FPD) would be approximately equal to the bankfull flow depth (BFD).
- The full valley depth (FVD) is the total of FPD and BFD.

Manning's values used for the main channels are the 0.15 for floodplain areas and 0.051 for the bankfull areas. The bankfull area Manning's value can also be 0.035 or 0.048 depending on land converges.

For the off-channels, the CVC GAWSER hydrologic model has used one (1) reference flow for rural land 0.05 m^3/s and uses and a second reference flow for urban land uses 0.15 m^3/s. The same approach has been used for the updated GAWSER hydrologic model.

A summary of the initial refinements to the parent CVC GAWSER hydrologic model has been provided in **Table 4.3.9**, with the most notable change being the increased catchment discretization, with 107 catchments representing the Credit River Tributaries and the associated routing elements.

Table 4.3.9. Summary of GAWSER Model Discretization and Parameterization Methodologies

Model Parameter/Component	Parent GAWSER Model	AMEC Refined GAWSER Model
Number of Subcatchments	3 Along Main Branch 6 Within Credit River Tributaries	10 Along Main Branch 75 Within Credit River Tributaries
Number of Routing Elements	3 Along Main Branch 0 Within Credit River Tributaries	4 Along Main Branch 44 Within Credit River Tributaries
Soil Parameterization	Calibrated Values From Previous GAWSER Applications	Same As Parent GAWSER Model
Subcatchment Length (L)	Measured length of longest tributary extended to Subcatchment Boundary	Measured length of longest tributary extended to Subcatchment Boundary
Subcatchment Width (W) for Headwater Subcatchments (i.e. CRT's)	Greater Value of Area/L or Area/L_T where L_T = total length of all "measurable" tributaries	Area/L
Subcatchment Width (W) for Lateral Inflow Subcatchments (i.e. subcatchments containing Credit River)	Greater Value of Area/6 or Area/(L_C + L) where L_C = length of channel routing reach that traverses the lateral inflow subcatchment	Area/L
Main Channel Routing Elements	"Borrowed" cross-sections with minor adjustments to slope and roughness to account for local conditions or determined based upon composite relationships developed by Annable	Cross-sections, slopes, and roughness measured and established based upon local data and mapping
Off Channel Routing Elements	Applied typical section data from previous GAWSER applications	Same as Parent GAWSER Model
Main Channel Reference Flow	"Corresponded in past applications to bankfull conditions but tend to be lower for the average conditions throughout the year"	Calculated based upon linear relationship determined from review of Subwatershed 9 Subcatchments in Parent GAWSER Model
Off Channel Reference Flow	"Corresponded in past applications to bankfull conditions but tend to be lower for the average conditions throughout the year"	Same as Parent GAWSER Model
Routing Elements	"Borrowed" cross-sections with minor adjustments to slope and roughness to account for local conditions or determined based upon composite relationships developed by Annable	Cross-sections, slopes, and roughness measured and established based upon local data and mapping

Meteorological Time Series Assembly

The CVC GAWSER hydrologic time series for the continuous model execution uses the Toronto Pearson, Orangeville and Georgetown data sets as per Tables 4.3.10 to 4.3.12.

Table 4.3.10. Toronto Pearson Airport (6158733) – Meteorologic Data

Meteorologic Data	Source	Period of Record	Format
Rainfall	HSP-F (CVC)	Jan. 1996 – Aug. 2001	Daily Rainfall (mm)
	HSP-F (CVC)	Jan. 1991 – Dec. 2001	Hourly Rainfall (mm)
	GAWSER (CVC)	Jan. 1960 – Dec. 1997	Hourly Rainfall (mm)
Temperature	HSP-F (CVC)	Jan. 1996 – Dec. 2000	Daily Min./Max. Temperature (ºC)
	HSP-F (CVC)	Jan. 1991 – Aug. 2001	Daily Min./Max. Temperature (ºC)
	HSP-F (CVC)	Jan. 1960 – Dec. 2000	Hourly Temperature (ºC)
	GAWSER (CVC)	Jan. 1960 – Jul. 1998	Average Daily Temperature (ºC)
Wind	HSP-F (CVC)	Jan. 1996 – Dec. 2000	Hourly Wind (km/hr)
Dew Point Temperature	HSP-F (CVC)	Jan. 1996 – Dec. 2000	Hourly Dew Point Temperature (ºC)

In addition to the Toronto Pearson Airport gauge, the Credit River GAWSER hydrologic model also uses the following meteorological data sets:

Table 4.3.11. Orangeville (Gauge b – 6155790) – Meteorologic Data

Meteorologic Data	Source	Period of Record	Format
Rainfall	HSP-F (CVC)	Jan. 1991 – Aug. 2001	Daily Rainfall (mm)
	GAWSER (CVC)	Jan. 1960 – Dec. 1999	Hourly Rainfall (mm)
Temperature	HSP-F (CVC)	Jan. 1991 – Aug. 2001	Daily Min./Max. Temperature (ºC)
	GAWSER (CVC)	Jan. 1960 – Dec. 1999	Average Daily Temperature (ºC)

Table 4.3.12. Georgetown (6152695) – Meteorologic Data

Meteorologic Data	Source	Period of Record	Format
Rainfall	GAWSER (CVC)	Jan. 1950 – Dec. 2005	Hourly Rainfall (mm)
Temperature	GAWSER (CVC)	Jan. 1960 – Dec. 1999	Average Daily Temperature (ºC)

Calibration/Validation

The CVC GAWSER hydrologic model had been calibrated in continuous mode and validated in event mode by Dr. Schroeter. The calibration process which Dr. Schroeter used involved refining monthly factors as listed below in **Table 4.3.13**. The monthly parameter factors shown in **Table 4.3.14** had been tested in continuous mode for November 1, 1990 to October 31, 2001 and the period of November 1, 1983 to October 31, 1990. The first period used seven (7) Water Survey of Canada stream flow gauges and the second period used data from the Shaw Creek and Erindale stream flow gauges. The calibration process included a review of monthly and annual hydrographs, from a volume basis, flow duration curves and other observed versus simulated flow data assessments. Calibration of local flows was not possible for Subwatershed 9 due to a lack of usable flow data, therefore the Water Survey of Canada stream flow gauges have been used for the main branch of the Credit River.

Table 4.3.13. CRT GAWSER Hydrologic Model Calibration Factors

Symbol	Description for adjustment factor
FDS	Maximum depth of depression storage factor
FKEFF	Effective hydraulic conductivity factor (for surface infiltration)
FCS	Maximum seepage rate (movement of water from layer 1 to 2)
FD	Maximum percolation rate (movement of water out of layer 2)
FKO	Overland runoff lag factor
FKSS	Combined subsurface and baseflow recession factor
FKMF	Combined refreeze/snowmelt factor
FNEW	Additional adjustment for new snowfall relative density
FIMCI	Initial soil-water content adjustment factor for soil layer 1
FIMCII	Initial soil-water content adjustment factor for soil layer 2
FEVAP	Potential evapotranspiration adjustment factor
FINS	Interception storage adjustment factor

Table 4.3.14. CRT GAWSER Hydrologic Model Monthly Adjustment Factors

Symbol	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
FDS	0.50	0.50	0.50	1.00	1.20	1.15	1.15	1.00	1.00	1.00	0.75	0.75
FKEFF	0.02	0.02	0.02	0.10	0.40	0.70	0.80	0.90	0.65	0.25	0.20	0.02
FCS	0.03	0.02	0.02	0.09	0.40	0.50	0.60	0.75	0.35	0.30	0.13	0.06
FD	0.04	0.03	0.03	0.05	0.05	0.05	0.05	0.06	0.07	0.06	0.05	0.05
FKO	1.75	2.00	1.75	2.00	1.50	2.25	2.75	3.00	2.50	1.50	1.50	1.50
FKSS	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
FKMF	0.25	0.33	0.93	1.23	1.46	1.57	1.52	1.33	1.05	0.76	0.25	0.15
FNEW	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
FEVAP	0.00	0.00	0.00	2.60	3.77	4.43	4.61	3.77	2.50	1.49	1.00	0.00
FINS	0.20	0.20	0.20	0.50	0.70	1.20	1.50	1.50	1.20	0.70	0.20	0.20

The CVC GAWSER hydrologic model has been validated by Dr. Schroeter in event mode by executing it for two 12 day event periods, May 1 to 12, 2008, and April 30 to May 11, 2009 based on a the level of agreement through comparison of observed and simulated hydrographs at key locations (ref. Figures Hydro 2 and 3).

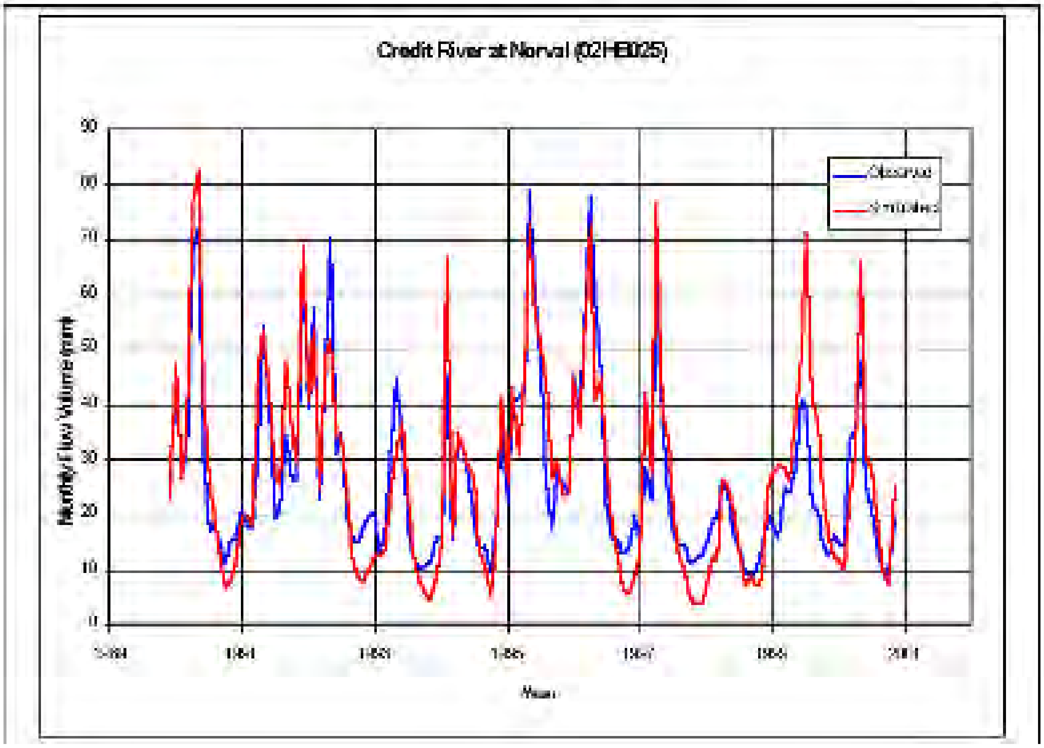


Figure Hydro 2. CVC GAWSER Hydrologic Model Calibration Hydrograph

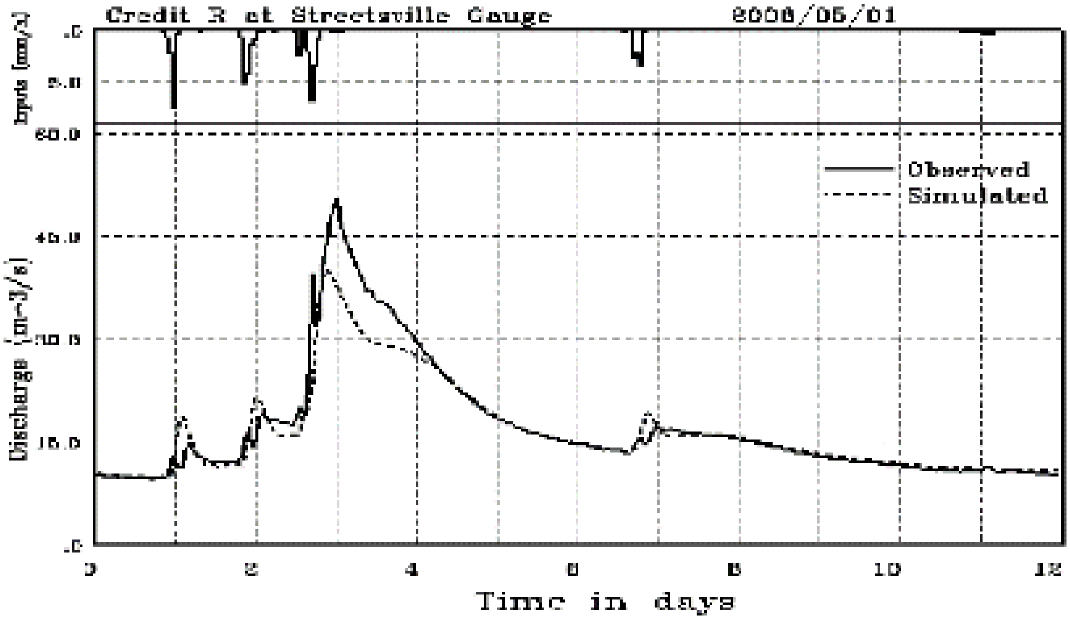


Figure Hydro 3. CVC GAWSER Hydrologic Model Validation Hydrograph

On March 7, 2012, Wood met with CVC and Dr. Schroeter to discuss the CRT GAWSER modelling approach and results. At the meeting, it was agreed by CVC that the CRT GAWSER hydrologic model was considered sufficiently calibrated and that Wood would validate the updated/refined CRT model as part of this study using a comparison of peak flows at key locations. This has been documented in Section 4.3.4.2.

Wood subsequently submitted the 2012 Phase 1 report with frequency flows and design flows resulting from the refined GAWSER modelling. CVC and Dr. Shroeter provided review of the modelling and results and indicated that the frequency flows and design event peak flows were to high and recommended reducing the modelling discretization and to revise the FTB parameter from 1.2 to 2 for the rural catchments. It was also recommended that a review of peak flow timing be conducted, as it was considered that timing of peak flows was increasing peak flow rates.

The purpose of the 2017 and 2019 flow monitoring program, was to provide observed flows within the CRTs for calibration of the refined GAWSER hydrologic model, and to address CVC and Dr. Schroeter's comments. In reviewing the 2017 observed flows on CRT2 and CRT3, the observed flows were extremely low, with CRT3 not exhibiting runoff responses and CRT2 exhibiting . The CRT2 flows were less than 0.15 m^3/s, apart from one (1) event on November 19, 2017, which did not coincide with a rainfall event.

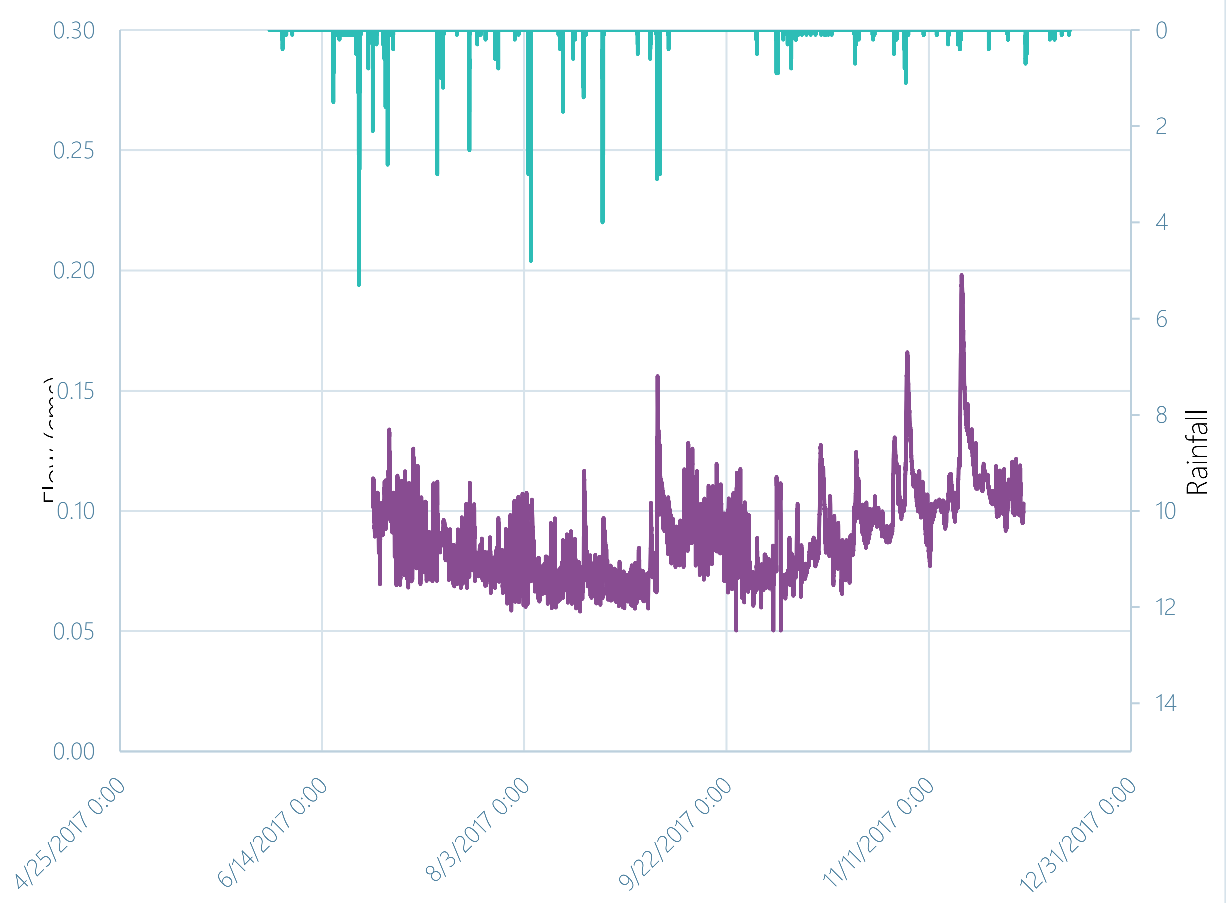


Figure Hydro 4. Observed Flow Hydrograph and Rainfall Hyetograph

Road and downstream of Heritage Road has been used for the purpose of calibration. Rainfall data from the CVC Norval rain gauge has been used.

Following, revision of the FTB parameter from 1.2 to 2 for rural catchments as per the 2013 CVC comments, the calibration process, assessed various parameter adjustments over a series of eighteen (18) trails. The calibration process considered catchment length, width, main and side channel reference flows and various soil parameters. The selected calibration parameter adjustments included the following:

- KEFF: 1st Soil Layer Infiltration Rate (mm/hr) - Increased by 70%
- CS: 2nd Soil Layer Infiltration (mm/ hr) - Increased 70%
- D: Infiltration out of the 2nd Soil Layer - Increased 70%
- HII: Depth of the 2nd Soil Layer - Increased 70%
- SMCII: Initial Soil Water Content of 2nd Soil Layer - Increased 70%
- DS: Maximum Depth of Depression Storage - Increased 30%

Figures Hydro 5 and 6 present observed flows/ simulated flows hydrographs and rainfall hyetographs for the CRT2 flow monitoring site located upstream of Bovaird Drive.

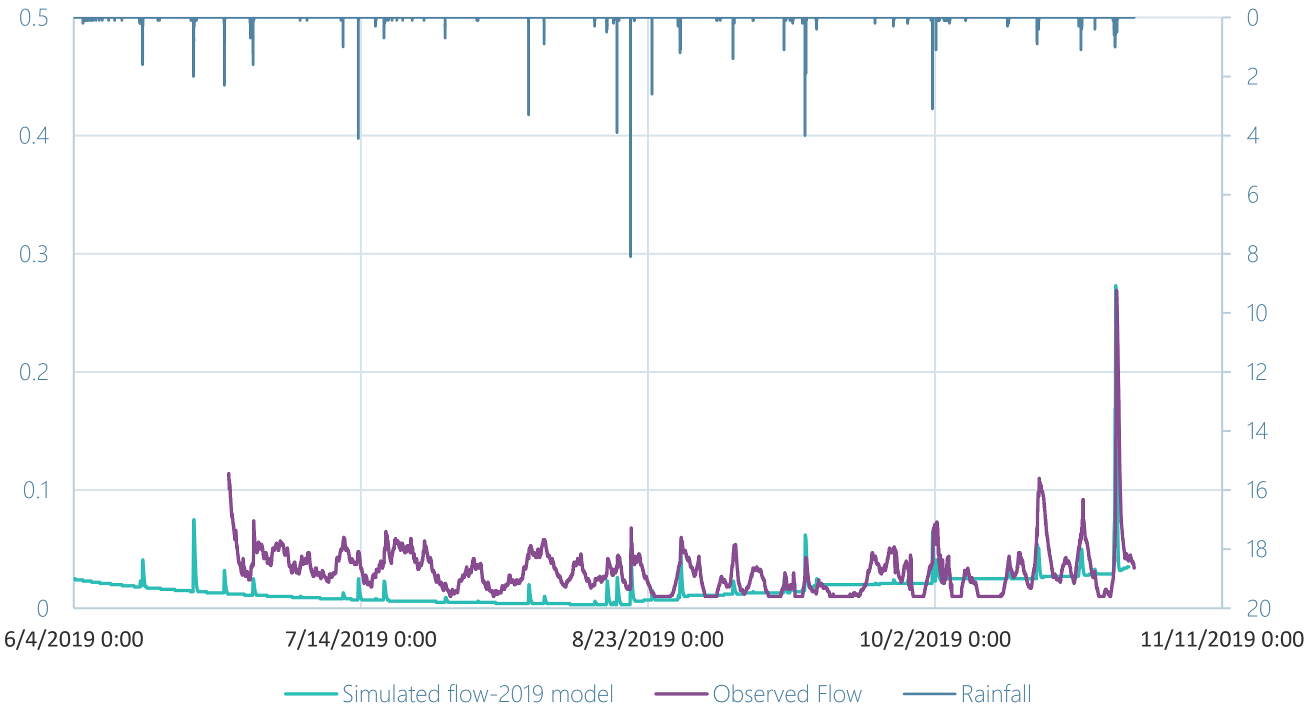


Figure Hydro 5. CRT2 (Upstream of Bovaird Drive) 2019 Observed Flow Hydrograph and Rainfall Hyetograph

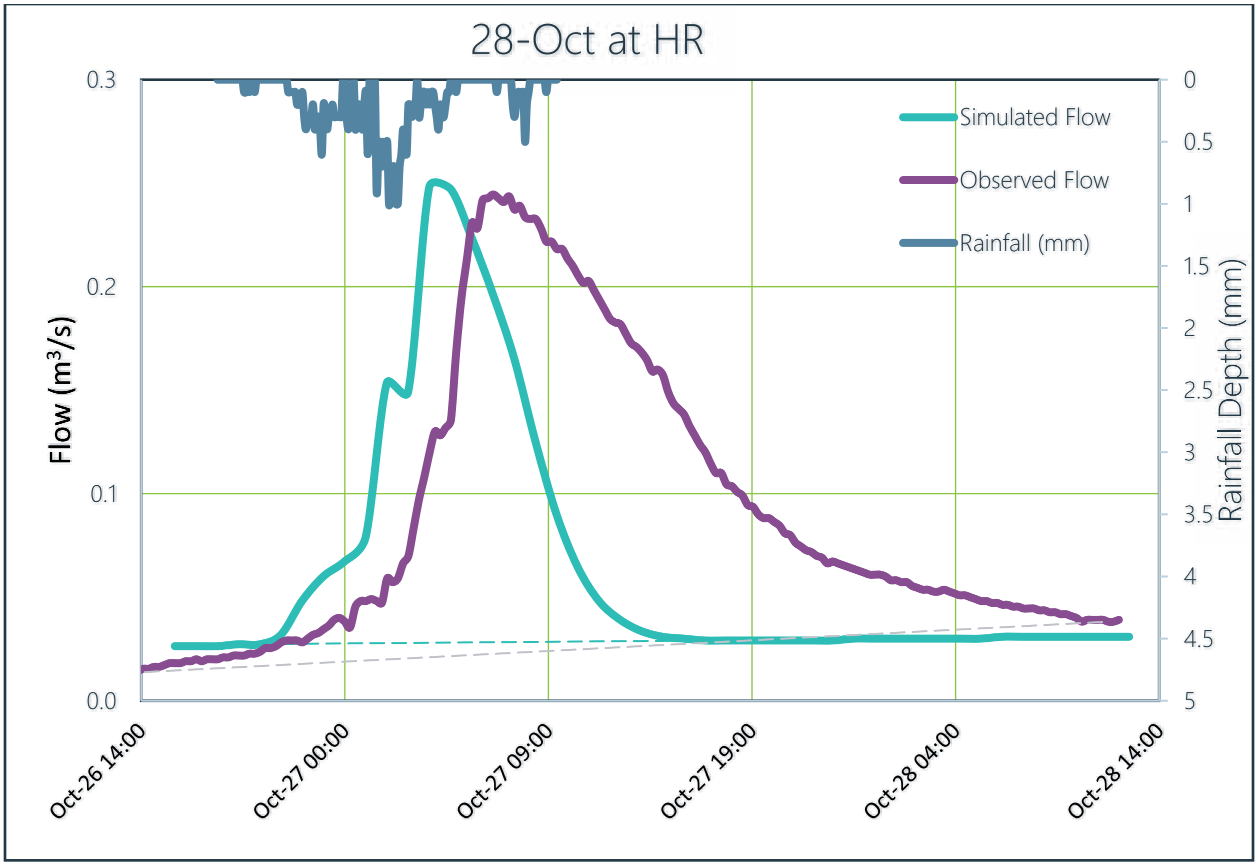


Figure Hydro 6. CRT2 (Upstream of Bovaird Drive) October 28, 2019 Observed Flow Hydrograph and Rainfall Hyetograph

The calibration of the refined GAWSER hydrologic model has been conducted using observed runoff response events at the two (2) flow monitoring sites on CRT2. The calibration has resulted in both event based peak flows and frequency flows being reduced compared to the peak flows resulting from the 2012 GAWSER CRTs hydrologic modelling. Based on a comparison of observed and simulated peak flows the calibrated GAWSER hydrologic model provides a reasonable comparison with the simulated peak flows being slightly above the observed at 7% difference (ref. Figure Hydro 7). The simulated runoff volumes are lower than the observed volumes (55% of observed). Throughout the calibration process, it became apparent that simulated peak flows would be significantly higher than observed, when attempting to reduce the difference between observed and simulated runoff volumes, therefore, the calibration, reached a compromise with lower runoff volumes to result in reasonable peak flows.

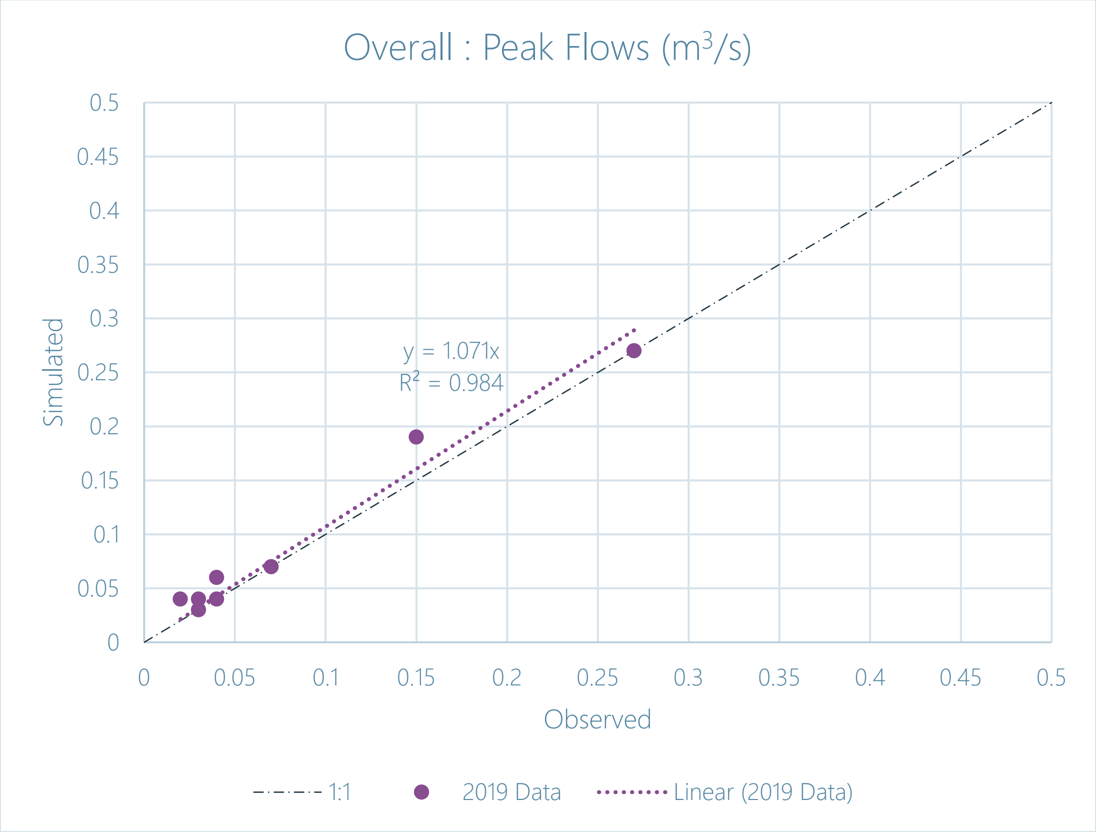


Figure Hydro 7. CRT2 (Both Gauges) Observed versus Simulated Peak Flows (m^3/s)

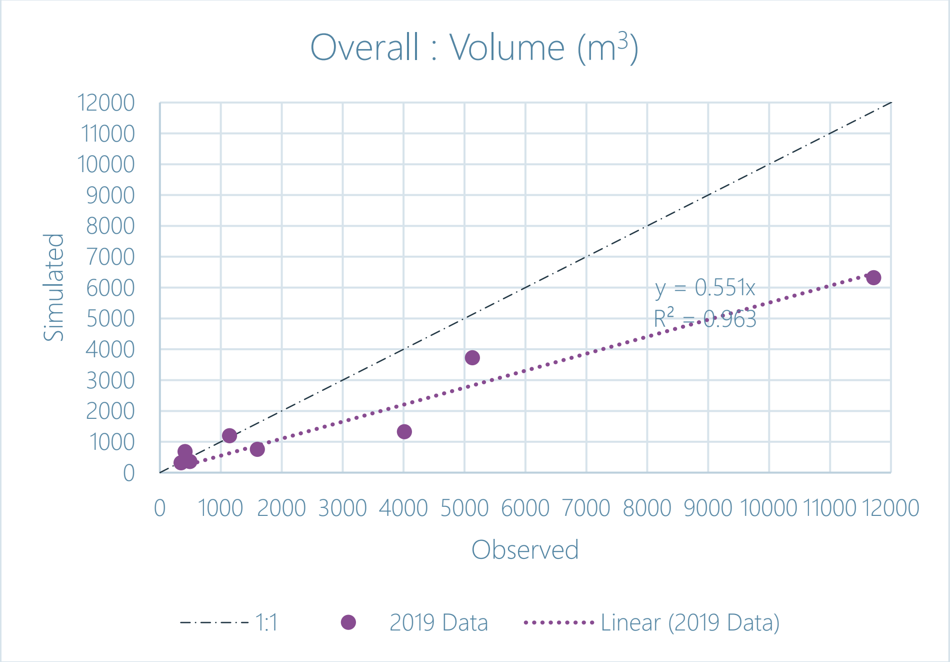


Figure Hydro 8. (Both Gauges) Observed versus Simulated Runoff Volumes (m^3)

Hydraulic Field Methods

Field methods for developing the hydraulic characterization of Huttonville Creek and the CRTs have consisted of the following:

i) Field observations of high water levels by observing water levels during storm events on West Huttonville (part of HFSWS, 2011)

ii) Geodetic survey of crossings considered significant to hydraulic performance

Hydraulic Analytic Methods

Hydraulic analytic characterization has been conducted using the HEC-RAS hydraulic model. The HEC-RAS model data has been based on the U.S. Army Corp of Engineers HEC-2 hydraulic model. HEC-RAS uses energy and momentum equations to determine water surface elevation for given channel geometric cross-sections, crossings and boundary conditions.

Previous Hydraulic Modeling

For Huttonville Creek, the earliest hydraulic model noted to have been developed from the information provided is the Credit Valley Subwatershed Study for Huttonville Creek, 2003. More recently HEC-2 hydraulic modeling has been completed by Stantec Consulting as part of the Sub Areas 1 and 3 (Blocks 1 and 3) Credit Valley Secondary Plan Area, March 2005. The Huttonville Creek hydraulic model commences at the confluence of the Credit River to approximately 400 m south of Highway 7. This HEC-2 hydraulic model was provided by CVC to the HFSWS Study Team. The HFSWS updated and refined the HEC-2 hydraulic through a conversion to HEC-RAS Version 3.1.3 and updating cross-sectional information using the 2004 topographic mapping.

For the current study of West Huttonville Creek, the downstream limit of West Huttonville Creek has been modelled as part of the Mississauga Road Class Environmental Assessment and Detailed Design with the main Huttonville Creek at Bovaird Drive modelled as part of the Bovaird Drive Class Environmental Assessment and Detailed Design. The Bovaird Drive crossing is 14 m by 3.6 m Conspan Arch with Regional Storm capacity, while the Mississauga Road crossing is a 3.6m by 1.2m box open box culvert with 100 year capacityFor the CRT's no hydraulic modelling exists, therefore new hydraulic models were created for this study. Downstream boundary conditions for each of the CRT's is the Credit River. Wood has requested CVC to provide the required boundary condition, however, no data has been provided; as such, the boundary conditions have been set to critical depth which is considered appropriate given the steep reach geometry near the outlets to the Credit River. . The CRT hydraulic model includes the culverts works and creek realignment at Bovaird Drive conducted in 2015

In developing the hydraulic models, both the existing West Huttonville Creek and CRTs have been extended from the current study limits to the south side of Mayfield Road. Culvert crossings that are located within the un-modeled sections of the creeks have been inventoried using the following:

- Land owner culvert database (ref. Appendix 'C'). The database provides culvert location, type, span and rise and elevations (ref. Drawing Hydra 1).
- Geodetic survey of crossings conducted by the Subwatershed Study Team of crossings considered to be significant and required for the hydraulic model (ref. Appendix 'C').
- 2011 LiDAR based topographic mapping for the verification of various culvert inverts
- 2009 aerial photography to verify culvert locations.

Culverts that are not located along roadways or rail tracks have been included in the model where they have a diameter of 600 mm or more. There are a significant number of culverts that have a diameter of less than 600 mm and are located on farm laneways or provide access for farm equipment to fields. The following table summarizes the crossings that have been determined to be significant and have been included in the hydraulic modeling:

Table 4.3.15. Culvert Inventory

Culvert Number	Culvert Location	Type	Span/ Diameter (m)	Rise (m)	Upstream and Downstream Inverts
West Huttonville Creek					
38	Bovaird Drive at Mississauga Road	RFO Bridge	14.0	3.60	233.38 / 232.58
37	Mississauga Road north of Bovaird Drive	CSP	0.63		236.53 / 235.62
33	Mississauga Road north of Bovaird Drive	CSP	0.45		235.10 / 234.74
32	Mississauga Road north of Bovaird Drive	Open Box	3.00	1.20	235.37 / 235.38
45	Bovaird Drive west of Mississauga Road	CSP	0.58		NA
31	Mississauga Road north of Bovaird Drive	RFO Bridge	4.94	1.50	237.04 / 236.36
30	CNR west of Mississauga Road	CSP	3.00		241.88 / 241.48
29	South of CNR west of Mississauga Road	RFO Stone Box	3.00	1.90	240.89 / 240.80
27	Mississauga Road north of CNR	CSP	0.48		246.76 / 246.75
25	North west of CNR/ Mississauga Road	CO	0.60		246.64 / 246.36
18	North west of CNR/ Mississauga Road	CSP	0.80		248.77 / 248.53
16	Mississauga Road south of Wanless Dr.	CSP	0.45		255.29 / 254.92
14	Wanless Drive	CSP	0.45		255.94 / 255.81
12	Mississauga Road north of Wanless Dr.	CSP	0.50		257.74 / 257.73
7	Mississauga Road north of Wanless Dr.	CSP	0.92	0.78	257.50 / 257.14
5	Mississauga Road north of Wanless Dr.	CSP	0.46		259.86 / 259.60
4	Mississauga Road north of Wanless Dr.	CSP	0.75		260.03 / 259.96
11	Wanless Dr. West of Mississauga Rd.	CSP	0.91		254.28 / 254.18
13	North of Wanless Dr. West of Mississauga Rd.	CSP	0.90		255.46 / 255.34
10	Wanless Drive east of Heritage Road	CSP	1.35		251.16, 251.19 / 251.09, 251.21
6	Heritage Road north of Wanless Dr.	CSP	0.46		256.23 / 256.16
1	Mayfield Road east of Heritage Rd.	PVC	0.46		260.40 / 260.24
2	Mayfield Road east of Heritage Rd.	PVC	0.61		261.96 / 261.87
3	Mayfield Road east of Heritage Rd.	CSP	0.47		262.58 / 261.99
Credit River Tributaries					
49	River Road	CSP	1.40		182.51/181.77
48	Ostrander Boulevard	CSP	1.40		210.22/209.94
47	Private Drive west of Mississauga Road	CSP	0.90		221.79/221.48
36	Bovaird Drive east of Heritage Road	BOX	1.22	0.60	235.12 / 235.18
46	South of Bovaird Drive West of Heritage Road	CSP	0.85, 1.25		208.55, 208.69 / 208.02, 208.02
41	South of Bovaird DriveWest of Heritage Road.	CSP	0.72, 0.7		217.43 / 216.82
40	Heritage Road south of Bovaird Drive.	CSP (Oval)	1.30	0.80	224.96 / 225.16
43	Heritage Road south of Bovaird Drive.	CSP	0.90		232.52 / 232.26
42	Bovaird Drive west of Heritage Drive	BOX	1.20	1.20	233.72 / 233.00

Culvert Number	Culvert Location	Type	Span/ Diameter (m)	Rise (m)	Upstream and Downstream Inverts
51	Private Drive north of Bovaird Drive	CSP	0.66		236.91 / 235.49
39	South of Bovaird Dr. West of Heritage Rd.	CSP (Oval)	1.30	0.80	233.89 / 233.77
35	Bovaird Drive west of Heritage Drive	BOX	0.91	0.60	235.75 / 235.63
34	Bovaird Drive west of Heritage Drive	BOX	1.20	2.80	205.99/203.95
28	North of Bovaird Drive west of Heritage Rd.	CSP	0.60		235.61 / 235.33
26	Heritage Road south of CNR	RFO Box	1.22	0.90	244.78 / 244.91
24	CNR east of Heritage Road	CSP	1.84		245.75 / 245.36
21	Heritage Road north of CNR	RFO Box	1.57	1.21	246.47 / 246.46
9	Wanless Drive west of Heritage Rd.	RFO Box	3.0	1.50	249.99 / 249.91
15	Private Drive west of Heritage Rd.	CSP	0.8		248.41 / 248.24
23	Winston Churchill Blvd. South of CNR	RFO Box	1.00	1.05	226.89 / 226.32
20	East of Winston Churchill Blvd south of CNR	CSP (Crushed)	0.80		238.75 / 238.53
17	CNR east of Winston Churchill Blvd.	BOX	0.84	1.96	246.32 / 246.22
44	CNR east of Winston Churchill Blvd.	CSP	0.80		246.94 / 246.87
8	Wanless Drive east of Winston Churchill Blvd.	CSP	0.46		250.93 / 250.76
50	Winston Churchill north of Wanless Drive.	CSP	0.45		259.99 / 259.74
52	Upstream end of private racetrack	CSP	0.35, 0.35		249.24, 249.28 / 249.14, 249.24
53	Downstream end of private racetrack	CSP	0.45		248.47 / 248.38

NA: Data not available and culverts are equalization culverts only

Cross-sections for both Huttonville Creek and the CRTs have been located at meanders, grade changes, confluences and crossings (ref. Drawing Hydra 3). Cross-sections have been established for the purpose of developing Regional Storm floodplain mapping. The floodplain mapping limits will be established using the 50 ha contributing drainage area guideline applied by Conservation Authorities for establishing Regulatory limits.

Low flow channel configurations (below water surface not picked up within LiDAR data) for both West Huttonville Creek and the CRTs have been based on, channel photographic interpretation, and stream morphology characterization.

Manning's Roughness has been established for channels as per the following, prior to roughness calibration:

- Undeveloped area north of Wanless Drive: channel 0.09, overbanks 0.20
- Undeveloped area south of Wanless Drive: channel 0.06, overbanks 0.15

The values of Manning's roughness north of Wanless Drive have been developed using the Manning's roughness values established for the H1 and H2 flow monitoring locations from the neighbouring Mount Pleasant Community Subwatershed. The rating curves for H1 and H2 had been determined by calibrating the Manning's roughness value for the channel in order that observed flow depth and velocity readings result in comparable theoretical flow depth velocities.

The values of Manning's roughness coefficient south of Wanless Drive for West Huttonville Creek had been derived as an 'average' between the values for north of Wanless Drive and the values within the original HEC-2 Huttonville Creek model for south of Highway 7. The channel becomes more defined as it moves south from Wanless Drive to Highway 7, therefore the channel and overbank Manning's roughness values are lower downstream compared to upstream. The same approach has been applied to the Credit River Tributaries, with wooded areas having a Manning's roughness of 0.15.

4.3.4 Results

Hydrology Field Methods

As the Huttonville Creek HSP-F model from the HFSWS, 2011, is considered to have been calibrated, rainfall and flow monitoring have not been conducted directly for the purpose of calibrating the HSP-F model.. An extensive field monitoring program had been conducted during 2006 and 2007 as part of the HFSWS, 2011, with flow gauges at sites H1 to H5 on Huttonville Creek and two local rainfall gauges (ref. Appendix 'C') for the purpose of calibrating the Huttonville Creek hydrologic modelling and providing flow data for water quality characterization.

As discussed in Section 4.3.3, a two year (2017, 2019) flow monitoring program has been conducted to facilitate calibration of the refined CRT GAWSER hydrologic model. The flow monitoring program has used observed flows on CRT2 for the 2019 monitoring year for the calibration process. The results of the calibrated GAWSER hydrologic model are provided in the following sections.

Hydrology Analytic Methods

West Huttonville Creek

The HSP-F hydrologic model has been developed based on the subcatchment plan (ref. Drawing Hydro 1) and the modeling schematic (ref. Drawing Hydro 3) for the baseline condition, representing undeveloped West Huttonville Creek and developed East and Main Huttonville Creek. The continuous hydrologic model has been used to determine frequency flows for the 1.05 to the 100 year storm event. The frequency analysis has been conducted using the Consolidated Frequency Analysis (CFA) program. As per the HFSWS, 2011, the Log Pearson Type III Distribution has been used for determining frequency flows.

A comparison of frequency peak flows at the downstream limits of the East and West Huttonville Creek has been provided in **Table 4.3.16** for validation of the updated hydrologic model.

Table 4.3.16. Peak Flow Comparison of Existing Huttonville Creek Land Use (m^3/s)

Location	Hydrologic Model	Frequency Years						
		2	5	10	20 (25)	50	100	Reg.
East Huttonville Creek Outlet	Current Study	1.43	2.43	3.26	4.17	5.54	6.73	39.80
	Mount Pleasant Subwatershed Study	1.96	3.20	4.21	5.35	7.08	8.59	41.40
West Huttonville Creek Outlet	Current Study	2.11	3.28	4.16	5.08	6.38	7.45	30.6
	Mount Pleasant Subwatershed Study	1.96	3.01	3.78	4.57	5.67	6.56	28.60

For the current study, Huttonville Creek peak flows reported are approximately 0.73 to 1.14 times the value of the flows reported within the HFSWS, 2011. Based on the comparison of current study and the Mount Pleasant HSP-F model results (peak flows), it has been determined that this difference is supportable and not unexpected. For East Huttonville Creek, the levels of impervious have been adjusted as per the proposed development thereby resulting in a slight reduction in peak flows. The peak flows for West Huttonville Creek have slightly increased due to the higher level of catchment discretization.

Frequency peak flows for West Huttonville Creek have been provided within **Table 4.3.17**. Hydrologic modelling nodes have been shown on Drawing Hydro-3.

Table 4.3.17. Huttonville Creek Frequency Flows (m^3/s) for Baseline Land Use

Node	Location	Frequency (years)							
		1.25	2	5	10	20	50	100	Regional
502	Outlet of sub 702	2.74	4.39	6.94	8.80	10.30	13.20	15.30	85.60
503	Outlet of sub 724 @ Bovaird Dr W	2.25	3.57	5.73	7.37	9.09	11.50	13.60	74.50
504	Outlet of sub 705 @ Mississauga Rd	1.27	1.92	2.92	3.64	4.38	5.39	6.19	26.30
505	Outlet of sub 706 @ CNR	1.21	1.84	2.88	3.89	4.54	5.79	6.84	27.10
580	Outlet of sub 721	0.20	0.38	0.79	1.23	1.80	2.86	3.96	6.21
579	Outlet of sub 707	0.91	1.37	2.13	2.72	3.34	4.24	5.00	20.10
506	Outlet of sub 708 @ Wanless Dr	0.82	1.42	2.72	4.01	5.66	8.58	11.50	20.80
587	Outlet of sub 736	0.76	1.20	2.02	2.75	3.61	4.99	6.27	19.40
513	Outlet of sub 720 @ Wanless Dr	0.18	0.32	0.62	0.90	1.23	1.80	2.34	3.15
512	HV17b @ Wanless Dr	0.12	0.19	0.35	0.49	0.66	0.96	1.25	1.51
589	Outlet of sub 715	0.42	0.75	1.45	2.15	3.03	4.56	6.09	9.97
5771	HV15 US of Confluence with HV11	0.08	0.15	0.32	0.47	0.68	1.03	1.39	1.89
575	HV14 US of Confluence with HV13	0.20	0.37	0.71	1.02	1.40	2.02	2.60	3.92
574	Outlet of sub 718	0.25	0.46	0.91	1.34	1.85	2.71	3.52	4.87
570	Outlet of sub 719 @ Mayfield Rd	0.08	0.15	0.32	0.48	0.69	1.06	1.44	2.05
509	Outlet of sub 709 @ Mayfield Rd	0.05	0.10	0.20	0.30	0.44	0.68	0.92	1.43
577	Outlet of sub 713	0.45	0.74	1.32	1.86	2.52	3.65	4.74	11.00
573	Outlet of sub 711	0.18	0.34	0.69	1.04	1.48	2.24	2.99	4.43
576	Outlet of sub 709	0.31	0.60	1.20	1.78	2.48	3.66	4.77	6.43
571	HV31 @ Mississauga Rd	0.094	0.14	0.24	0.32	0.41	0.56	0.7	1.06
514	HV17b @ Mississauga Rd	0.12	0.21	0.42	0.62	0.89	1.36	1.85	1.65

Credit River Tributaries

The Credit River Tributaries have been modelled in both event and continuous modes as per the base Subwatershed 9 CVC GAWSER hydrologic model. The event mode uses the SCS 24 hour storm event as per previous applications (e.g. TSH, 1998; Schroeter & Boyd, 1998, CH2M-Hill, 1996). Event based peak flows have been provided at key locations within Table 4.3.18 with flow nodes shown on Drawing Hydro-2. A comparison of design event peak flows and unitary flow rates from the current study to the CVC GAWSER results for Credit River Tributaries outlets have been provided in Table 4.3.19 and Table ***4.3.20***. Credit River Tributaries flow node locations have been shown on Drawing Hydro-2. Based on a comparison of peak flows at the CRT outlets to the Credit River, peak flows within the study area along the main branch of the Credit River have been validated. A comparison of peak flows and the unitary peak flow rates at the CRT outlets demonstrates that the more discretized GAWSER hydrologic model developed as part of this study results in reasonable peak flows. The 100 year design event peak flows are approximately 11% to over 125% greater than the original parent GAWSER peak flows. The updated Regional Storm unitary peak flow rates at the CRT outlets are approximately 1% to 59% above the original GAWSER modelling peak flows.

Table 4.3.18. Credit River Tributaries Peak Flows (m^3/s) for Baseline Land Use (Event-based)

CRT	NODE NAME	NODE	Location	DA (ha)	2YR	5YR	10YR	25YR	50YR	100YR	REG
CRT1	9020	9020	CRT-1 Wanless Drive Crossing	45.40	0.85	1.62	1.91	2.96	3.52	4.07	4.49
	9135	9135	CRT-1 North of CNR	72.06	1.27	2.54	3.02	4.73	5.61	6.50	7.26
	9160	9160	CRT-1 CNR Crossing	85.45	1.57	3.13	3.68	5.64	6.74	7.81	8.70
	9280	9280	Outlet of Subcatchment 928	41.76	0.66	1.29	1.50	2.29	2.72	3.14	4.02
	9255	9255	Major Node Downstream of Node 9160	170.60	2.85	5.64	6.58	10.05	11.90	13.84	16.86
	9405	9405	CRT-1 Winston Churchill Boulevard Crossing	186.60	2.89	5.72	6.70	10.30	12.29	14.28	18.10
	9251	9251	Major Node Downstream of Node 9405	228.20	3.07	6.12	7.17	11.05	13.16	15.28	21.00
	9256	9256	Outlet of CRT-1	246.43	3.07	6.10	7.14	11.13	13.34	15.58	22.17
CRT2	9035	9035	Outlet of Subcatchments 903 and 904	38.56	0.69	1.32	1.55	2.39	2.84	3.27	3.74
	9080	9080	Major Node Downstream of Node 9035	50.20	0.91	1.88	2.19	3.33	3.93	4.50	4.97
	9090	909	Outlet of Subcatchment 909	11.41	0.23	0.44	0.52	0.81	0.96	1.11	1.16
	9095	9095	Major Node Downstream of Node 9080	78.92	0.50	0.95	1.12	1.80	2.16	2.50	2.83
	9055	9055	Major Node Downstream of Node 9095	117.94	1.87	3.79	4.47	7.01	8.34	9.63	11.36
	9060	9060	CRT-2 Wanless Drive Crossing	128.36	2.03	4.12	4.82	7.40	8.79	10.20	12.39
	9150	9150	Major Node Downstream of Node 9060	172.18	2.17	4.49	5.27	8.26	9.81	11.30	14.26
	9180	9180	CRT-2 Heritage Road Crossing - North	191.63	2.62	5.54	6.47	10.16	12.23	14.12	18.24
	9220	9220	CRT-2 Local Outlet Node East of Node 9180	34.13	0.65	1.27	1.49	2.25	2.66	3.05	3.41
	9195	9195	Major Node Downstream of Node 9180	234.63	3.10	6.62	7.73	12.28	14.77	17.05	22.38
	9230	9230	CRT-2 CNR Crossing	249.42	3.26	6.95	8.15	12.88	15.57	17.99	23.77

CRT	NODE NAME	NODE	Location	DA (ha)	2YR	5YR	10YR	25YR	50YR	100YR	REG
	9310	9310	CRT-2 Heritage Road Crossing - South	267.48	3.38	7.24	8.52	13.42	16.31	18.89	25.40
	9295	9295	Major Node Downstream of Node 9310	297.73	3.60	7.77	9.19	14.53	17.63	20.46	28.10
	0003	3	Major Node Downstream of Node 9295	308.18	3.66	7.90	9.34	14.86	18.00	20.92	29.03
	9365	9365	Major Node Downstream of Node 0003	332.72	3.83	8.30	9.82	15.67	18.91	22.07	31.09
	9370	937	Outlet of Subcatchment 937	9.01	0.19	0.36	0.43	0.68	0.81	0.94	0.94
	9375	9375	Major Node Downstream of Node 9365	376.40	4.12	9.11	10.80	17.28	20.92	24.46	35.09
	9425	9425	Major Node Downstream of Node 9375	399.84	4.27	9.57	11.34	18.16	22.07	25.82	37.27
	9490	9490	CRT-2 North of Bovaird Drive West Crossing	445.39	4.52	10.20	12.08	19.48	23.63	27.73	41.05
	9495	9495	CRT-2 Bovaird Drive West Crossing	458.47	4.61	10.40	12.31	19.88	24.12	28.32	42.17
	9610	9610	Outlet of CRT-2	466.01	4.64	10.48	12.39	20.03	24.27	28.52	42.76
CRT2A	9570	9570	CRT-2A Major Node upsteam of Outlet	26.02	0.63	1.16	1.38	2.11	2.48	2.86	2.70
	9590	9590	Outlet of CRT-2A	28.21	0.61	1.14	1.37	2.12	2.50	2.89	2.91
CRT3	9550	9550	Outlet of Subcatchments 951 and 954	35.54	0.86	1.60	1.88	2.90	3.46	3.98	3.83
	9540	9540	Outlet of Subcatchments 945 and 955	14.34	0.29	0.54	0.65	1.02	1.23	1.45	1.53
	9545	9545	CRT-3 Major Node upstream of Heritage Road Crossing	49.88	1.15	2.13	2.50	3.92	4.69	5.43	5.36
	9660	9660	Outlet of CRT-3	120.16	2.01	3.82	4.51	7.02	8.37	9.76	11.45
CRT4B	9470	9470	Outlet of CRT-4B	37.37	4.30	9.67	11.46	18.39	22.36	26.17	37.98
CRT4	9340	934	Outlet of Subcatchment 934	31.87	0.47	0.87	1.03	1.62	1.93	2.25	2.92
	9330	933	Outlet of Subcatchment 933	12.37	0.28	0.52	0.61	0.94	1.11	1.28	1.28
	9325	9325	CRT-4 Bovaird Drive West Crossing	83.06	1.23	2.41	2.82	4.37	5.20	6.01	7.69

CRT	NODE NAME	NODE	Location	DA (ha)	2YR	5YR	10YR	25YR	50YR	100YR	REG
	9525	9525	Major Node Downstream of Node 9325	133.34	1.87	3.84	4.51	7.10	8.50	9.82	12.52
	9680	9680	Major Node Downstream of Node 9525	158.17	2.12	4.31	5.04	8.05	9.70	11.23	14.72
	9720	9720	Major Node Downstream of Node 9680	176.65	2.29	4.70	5.51	8.73	10.55	12.24	16.37
	9725	9725	Outlet of CRT-4	198.19	2.55	5.22	6.11	9.74	11.75	13.63	18.36
CRT5B	9710	9710	Outlet of CRT-5B	16.73	1.63	2.80	3.13	4.22	4.79	5.43	2.40
CRT4A	9810	9810	Outlet of CRT-4A	33.32	1.64	2.82	3.15	4.48	5.25	6.11	4.85
CRT5	0041	41	Outlet of Subcatchments 970 and 9822	45.18	5.03	8.90	9.98	13.84	15.68	17.65	7.58
	0042	42	Outlet of Subcatchments 9821 and 9823	21.80	3.03	4.60	5.06	6.67	7.55	8.43	3.21
	9820	9820	Major Node Downstream of SWM 801	66.99	5.05	8.93	10.02	13.89	15.74	17.72	10.79
	9840	9840	Outlet of CRT-5	82.18	4.73	8.35	9.60	14.82	16.92	19.18	12.61
	983	983	Outlet of Subcatchment 983	50.59	0.05	0.04	0.03	0.02	0.02	0.02	0.20
	984	984	Outlet of Subcatchment 984	15.19	1.35	1.99	2.22	3.09	3.58	4.17	1.82

Table 4.3.19. Credit River Tributaries Design Event Peak Flow Comparison for Existing Land Use (m^3/s) 2021 Report

Location	Hydrologic Model	Area (ha)	Frequency Years						
			2	5	10	25	50	100	Reg.
CRT Outlet 1	Current Study	246.43	3.07	6.10	7.14	11.13	13.34	15.58	22.17
	CVC Parent CRT GAWSER Parent Model	248.9	2.59	4.52	6.46	7.86	8.72	10.18	18.51
CRT Outlet 2	Current Study	466.01	4.64	10.48	12.39	20.03	24.27	28.52	42.76
	CVC Parent CRT GAWSER Parent Model	408.2	1.88	3.92	4.7	7.98	9.82	11.67	23.51
CRT Outlet 2A	Current Study	28.21	0.61	1.14	1.37	2.12	2.50	2.89	2.91
	CRT GAWSER Parent Model	37.9	0.18	0.69	0.89	1.61	2.01	2.39	3.24
CRT Outlet 3	Current Study	120.1	2.01	3.82	4.51	7.02	8.37	9.76	11.45

Location	Hydrologic Model	Area (ha)	Frequency Years						
			2	5	10	25	50	100	Reg.
	CVC Parent CRT GAWSER Parent Model	133.5	0.28	1.15	1.51	3.05	3.93	4.8	9.39
CRT Outlet 4	Current Study	198.19	2.55	5.22	6.11	9.74	11.75	13.63	18.36
	CVC Parent CRT GAWSER Parent Model	196.7	2.23	3.63	4.1	7.71	9.95	12.18	18.11
CRT Outlet 4A	Current Study	33.32	1.64	2.82	3.15	4.48	5.25	6.11	4.85
	CVC Parent CRT GAWSER Parent Model	31.4	0.95	1.58	1.78	2.45	2.8	3.15	3.13

Table 4.3.20. Credit River Tributaries Design Event (Event-based) Unitary Flow Comparison for Existing Land use (m^3/s) 2021 Report

Location	Hydrologic Model	Area (ha)	Frequency Years						
			2	5	10	25	50	100	Reg.
CRT Outlet 1	Current Study	246.43	0.012	0.025	0.029	0.045	0.054	0.063	0.090
	CVC Parent CRT GAWSER Parent Model	248.9	0.010	0.018	0.026	0.032	0.035	0.041	0.074
CRT Outlet 2	Current Study	466.01	0.010	0.022	0.027	0.043	0.052	0.061	0.092
	CVC Parent CRT GAWSER Parent Model	408.2	0.005	0.010	0.012	0.020	0.024	0.029	0.058
CRT Outlet 2A	Current Study	28.21	0.022	0.041	0.049	0.075	0.088	0.102	0.103
	CRT GAWSER Parent Model	37.9	0.005	0.018	0.023	0.042	0.053	0.063	0.085
CRT Outlet 3	Current Study	120.1	0.017	0.032	0.038	0.058	0.070	0.081	0.095
	CVC Parent CRT GAWSER Parent Model	133.5	0.002	0.009	0.011	0.023	0.029	0.036	0.070
CRT Outlet 4	Current Study	198.19	0.013	0.026	0.031	0.049	0.059	0.069	0.093
	CVC Parent CRT GAWSER Parent Model	196.7	0.011	0.018	0.021	0.039	0.051	0.062	0.092
CRT Outlet 4A	Current Study	33.32	0.049	0.085	0.094	0.134	0.158	0.183	0.145
	CVC Parent CRT GAWSER Parent Model	31.4	0.030	0.050	0.057	0.078	0.089	0.100	0.100

For the baseline existing land use condition, the frequency and Regional Storm peak flows have been provided within Table 4.3.2.1. Frequency flows (based on continuous simulation) for the CRT have been determined using the three-parameter lognormal (LN3P) distribution (regression fit) within the GAWSER frequency analysis routine, as per the methodology used for developing frequency flows from the CVC's CRT GAWSER hydrologic model.

Table 4.3.21. Credit River Tributaries Frequency Flows (m^3/s) for Existing Land Use

CRT	NODE NAME	NODE	Location	DA (ha)	1.25	2	5	10	20	50	100
CRT1	9020	9020	CRT-1 Wanless Drive Crossing	45.4	0.17	0.31	0.55	0.73	0.9	1.14	1.32
	9135	9135	CRT-1 North of CNR	72.06	0.25	0.48	0.86	1.14	1.43	1.82	2.12
	9160	9160	CRT-1 CNR Crossing	85.45	0.32	0.61	1.14	1.55	1.99	2.62	3.13
	9280	9280	Outlet of Subcatchment 928	41.76	0.16	0.32	0.57	0.74	0.89	1.08	1.22
	9255	9255	Major Node Downstream of Node 9160	170.6	0.56	1.15	2.1	2.75	3.36	4.12	4.66
	9405	9405	CRT-1 Winston Churchill Boulevard Crossing	186.6	0.61	1.18	2.11	2.77	3.42	4.27	4.91
	9251	9251	Major Node Downstream of Node 9405	228.2	0.65	1.26	2.25	2.95	3.64	4.52	5.17
	9256	9256	Outlet of CRT-1	246.43	0.62	1.27	2.29	2.97	3.59	4.35	4.87
CRT2	9035	9035	Outlet of Subcatchments 903 and 904	38.56	0.15	0.27	0.48	0.63	0.78	0.97	1.12
	9080	9080	Major Node Downstream of Node 9035	50.2	0.19	0.35	0.62	0.83	1.03	1.32	1.54
	9090	909	Outlet of Subcatchment 909	11.41	0.04	0.08	0.15	0.19	0.24	0.29	0.33
	9095	9095	Major Node Downstream of Node 9080	78.92	0.1	0.18	0.33	0.43	0.54	0.68	0.79
	9055	9055	Major Node Downstream of Node 9095	117.94	0.41	0.77	1.36	1.79	2.22	2.8	3.25
	9060	9060	CRT-2 Wanless Drive Crossing	128.36	0.44	0.83	1.46	1.93	2.4	3.03	3.52
	9150	9150	Major Node Downstream of Node 9060	172.18	0.49	0.91	1.62	2.14	2.68	3.41	3.98
	9180	9180	CRT-2 Heritage Road Crossing - North	191.63	0.61	1.15	2.04	2.7	3.37	4.27	4.98
	9220	9220	CRT-2 Local Outlet Node East of Node 9180	34.13	0.13	0.24	0.42	0.55	0.69	0.87	1.01
	9195	9195	Major Node Downstream of Node 9180	234.63	0.75	1.41	2.51	3.33	4.16	5.28	6.15
	9230	9230	CRT-2 CNR Crossing	249.42	0.79	1.5	2.66	3.53	4.4	5.59	6.51
	9310	9310	CRT-2 Heritage Road Crossing - South	267.48	0.83	1.56	2.79	3.69	4.61	5.85	6.82
	9295	9295	Major Node Downstream of Node 9310	297.73	0.91	1.71	3.05	4.03	5.03	6.38	7.42
	0003	3	Major Node Downstream of Node 9295	308.18	0.92	1.73	3.09	4.09	5.11	6.48	7.55
	9365	9365	Major Node Downstream of Node 0003	332.72	0.97	1.83	3.27	4.32	5.39	6.83	7.94
	9370	937	Outlet of Subcatchment 937	9.01	0.03	0.06	0.11	0.15	0.19	0.25	0.29
	9375	9375	Major Node Downstream of Node 9365	376.4	1.07	2.03	3.63	4.81	6.01	7.62	8.86
	9425	9425	Major Node Downstream of Node 9375	399.84	1.13	2.14	3.84	5.08	6.34	8.04	9.36
	9490	9490	CRT-2 North of Bovaird Drive West Crossing	445.39	1.21	2.29	4.1	5.45	6.8	8.64	10.07
	9495	9495	CRT-2 Bovaird Drive West Crossing	458.47	1.16	2.36	4.28	5.59	6.82	8.35	9.43
	9610	9610	Outlet of CRT-2	466.01	1.17	2.37	4.3	5.63	6.89	8.47	9.61

CRT	NODE NAME	NODE	Location	DA (ha)	1.25	2	5	10	20	50	100
CRT2A	9570	9570	CRT-2A Major Node upstream of Outlet	26.02	0.11	0.22	0.41	0.57	0.73	0.97	1.17
	9590	9590	Outlet of CRT-2A	28.21	0.12	0.23	0.43	0.59	0.77	1.02	1.22
CRT3	9550	9550	Outlet of Subcatchments 951 and 954	35.54	0.15	0.28	0.5	0.69	0.9	1.21	1.47
	9540	9540	Outlet of Subcatchments 945 and 955	14.34	0.06	0.11	0.19	0.25	0.31	0.4	0.46
	9545	9545	CRT-3 Major Node upstream of Heritage Road Crossing	49.88	0.2	0.38	0.7	0.94	1.19	1.55	1.84
	9660	9660	Outlet of CRT-3	120.16	0.37	0.72	1.31	1.76	2.22	2.84	3.33
CRT4B	9470	9470	Outlet of CRT-4B	37.37	1.14	2.16	3.87	5.13	6.4	8.12	9.45
CRT4	9340	934	Outlet of Subcatchment 934	31.87	0.1	0.2	0.35	0.45	0.55	0.67	0.75
	9330	933	Outlet of Subcatchment 933	12.37	0.05	0.1	0.17	0.23	0.28	0.36	0.41
	9325	9325	CRT-4 Bovaird Drive West Crossing	83.06	0.29	0.53	0.94	1.23	1.52	1.91	2.21
	9525	9525	Major Node Downstream of Node 9325	133.34	0.45	0.84	1.48	1.95	2.42	3.06	3.55
	9680	9680	Major Node Downstream of Node 9525	158.17	0.51	0.95	1.68	2.22	2.76	3.49	4.06
	9720	9720	Major Node Downstream of Node 9680	176.65	0.55	1.02	1.79	2.36	2.94	3.72	4.32
	9725	9725	Outlet of CRT-4	198.19	0.62	1.15	2.02	2.67	3.32	4.19	4.87
CRT5B	9710	9710	Outlet of CRT-5B	16.73	0.11	0.23	0.44	0.61	0.79	1.03	1.23
CRT4A	9810	9810	Outlet of CRT-4A	33.32	0.11	0.25	0.5	0.71	0.92	1.21	1.45
CRT5	0041	41	Outlet of Subcatchments 970 and 9822	45.18	0.34	0.75	1.48	2	2.52	3.17	3.65
	0042	42	Outlet of Subcatchments 9821 and 9823	21.8	0.42	0.66	1.05	1.34	1.65	2.09	2.44
	9820	9820	Major Node Downstream of SWM 801	66.99	0.35	0.77	1.5	2.05	2.6	3.33	3.88
	9840	9840	Outlet of CRT-5	82.18	0.42	0.82	1.63	2.34	3.15	4.42	5.53

A comparison of the frequency peak flows and unitary frequency flow rates at key nodes has been provided in Table 4.3.22 and Table 4.3.23 respectively. Frequency peak flows for the updated GAWSER hydrologic modelling are typically above the parent model peak flows. The decrease/ increase in the 100 year peak flows range from 10% to 260%. The increase in the Regional peak flows range from 1% to 58%. Based a comparison in Charts 4.3.1 to 4.3.3 of the GAWSER versus the HSP-F model results, (2, 10 and 100 year unitary peak flows on an area basis), the GAWSER results are considered to be reasonable. Chart 4.3.4 provides a comparison between the CRT GAWSER Regional Storm unitary peak flows (Wood GAWSER) to other local watersheds, and as can be seen by the chart, the CRT GAWSER unitary flows are within the expected range, although towards the high end of the range for the 100 year, the unitary peak flows are slightly low for areas less than 100 ha. The changes in peak flows from the parent GAWSER hydrologic model to the current CRT GAWSER model are due to the level of discretization and routing compared to the parent model. The parent hydrologic model had 6 catchments for the CRT, whereas the current model has 107 catchments. The parent hydrologic model did not have routing elements as the CRT catchments were singular, whereas the current model has 44 routing elements within the CRTs.

Table 4.3.22. Credit River Tributary Frequency Flows Baseline Peak Comparison of Existing Land Use (m^3/s)

Location	Hydrologic Model	Area (ha)	Frequency Years						
			2	5	10	25	50	100	Reg.
CRT Outlet 1	Current Study	246.43	1.27	2.29	2.97	3.59	4.35	4.87	22.17
	CVC Parent CRT GAWSER Parent Model	248.9	1.48	2.23	2.87	3.82	4.64	5.56	18.51
CRT Outlet 2	Current Study	466.01	2.37	4.30	5.63	6.89	8.47	9.61	42.76
	CVC Parent CRT GAWSER Parent Model	408.2	1.35	2.2	2.86	3.81	4.59	5.44	23.51
CRT Outlet 2A	Current Study	28.21	0.23	0.43	0.59	0.77	1.02	1.22	2.91
	CRT GAWSER Parent Model	37.9	0.04	0.14	0.2	0.29	0.36	0.44	3.24
CRT Outlet 3	Current Study	120.1	0.72	1.31	1.76	2.22	2.84	3.33	11.45
	CVC Parent CRT GAWSER Parent Model	133.5	0.35	0.64	0.88	1.26	1.06	1.98	9.39
CRT Outlet 4	Current Study	198.19	1.15	2.02	2.67	3.32	4.19	4.87	18.36
	CVC Parent CRT GAWSER Parent Model	196.7	1.84	2.84	3.6	4.66	5.53	6.45	18.11
CRT Outlet 4A	Current Study	33.32	0.25	0.50	0.71	0.92	1.21	1.45	4.85
	CVC Parent CRT GAWSER Parent Model	31.4	0.38	0.58	0.75	0.98	1.17	1.38	3.13

Table 4.3.23. Credit River Tributary Frequency Unitary Flow Comparison of Existing Land Use ($m^3/s/ha$)

Location	Hydrologic Model	Area (ha)	Frequency Years						
			2	5	10	25	50	100	Reg.
CRT Outlet 1	Current Study	246.43	0.005	0.009	0.012	0.015	0.018	0.020	0.090
	CVC Parent CRT GAWSER Parent Model	248.9	0.006	0.009	0.012	0.015	0.019	0.022	0.074
CRT Outlet 2	Current Study	466.01	0.005	0.009	0.012	0.015	0.018	0.021	0.092
	CVC Parent CRT GAWSER Parent Model	408.2	0.003	0.005	0.007	0.009	0.011	0.013	0.058
CRT Outlet 2A	Current Study	28.21	0.008	0.015	0.021	0.027	0.036	0.043	0.103
	CRT GAWSER Parent Model	37.9	0.001	0.004	0.005	0.008	0.009	0.012	0.085
CRT Outlet 3	Current Study	120.1	0.006	0.011	0.015	0.018	0.024	0.028	0.095
	CVC Parent CRT GAWSER Parent Model	133.5	0.003	0.005	0.007	0.009	0.008	0.015	0.07

Location	Hydrologic Model	Area (ha)	Frequency Years						
			2	5	10	25	50	100	Reg.
CRT Outlet 4	Current Study	198.19	0.006	0.010	0.013	0.017	0.021	0.025	0.093
	CVC Parent CRT GAWSER Parent Model	196.7	0.009	0.014	0.018	0.024	0.028	0.033	0.092
CRT Outlet 4A	Current Study	33.32	0.008	0.015	0.021	0.028	0.036	0.044	0.145
	CVC Parent CRT GAWSER Parent Model	31.4	0.012	0.018	0.024	0.031	0.037	0.044	0.1

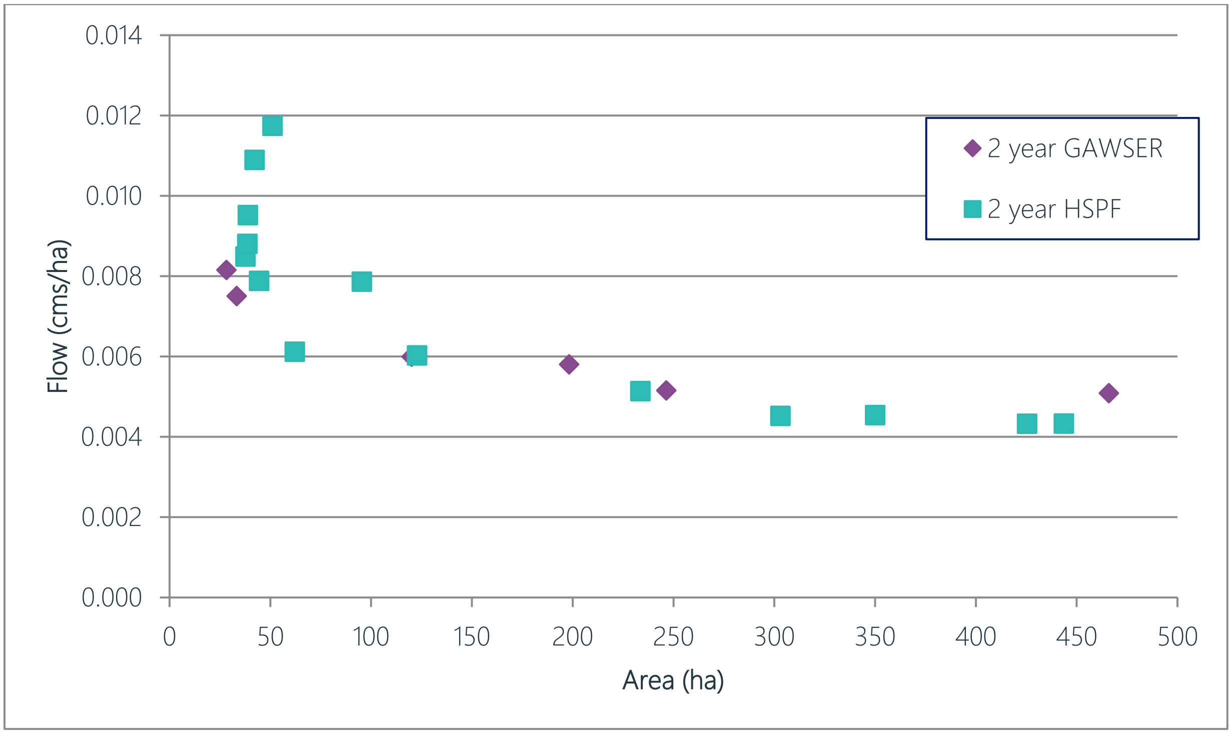


Chart 4.3.3. 2 Year Unitary Peak Flow Comparison (CRT GAWSER vs. Huttonville HSP-F)

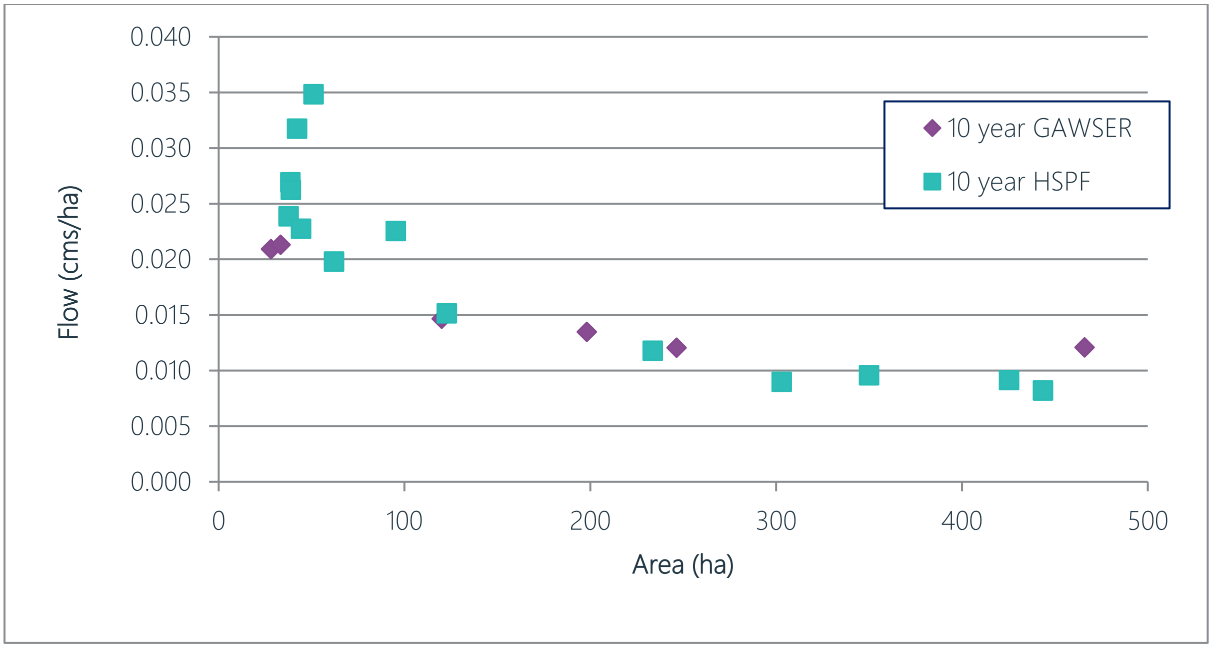


Chart 4.3.4. 10 Year Unitary Peak Flow Comparison (CRT GAWSER vs. Huttonville HSP-F)

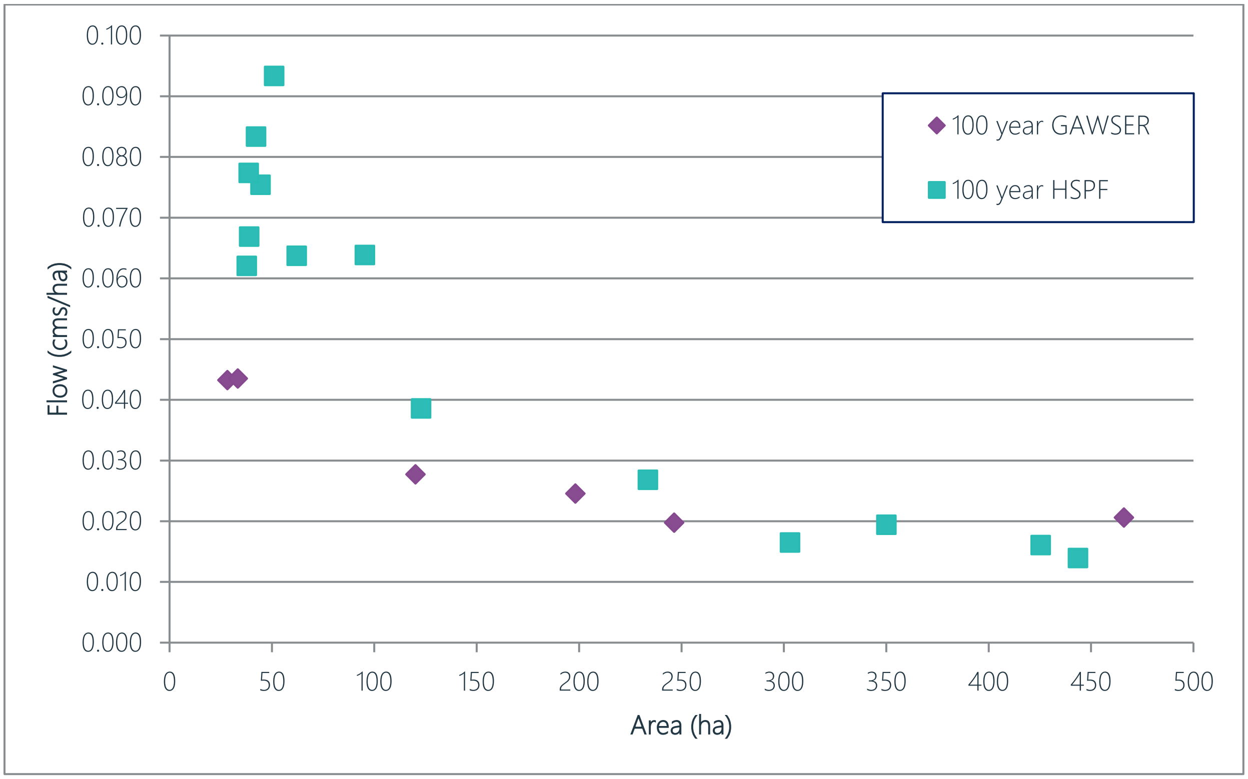


Chart 4.3.5. 100 Year Unitary Peak Flow Comparison (CRT GAWSER vs. Huttonville HSP-F)

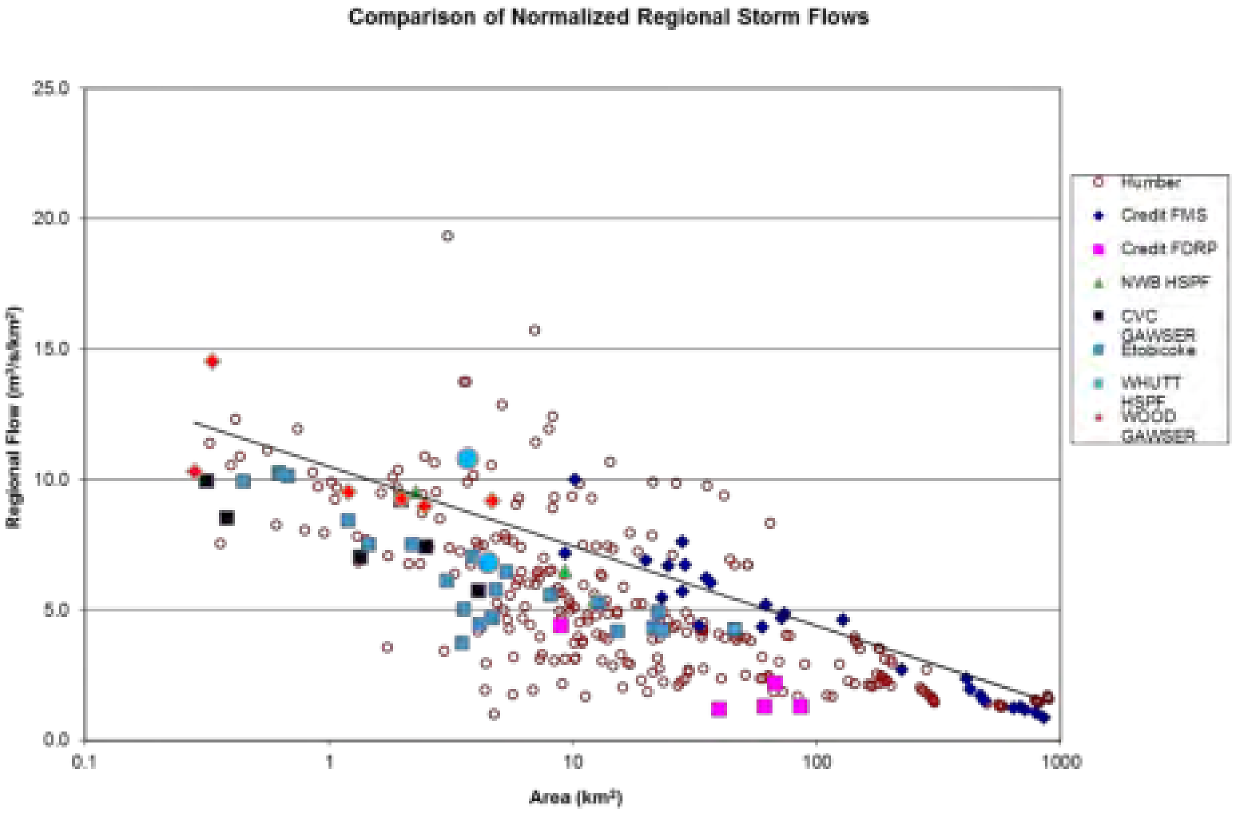


Chart 4.3.6. Regional Storm Year Unitary Peak Flow Comparison

Hydraulic Field Methods

Hydraulic field work has not been conducted as part of this study, apart from observing field conditions on April 5, 2012 as flow and rainfall monitoring have not been conducted for the purpose of hydrologic model calibration. As part of the Mount Pleasant Subwatershed Study, 2011, field observations of water surface elevations at key locations during wet weather conditions had been used to verify the HEC-RAS hydraulic modeling.

Hydraulic Analytic Methods

The hydraulic cross-section and Regional Storm floodplain plan (ref. Drawing Hydra 3) has been established and used in preparing the hydraulic models for both Regulatory floodplain mapping and hydraulic routing elements, for use in the HSP-F hydrologic model. The detailed HEC-RAS hydraulic modeling results have been provided within Appendix 'C'. A summary of crossing capacity has been provided in **Table 4.3.24**, based on the storm that can be conveyed without overtopping the crossing.

Table 4.3.24. Culvert Flow Capacity Summary

Culvert Number	Culvert Location	Type	Span/ Diameter (m)	Rise (m)	*Storm Capacity* (2-100, Reg) Storm Frequency
West Huttonville Creek					
38	Bovaird Drive at Mississauga Road	RFO Bridge	14.0	3.60	Regional
37	Mississauga Road north of Bovaird Road	CSP	0.63		NA
33	Mississauga Road north of Bovaird Road	CSP	0.45		NA
32	Mississauga Road north of Bovaird Road	Open Box	3.00	1.20	100 Year
45	Bovaird Drive west of Mississauga Road	CSP	0.58		NA
31	Mississauga Road north of Bovaird Road	RFO Bridge	4.94	1.50	100 Year
30	CNR west of Mississauga Road	CSP	3.00		Regional
29	South of CNR west of Mississauga Road	RFO Stone Box	3.00	1.90	100 Year
27	Mississauga Road north of CNR	CSP	0.48		NA
25	North west of CNR/ Mississauga Road	CO	0.60		< 1.25 Year
18	North west of CNR/ Mississauga Road	CSP	0.80		< 1.25 Year
16	Mississauga Road south of Wanless Dr.	CSP	0.45		NA
14	Wanless Drive	CSP	0.45		NA
12	Mississauga Road north of Wanless Dr.	CSP	0.50		NA
7	Mississauga Road north of Wanless Dr.	CSP	0.92	0.78	Regional
5	Mississauga Road north of Wanless Dr.	CSP	0.46		NA
4	Mississauga Road north of Wanless Dr.	CSP	0.75		NA
11	Wanless Dr. West of Mississauga Rd.	CSP	0.91		10 Year
13	North of Wanless Dr. West of Mississauga Rd.	CSP	0.90		50 Year
10	Wanless Drive east of Heritage Road	CSP	1.35		25 Year
6	Heritage Road north of Wanless Dr.	CSP	0.46		< 1.25 Year
1	Mayfield Road east of Heritage Rd.	PVC	0.46		10 Year
2	Mayfield Road east of Heritage Rd.	PVC	0.61		10 Year
3	Mayfield Road east of Heritage Rd	CSP	0.47		NA
Credit River Tributaries					
49	River Road	CSP	1.40		100 Year
48	Ostrander Boulevard	CSP	1.40		100 Year
47	Private Drive west of Mississauga Road	CSP	0.90		5 Year
36	Bovaird Drive east of Heritage Road	BOX	1.22	0.60	Regional
46	South of Bovaird Dr. West of Heritage Rd.	CSP	0.85, 1.25		100 Year
41	South of Bovaird Dr. West of Heritage Rd.	CSP	0.72, 0.7		10 Year
40	Heritage Road south of Bovaird Drive.	CSP (Oval)	1.30	0.80	25 Year
43	Heritage Road south of Bovaird Drive.	CSP	0.90		25 Year

Culvert Number	Culvert Location	Type	Span/ Diameter (m)	Rise (m)	*Storm Capacity* (2-100, Reg) Storm Frequency
42	Bovaird Drive west of Heritage Drive	BOX	1.20	1.20	100 Year
51	Private Drive north of Bovaird	CSP	0.66		25 Year
39	South of Bovaird Dr. West of Heritage Rd.	CSP (Oval)	1.30	0.80	100 Year
35	Bovaird Drive west of Heritage Drive	BOX	0.91	0.60	50 Year
34	Bovaird Drive west of Heritage Drive	BOX	1.20	2.80	100 Year
28	North of Bovaird Drive west of Heritage Rd.	CSP	0.60		1.25 Year
26	Heritage Road south of CNR	RFO Box	1.22	0.90	2 Year
24	CNR east of Heritage Road	CSP	1.84		100 Year
21	Heritage Road north of CNR	RFO Box	1.57	1.21	2 Year
9	Wanless Drive west of Heritage Rd.	RFO Box	3.0	1.50	5 Year
15	Private Drive west of Heritage Rd.	CSP	0.8		1.25 Year
23	Winston Churchill Blvd. South of CNR	RFO Box	1.00	1.05	5 Year
20	East of Winston Churchill Blvd south of CNR	CSP (Crushed)	0.80		1.25 Year
17	CNR east of Winston Churchill Blvd.	BOX	0.84	1.96	100 Year
44	CNR east of Winston Churchill Blvd.	CSP	0.80		5 Year
8	Wanless Drive east of Winston Churchill Blvd.	CSP	0.46		1.25 Year
50	Winston Churchill north of Wanless Drive.	CSP	0.45		50 Year
52	Upstream end of private racetrack	CSP	0.35, 0.35		1.25 Year
53	Downstream end of private racetrack	CSP	0.45		1.25 Year

NA – culverts have not been modelled due to culvert location or lack of data

4.3.5 Interpretation

West Huttonville Creek is typically dry, apart from perennial flow at the confluence of the west and east Huttonville Creek. Credit River Tributaries 1,2 and 3 are not dry and have had baseflow measured at the outlets to the Credit River, that said the baseflow is considered minimal and in the case of CRT3 is barely measureable. Based on the hydraulic modelling of the existing crossings, there are numerous culverts that are overtopped by the Regional Storm. Both the City of Brampton and the Region of Peel have policies in place that require culverts and bridges to convey the Regional Storm, as such, there will be culverts that need upgrading from a hydraulics perspective. The CNR crossings of both the CRTs and West Huttonville Creeks results in significant backwater affects, which is considered typical for rail crossings. As an example, the 0.8 m diameter CNR culvert just east of Winston Churchill Blvd. has only a 5 year capacity.

4.4 Terrestrial Resources

4.4.1 Importance/Purpose

The biological systems include both aquatic (Section 4.7) and terrestrial resources. The latter are generally include various vegetation communities (e.g., wetland, forest, meadow), which in turn provide habitat to a variety of organisms (e.g., birds, mammals, reptiles, amphibians, insects, and plants).

These biological features are influenced by the abiotic characteristic of the environment they are in. Vegetation is affected by soils, topography and climate, and the vegetation communities in turn present a diversity of opportunities for wildlife habitat. The terrestrial resources, especially those delineated as wetlands, have an important relationship with hydrological/hydrogeological characteristics.

Terrestrial components of an ecosystem contribute to several important functions or ecosystem services including the amelioration of microclimates, predominant roles in carbon, mineral and nutrient cycling, contributions to hydrology storage, quality and temperature control and the provision of habitat. At watershed and regional scales, these terrestrial functions, services, and features are important to sustaining hydrologic and chemical cycles.

This terrestrial characterization documents and refines the understanding of existing conditions in the Heritage Heights Study Area. The characterization focuses on vegetative cover, flora and fauna species, and important functions and interactions. At a broader geographic scale, the related and parallel *Landscape Scale Analysis Update* study, will inform decisions on future development including the preferred configuration of a Natural Heritage System (NHS) as required under Provincial, Regional and City policies.

4.4.2 Background Information

The reports and maps that were reviewed, along with the results from other disciplines in the current study, have been documented in Section 2.3 and below.

Natural Heritage Information Centre

Geographic queries of rare species and natural areas in the Study Area were conducted using the following provincial and local online databases:

- MNRF Land Information Ontario (LIO) Natural Features Mapping;
- Natural Heritage Information Centre (NHIC) database;
- Aquatic SAR distribution maps;
- Ontario Breeding Bird Atlas;
- Ontario Nature Reptile and Amphibian Atlas;
- Ontario Butterfly Atlas; and
- Citizen Science databases such as iNaturalist and eBird.

According to the search results, six provincially and nationally rare terrestrial species are noted for the Study Area:

- Bobolink (Dolichonyx oryzivorus) – Threatened in Ontario;
- Eastern Meadowlark (Sturnella magna) – Threatened in Ontario;
- Eastern Wood-pewee (Contopus virens) – Special Concern in Ontario;
- Redside Dace (Clinostomus elongates) – Endangered in Ontario;
- American Eel (Anguilla rostrata) – Endangered in Ontario; and,
- Butternut (Juglans cinerea) – Endangerd in Ontario.

Species at Risk occurrences within the Study Area, are described later in this report (Section 4.4.4.4).

Michael Oldham (Herpetologist, MNR, Natural Heritage Information Centre) queried the Ontario Herpetological Summary database for records for the North West Brampton Study Area and vicinity (including the Landscape Scale Analysis area). Eastern Milksnake was identified as a potential occurrence in the Study Area. This species was recorded within one cultural meadow community in the Study Area by a local expert (P. Clarkson, pers. comm. October 2012) and reported to the CVC in 2011.

Citizen Science Databases – iNaturalist

The iNaturalist (2021) database is a large citizen science-based project that aims to collect, archive, and share sightings of flora and fauna species. Users can submit observations to be reviewed and identified by naturalists and scientists to help provide accurate species observations. As the observations can be submitted by anyone, and the records are not officially vetted, the data obtained from this tool should not be used as a clear indicator of species presence. It should be noted that only "research grade" observations will be referenced.

A total of 733 species were identified within 2 km of the Study Area. The following species of interest were noted:

- Species listed as Threatened or Endangered on the SARO list:
    - Butternut – Endangered in Ontario.
- Species of Conservation Concern (i.e., listed as Special Concern on the SARO list, or identified as an S1-S3 species):
    - Monarch (*Danaus plesippus*) – Special Concern in Ontario;
    - Snapping Turtle (*Chelydra serpentina*) – Special Concern in Ontario; and,
    - Peregrine Falcon (*Falco peregrinus*) – Special Concern in Ontario.

Three Butternuts were noted within 2 km southwest of the Study Area. No observations were noted on iNaturalist on or within 120 m of the Study Area.

Monarch Butterfly was noted on and within 120 m of the Study Area. An adult Monarch was observed on a Common Milkweed (*Asclepias syriaca*) plant south of Bovaird Drive and west of Heritage Road within the Study Area. A Monarch caterpillar was observed on a Common Milkweed at the northeast corner of Wanless Drive and Heritage Road within the Study Area. Eleven observations of Monarch (adults and caterpillars) were also noted within 2 km, but greater than 120 m from the Study Area.

Three Snapping Turtle (Two adult, one hatchling) were noted 500 m west of the Study Area along West Huttonville Creek. No Snapping Turtles were noted in iNaturalist on or within 120 m of the Study Area.

One Peregrine Falcon was noted approximately 1 km west of the Study Area at the intersection of 10 Side Road and 10th Line. No Peregrine Falcon were noted in iNaturalist on or within 120 m of the Study Area.

Ontario Butterfly and Moth Atlas

The Ontario Butterfly and Moth Atlases (Toronto Entomologists' Association 2018a, 2018b) contain detailed information on the population and distribution status of Ontario butterflies and moths. The data is presented on 100 km^2 area squares with one square overlapping a portion of the Study Area (17NJ94, 17NJ93). It should be noted that the Study Area is a small component of the overall atlas square, and therefore it is unlikely that all butterfly and moth species noted are found within the Study Area. Habitat type, availability and size are all contributing factors in butterfly and moth species presence and use.

A total of 111 species was recorded in the atlas square that overlaps with the Study Area, of which 57 are butterfly species and 54 are moth species. Of these species, one Species of Conservation Concern (i.e., listed as Special Concern on the SARO list, or identified as an S1-S3 species) was noted: Monarch (*Danaus plexippus*) ranked Special Concern in Ontario and Endangered in Canada.

2006-2007 MNR Wildlife Survey Data

In 2006, Mark Heaton (MNR Aurora District Fish and Wildlife Biologist) conducted wildlife surveys within the Northwest Brampton Study Area. The results of these surveys specific for the Study Area are summarized in **Table 4.4.1** below by OMNR ID number.

Table 4.4.1. MNR 2006 Wildlife Survey Results for Blocks Visited

Date	MNR Block Survey Block ID	Species Observed
June 13, 2006	“C” described as woodlot north of Wanless Drive, East of Heritage Road and west of Mississauga Road	• Red Eyed Vireo • American Robin • White Breasted Nuthatch • Rose Breasted Grosbeak • Chickadee • Song Sparrow • Coyote
June 13, 2006	“D” described as woodlot south of Wanless Drive, East of Heritage Road and west of Mississauga Road	• Downy Woodpecker • Hairy Woodpecker • Chickadee • Grosbeak • Crow • Crackle • American Robin • Red Tailed Hawk • Red Eyed Vireo • Cedar Waxwing • Eastern Wood Pewee • Oriole • White Tailed Deer
June 16, 2006	“E” described as woodlot north of Hwy. 7 (Bovaird Dr.), east of Heritage Road, west of Mississauga Road	• Red-Eyed Vireo • Pileated Woodpecker • Chickadee • Red Winged Blackbird • Goldfinch • Cardinal • Eastern Wood Pewee • Indigo Bunting • Song Sparrow • Crackle • Wild Turkey • Coyote • Raccoon

After the receipt of this data, MNRF staff completed wetland inventories for North West Brampton.

MNRF Wetland Inventories for North West Brampton Area

The Ministry of Natural Resources conducted wetland inventories and fieldwork in the North West Brampton Area and vicinity in the early 2000's (including the Huttonville Creek & Area Wetland Complex, Churchville-Norval Wetland Complex and West Upper Fletcher's Creek Wetland Complex).

Two provincially significant wetland complexes are present within the Study Area: Huttonville Creek and Area Wetland Complex (2018) and Churchville-Norval Wetland Complex (2012). Both Wetland Complexes occur within the South Slope physiographic region. All wetlands within the Churchville-Norval Wetland Complex are located along the Credit River valley and seven small contributing tributaries and are within the Natural Heritage System of the Greenbelt. The Huttonville Creek & Area Wetland Complex is located east of Winston Churchill Boulevard, south of Mayfield Road, west of Creditview Road and north of Steeles Avenue. The Huttonville and Area Wetland Complex is comprised of tableland wetlands, and wetlands along headwater drainage features and tributaries to the Credit River. Significant wetlands are illustrated on Figure T1, Appendix D. Significant wetlands are discussed further in Section 4.4.5.2.

In 2018, MNRF updated the Huttonville Creek & Area Wetland Complex mapping. The Complex was refined through a combination fieldwork carried out by MNRF in 2012, 2016 and 2017, wetland aerial photo delineations by MNRF and wetland boundary staking completed by the MNRF and consultants in 2009, 2012 and 2016.

In February 2019, the City received:

- 1:10,000 mapping depicting external wetland polygon boundaries and internal wetland community boundaries;
- Wetland vegetation community descriptions;
- Significant species (Threatened or Endangered; Provincially, Regionally, Locally Significant of Uncommon);
- Checklists of fish records, vascular plants, fauna, and birds; and
- Detailed wildlife observations.

In October 2019, on behalf of Bramwest, Savanta submitted a boundary update on Wetland 42. MNRF approved the boundary update in December 2020. The updated mapping of Wetland 42 has been depicted in Figure T1, Appendix D rather than the current mapping available on LIO as it is more up-to-date.

In May 2020, Savanta prepared a wetland evaluation update and boundary update submission on behalf of the Heritage Heights Landowner Group. The submission considered wetland units 14, 22, 27, 30, 31, 32 and 44 of the Huttonville Creek & Area Wetland Complex shown on Figure T1, Appendix D. The wetlands were pre-staked in September 2019 by an OWES trained Botanist (J. Leslie). The boundaries of these wetlands were surveyed on October 3, 11 or 23, 2019, in the field with representatives of CVC (C. Wilson and D. DiBerto) and the City of Brampton (S. Kassaris). The wetland evaluation update was submitted to MNRF for their approval in June 2020. A technical response was received March 2021 from MNRF indicating some wetland boundary updates had been accepted. MNRF provided updated mapping in relation to these wetlands in March 12, 2021. This mapping has been depicted in Figure T1, Appendix D. The review of these wetlands is ongoing and the wetland mapping will be updated as needed throughout the completion of the HHSWS based on further MNRF consultation.

Wetland 28 located on the Mount Pleasant Heights lands was staked in 2016 with MNRF, the City and CVC on site. However, the landowners delineation and the MNRF delineation do not match. This discrepancy is being investigated by the landowner. This wetland unit mapping will be updated as needed throughout the completion of the HHSWS.

Ontario Breeding Bird Atlas

The Study Area falls within atlas squares 17NJ93 (102 species recorded by OBBA) and 17NJ94 (106 species recorded by OBBA). All of the Ontario Breeding Bird Atlas records associated with these squares were acquired from the Ontario Breeding Bird Atlas website (http://www.birdsontario.org/atlas/datasummaries.jsp) and have been reproduced for convenience in Table 1, Appendix C. This represents all of the breeding bird observations collected between 2001 and 2005.

Of the breeding bird species documented from these two 10 x 10 km atlas squares, 12 are designated as 'Species at Risk'; i.e. "Special Concern", "Threatened", or "Endangered" in Ontario (NHIC 2020), and three (3) are listed as an S1-S3 species in Ontario, as follows:

- Species listed as Threatened or Endangered on the SARO list:
    - Barn Swallow *(Hirunda rustica)* – Threatened Species in Ontario;
    - Bank Swallow (*Riparia riparia*) – Threatened Species in Ontario;
    - Eastern Whip-poor-will (*Caprimulgus vociferus)* – Threatened Species in Ontario;
    - Chimney Swift *(Chaetura pelagica)* – Threatened Species in Ontario;
    - Bobolink – Threatened in Ontario; and,
    - Eastern Meadowlark – Threatened in Ontario.
- Species of Conservation Concern (i.e., listed as Special Concern on the SARO list, or identified as an S1-S3 species):
    - Red-headed Woodpecker *(Melanerpes erythrocephalus)* – Special Concern in Ontario;
    - Common Nighthawk *(Chordeiles minor)* – Special Concern in Ontario;
    - Eastern Wood-pewee – Special Concern in Ontario;
    - Wood Thrush (Hylocichla mustelina) – Special Concern in Ontario;
    - Grasshopper Sparrow (*Ammodramus savannarum*) – Special Concern in Ontario; and,
    - Purple Martin (*Progne subis*) – Listed as S3S4B in Ontario.

The six (6) species listed as "Threatened" in Ontario are listed as "Threatened" at the federal level as well. Of the five (5) species listed as "Special Concern" in Ontario, one (1) is listed as "Endangered" federally, one (1) is listed as "Threatened" federally, three (3) are listed as "Special Concern" federally, on the federal level. The one (1) species listed S1-S3 in Ontario is listed as SAR on the federal level.

Barn Swallow was breeding in both atlas squares. The species was recorded on five point counts (representing 11.3% of all point counts) in atlas square 17NJ93, and six point counts in atlas square 17NJ93 (representing 24% of all point counts).

Bank Swallow was recorded in both atlas squares, where the highest breeding evidence observed was "Confirmed" breeding evidence. Adults were observed entering and leaving a nest site, indicating an occupied nest, in 17NJ94. Occupied nests with young were observed in 17NJ93.

The **Eastern Whip-poor-will** was only recorded in atlas square 17NJ93, and was "Confirmed" as breeding. Adults were documented leaving or entering a nest site in circumstances indicating an occupied nest.

The **Chimney Swift** was recorded from both atlas squares. In atlas square 17NJ93, it had "Probable" breeding evidence based on the species observed visiting a probable nest site. Chimney Swift was also documented on two point counts in 17NJ93 (representing 4.55% of point counts conducted in the square). In atlas square 17NJ94, Chimney Swift was simply observed from suitable nesting habitat in the breeding season, or "Possible" breeding evidence. It was not recorded on any point counts.

Bobolink was recorded nesting successfully in both atlas squares, and nests with young were seen or heard. How many individuals were recorded from the immediate study area is uncertain. The species was recorded at 4 point counts (representing 9.09% of all point counts) in atlas square 17NJ93, and 7 point counts in atlas square 17NJ94 (representing 28% of all point counts). Since Bobolinks commonly breed in actively farmed hayfields, which are sometimes rotated to other crops, acquiring exact breeding location information during atlas surveys was considered to be of marginal value. The field survey data collected as part of this subwatershed study is more recent and more precise than that of Ontario Breeding Bird Atlas.

Eastern Meadowlark was confirmed to be breeding in both atlas squares. The species was recorded on seven point counts in atlas square 17NJ93 (representing 15.9% of all point counts), and six point counts in atlas square 17NJ93 (representing 24% of all point counts).

Red-headed Woodpecker was historically present (2001 or 2002, OBBA) in a woodlot within the Study Area (ELC polygon 155-2, Figure T2). Targeted searches of this woodlot were conducted in 2008 by Savanta Inc., which produced no evidence that the species was still present. The Red-headed Woodpecker record was investigated during the preparation of the North West Brampton Environmental Open Space Study (Dougan & Associates 2005). In addition, Bill McIlveen, the coordinator responsible for the Ontario Breeding Bird Atlas square associated with the property, was consulted specifically to determine the presence of Red-headed Woodpecker. There is no recent evidence that this species is currently present in Heritage Heights. According to Mr. Ross Evans, (bird atlasser) this species nested successfully (i.e. nest with young seen or heard) in a woodlot just west of the Mount Pleasant subwatershed boundary in 2001. One of the adult birds was apparently hit by a car and the species has not been seen since. Mr. Evans was not aware of any other records of the species in his atlas square (R. Evans, pers. comm., 2007).

Common Nighthawk was documented from both atlas squares, but the highest breeding evidence recorded was of breeding calls heard, or “Possible” breeding evidence. Since this species was not documented as being on territory (i.e., heard on at least two occasions from the same general location) the birds heard were likely only foraging in the square.

Eastern Wood-pewee was recorded in both atlas squares, where the highest breeding evidence recorded was of presumed territory, or “Probable” breeding evidence in 17NJ93. Agitated behaviour or alarm calls, also considered “Probable” breeding evidence was observed in 17NJ94. An adult must be observed or heard singing in suitable nesting habitat on two occasions two weeks apart.

Wood Thrush was recorded in both atlas squares, where fledged young were observed in both squares, considered “Confirmed” breeding evidence.

Grasshopper Sparrow was recorded in atlas square 17NJ94, where the highest breeding evidence recorded was of presumed territory, or “Probable” breeding evidence based on territorial behaviour or alarm calls observed. This species was observed at 76% of point count stations within atlas square 17NJ94.

Purple Martin was only documented in the 17NJ93 atlas square, where the highest breeding evidence recorded was of occupied nests with young, or “Confirmed” breeding evidence.

Dougan and Associates

Portions of the northeast portion of the Study Area were surveyed for wildlife and vegetation resources by Dougan and Associates (Dougan) from 2005-2007 as part of the Huttonville and Fletcher’s Creeks Subwatershed Study (HFSWS). Surveys included Ecological Land Classification, breeding bird surveys, calling amphibian surveys, pond-breeding salamander surveys, and incidental wildlife observations.

Ages Consultants Ltd

Ecological inventories were completed by Ages Consultants Ltd. in 2009 for the Osmington Inc. property (polygon 108 on Figure T1) located west of Mississauga Road and north of Bovaird Drive, now the Mount Pleasant Heights lands. Terrestrial surveys included a vegetation community assessment, hedgerow study, breeding owl survey, breeding bird survey, amphibian survey, reptile survey, butterfly and odonata survey and winter and early spring wildlife observations.

Credit Valley Conservation

Credit Valley Conservation provided digital GIS data for use in this Subwatershed Study and the accompanying Landscape Scale Analysis Update. The GIS data include boundaries for land designations, including the Oak Ridges Moraine, Ontario Greenbelt, Niagara Escarpment Plan, and Environmentally Sensitive Areas. Data provided by CVC also included contour mapping, crest of slope, CVC generic regulated areas, lakes and ponds, rivers and streams, wetlands, potential locations of old growth forest, ELC communities (to Community Series), fish communities, and soils mapping.

4.4.3 Methods

The terrestrial characterization includes data collected between 2005 and 2012, as well as data collected from 2017 to 2019 within participating lands. The data sources include MNRF (i.e., wetland evaluations and associated assessments) and the landowners' group (i.e., site-specific investigations to validate previous records, support conceptual NHS design, and as input to Environmental Implementation Report (EIR) studies).

The scope of Subwatershed terrestrial studies included seasonal observations of wildlife, botanical surveys (spring, summer, and late summer/fall as appropriate), and Ecological Land Classification. The terrestrial observations form a baseline of data for the Study Area. It is intended that a future monitoring approach for the terrestrial ecosystem be formulated based on the findings of this characterization report and conclusions from the Phase 2 Impact Assessments.

The 2017 scope of work was updated and informed through a meeting in March 2017 with CVC, as well as in consultation with the City and MNRF. The updated 2017 scope of work focused on adequacy of the current subwatershed data and analysis going forward, to support this 'restart' and completion of the Subwatershed Study. Reviewers of the HHSWS Phase 1 identified some potential gaps which have been addressed by the 2017 and 2018 surveys. Also, in the intervening timeline since project inception in 2011, a number of updated policies, guidelines and practices have arisen in the industry. These were also addressed in the 2017 and 2018 scope of work.

Vegetation Resources

All accessible (i.e. where landowner access permission was granted) natural and cultural communities located in the Study Area were surveyed by Savanta during 2010-2012 and 2017 field seasons. Part of northeast portion of the Study Area was addressed in the HFSWS including vegetation mapping performed by Dougan in 2006. Ecological inventories, including a vegetation assessment, were also completed by Ages Consultants Ltd in 2009 for the Osmington Inc. property (Figure T1 polygon #108). In 2012, Savanta revisited all vegetation communities mapped by Dougan and Ages Consulting (where landowner permission to access was granted) to confirm and, where necessary, update vegetation classification. A summary of dates of field visits, by Savanta, Dougan and Ages Consultants, is presented in **Table 4.4.2**,

Table 4.4.2. Summary of Survey Dates - Vegetation

Date	Polygons Visited	Purpose	Staff
2006 Survey Dates			
May 3 and 5, 2006	136-1 to 136-3, 137,128-1 to 128-4, 121-2, 116-7 to 116-10	Botanical Surveys	C. Cecile
June 3 and 7, 2006	136-1 to 136-3, 137, 128-1 to 128-4, 121-2, 116-7 to 116-10, 116-2 to 116-5, 109-1, 114-1 to 114-4, 140-2 to 140-5	Botanical Surveys	C. Cecile
July 7, 2006	108-1 to 108-7 and 126-4	Botanical Surveys	C. Cecile
September 13, 2006	137	Vegetation Mapping, ELC Classification, Botanical Surveys	B. Brinker, C. Cecile
September 13, 2006	128-1 and 128-2, 116-2 to 116-10	Vegetation Mapping, ELC Classification, Botanical Surveys	M. Black, G. Buck
September 15, 2006	128-3 and 128-4, 121-2	Vegetation Mapping, ELC Classification, Botanical Surveys	M. Black, G. Buck
2009 Survey Dates			
May 13, July 9, and October 7, 2009	108	Botanical Survey and Ecological Land Classification	Ages Consultants Ltd.
June 12, 2009	108	Butternut Survey and Hedgerow Assessment	Ages Consultants Ltd.
2010 Survey Dates			
April 23, 2010	210-5; 210-3; 210-1; 210-8; 210-7; 209-3; 209-8; 210-4; 211-5; 211-10	ELC and plant inventories	C. Zoladeski
May 5, 2010	155-3; 155-2; 155-1, 151; 210-2; 210-4; 210-6; 209-7; 209-2; 209-6; 209-5	ELC and plant inventories	C. Zoladeski
June 7, 2010	188-4; 188-2; 188-1; 191-2; 188-2; 188-3; 191-1; 191-3; 191-4	ELC and plant inventories	C. Zoladeski
June 10, 2010	148; 147; 145; 211-7; 211-6; 211-8; 211-5; 211-10; 211-9; 211-11; 211-9	ELC and plant inventories	C. Zoladeski
June 19, 2010	167-5; 168-3; 167-1; 167-2, 167-3; 167-4; 168-4; 168-3; 211-2; 211-12; 211-4; 211-5; 215-6; 155-3; 155-2	ELC and plant inventories on Laidlaw property	G. Buckton
July 27, 2010	109; 108-12; 108-11; 108-10; 108-17; 108-16; 96-3; 96-2; 96-1; 96-5; 96-4; 96-3; 93-1; 93-4; 93-2	ELC and plant inventories	C. Zoladeski
August 25, 2010	144-1; 144-2; 142; 141; 215-5; 215-1; 215-3; 215-2; 215-3;	ELC and plant inventories	C. Zoladeski

Date	Polygons Visited	Purpose	Staff
	215-4; 218-4; 218-1; 218-2; 218-3		
2011 Survey Dates			
May 27, 2011	108-4; 108-3; 108-5; 108-7; 108-1; 108-2; 108-6; 108-16; 108-9; 108-8; 209-3; 126; 104; 106; 107; 210-2	Spring botany survey	C. Zoladeski
September 28, 2011	85-2; 85-1; 99-7; 99-2; 99-1; 99-10; 99-3; 99-6; 99-4; 99-8; 99-9; 99-5; 96-6	ELC and plant inventories	C. Zoladeski
September 29, 2011	118; 170-1; 170-2; 170-5; 170-3; 170-6; 180-5; 170-4; 180-3; 180-1; 180-4; 180-2	ELC and plant inventories	C. Zoladeski
2012 Survey Dates			
May 23, 2012	119-2; 119-3; 119-4; 119-1; 119-7; 119-5; 119-6; 118	Update of units at Heritage and CN tracks; spring botany	C. Zoladeski
July 11, 2012	124; 129, 127-1; 114-1; 114-2; 114-3; 114-4; 86-3; 86-1; 86-2; 231; 89-2; 89-3; 89-4; 89-1; 224	Confirm and, where necessary, update ELC performed by Dougan and Associates 2005-2007	C. Zoladeski
July 12, 2012	116-1; 116-3; 116-4; 116-5; 116-6; 116-8; 116-10; 116-9; 116-7; 110-1; 110-2; 112-1; 119-3	Confirm and, where necessary, update ELC performed by Dougan and Associated 2005-2007	C. Zoladeski
July 19, 2012	123-1; 123-2; 120-1; 120-2; 120-3; 120-4; 112-2	Confirm and, where necessary, update ELC performed by Dougan and Associated 2005-2007	C. Zoladeski
July 25, 2012	168-5; 120-3; 119-6; 168-1; 168-2	Confirm and, where necessary, update ELC performed by Dougan and Associated 2005-2007	C. Zoladeski
August 8, 2012	120-1; 160-1; 160-2; 160-3; 161-4; 162; 161-1; 161-2; 161-3; 184-1; 184-2; 186-1; 186-2; 187-1; 187-2	ELC and plant inventories on newly accessible lands in Study Area.	C. Zoladeski
2017 Survey Dates			
May 31, 2017	NE-1-HR; NE-4-MAM; NE-3-FOD; NE-5-CUM; NE-6-CUT	ELC and plant inventories on newly accessible lands in Study Area.	J. Leslie
June 1, 2017	NE-8-CUW; NE-10-FOD7; SE-1-CUM; NE-9-MAM; NE-12-MAM; SE-2-FOD7; SE-5-CUM; SE-4-CUM; NE-11-CUW; SE-3-MAM	ELC and plant inventories on newly accessible lands in Study Area.	J. Leslie
June 2, 2017	NW-7-FOD; NW-1-CUW; NW-7-FOD; NW-6-FOD; NW-2-FOD; NW-	ELC and plant inventories on newly accessible lands in Study Area.	J. Leslie

Date	Polygons Visited	Purpose	Staff
	3-FOD; NW-5-FOD; SW-2-SWD; SW-1-FOD		
July 17, 2017	SW-4-FOM2; SW-7-SAF; SW-5-CUP1; SW-6-CUW; SW-8-CUW; SW-9-FOD5	ELC and plant inventories on newly accessible lands in Study Area.	J. Leslie
July 18, 2017	SW-3-MAM2/CUM	ELC and plant inventories on newly accessible lands in Study Area.	J. Leslie
August 14, 2017	SE-7-MAM; SW-11-SWD; SE-1-CUM; SE-5-CUM; SW-10-PAS; SE-3-MAM; SW-2-SWD; SW-1-FOD	ELC and plant inventories on newly accessible lands in Study Area.	J. Leslie
August 15, 2017	SE-4-CUM	ELC and plant inventories on newly accessible lands in Study Area.	J. Leslie
August 17, 2017	NE-4-MAM; NE-3-FOD; NE-5-CUM; NE-8-CUW; NE-6-CUT; NE-10-FOD7; NE-pond; NE-9-MAM; NE-11-CUW	ELC and plant inventories on newly accessible lands in Study Area.	J. Leslie
August 23, 2017	NW-9-CUP3; NW-10-CUP1; NW-11-CUM1; NW-7-FOD; NW-7-FOD	ELC and plant inventories on newly accessible lands in Study Area.	J. Leslie
August 24, 2017	NW-80-MAM	ELC and plant inventories on newly accessible lands in Study Area.	J. Leslie
October 10, 2017	SW-4-FOM2; SW-7-SAF; SW-5-CUP1; SW-6-CUW; SW-8-CUW; SW-9-FOD5; SW-11-SWD; NW-9-CUP3; NW-80-MAM; NW-10-CUP1; NW-11-CUM1; NW-7-FOD; NW-12-MAM/SWD; NW-7-FOD; SW-2-SWD; SW-1-FOD	ELC and plant inventories on newly accessible lands in Study Area.	J. Leslie
October 13, 2017	NE-4-MAM; NE-3-FOD; NE-5-CUM; SE-7-MAM; SE-1-CUM	ELC and plant inventories on newly accessible lands in Study Area.	J. Leslie

Savanta categorized, mapped, and inventoried both natural and cultural vegetation communities within the Subject Lands using the methodology of the Ecological Land Classification for Southern Ontario: First Approximation and Its Application (Lee et al. 1998). Observations included disturbance, notes on soil type, community structure, community composition and moisture regime. Where vegetation features significantly differed from those listed for vegetation types in Lee et al. (1998), temporary labels and descriptors were provided.

A botanical inventory was completed during ELC surveys and can be found in Table 1, Appendix B. The provincial status of all plant species and vegetation communities is based on NHIC S-Ranks (2020). Latin and colloquial names of plant species follow Newmaster et al. (1998). ELC mapping (Figure T2, Appendix D) is provided on an ortho-rectified aerial imagery base from First Base Solutions (2019). Rarity status was confirmed using the following sources:

CVC Watershed Status and Region of Peel:

Credit Valley Conservation, 2002. Plants of the Credit River Watershed. Checklist on CVC website.

Rankings of vascular plant species are based primarily on the checklist of Credit Valley Conservation (2002), which is an official annotated list of flora in the Region of Peel and the Credit Valley Conservation (CVC) area of jurisdiction. A secondary source for rankings of species within Site District 6E-7 and Greater

Toronto Area (GTA) is Varga (2000), which was not utilized as this list has since been updated, remains in draft format and may not include the CVC area.

Provincial Status:

Species List for Provincially-Tracked Vascular Plants. Ontario Natural Heritage Information Centre Home Page and updates.
http://nhic.mnr.gov.on.ca/MNR/nhic/species/listout_track.cfm?el=p&alpha=a

Natural Heritage Resources of Ontario: Rare Vascular Plants. Third Edition. Natural Heritage Information Centre, Ontario Ministry of Natural Resources, Peterborough, Ontario (Oldham, 1999).

Species at Risk in Ontario (SARO) List. List updated September 29, 2010 by Ontario Ministry of Natural Resources Species at Risk Unit. (OMNR 2010)
http://www.mnr.gov.on.ca/en/Business/Species/2ColumnSubPage/276722.html

Federal Status:

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2010. *Canadian Wildlife Species at Risk. Committee on the Status of Endangered Wildlife in Canada, October 2010*. 115 pp. http://www.cosewic.gc.ca/eng/sct0/rpt/rpt_csar_e.cfm

The identification of potentially sensitive plant species is based on assignment of a coefficient of conservatism value (CC) to each native species in southern Ontario (Oldham et al. 1995). The value of CC, ranging from 0 (low) to 10 (high), is based on a species' tolerance of disturbance and fidelity to a specific habitat. Species with a CC value of 9 or 10 generally exhibit a high degree of fidelity to a narrow range of habitat parameters.

Potential sensitivity of natural heritage features, ecosystem attributes, and communities was evaluated through an assessment of vegetation communities (age, habitat quality, degree of disturbance, weediness) and presence of sensitive species (plants with a high CC value, area-sensitive bird species).

Wetland Evaluations

The City provided MNRF with wetland mapping from 2012 Phase 1 HHSWS for MNRF's 2018 PSW update.

The MNRF is responsible for the evaluation of wetlands at a landscape scale in Ontario. The Ontario Wetland Evaluation System (OWES), defines wetlands as:

> *"Lands that are seasonally or permanently flooded by shallow water as well as lands where the water table is close to the surface; in either case, the presence of abundant water has caused the formation of hydric soils and has favoured the dominance of either hydrophytic or water-tolerant plants. (MNR, 1994) "*

Under OWES, wetlands within 750 m of each and within the same watershed are complexed.

OWES evaluates wetlands based on four components: Biological, Social, Hydrological, and Special Features. These four components are further subdivided into subcomponents, attributes, and sub-attributes. Relevant wetland information is ascribed points according to predefined numerical values in the OWES manual. Thus, relevant wetland information is evaluated and scored on a numerical basis, allowing for a final relative score for each of the major components and for a final total score. The maximum number of points a wetland can receive in any one of the four main components is 250, and an individual wetland can score up to 1000 points. An evaluated wetland is a Significant Wetland (PSW) if:

- The wetland achieves a score of 200 points in either the Biological component or the Special Features component, or
- The wetland achieves a total score of 600 points or more.

The MNRF sets minimum size criteria for wetlands and wetland complexes to be evaluated under OWES. In general, wetlands or wetland complexes smaller than 2 ha in total are not evaluated (MNR, 1994). However, in recognition of the relative rarity of wetlands on the Southern Ontario landscape and the value of smaller wetlands to local wildlife and hydrology, wetlands below the minimum size criteria can be evaluated granted that a rationale is provided by the wetland evaluator or a governing agency (MNR, 1994).

Supplementary criteria developed by the MNRF Aurora District Office were applied by MNRF as further rationale for the inclusion of these small wetlands, 2 hectares or less in size, in the Wetland Complex. The MNRF Aurora District Office's supplementary criteria list for the Huttonville Creek and Area Wetland Complex to justify the complexing of wetland units 2 hectares or less is intended to identify important ecological benefit. According to this list, the inclusion of a wetland in the complex is justified if it fulfils one or more of the following criteria. It should be noted that this list has been created and used only by Aurora District staff; it is not a list that is understood to be in use by other Districts and it has not been incorporated in the most recent OWES Manual (MNRF 2014). The criteria are as follows:

Two hectares or less:

1) *"Support wetland types not well represented elsewhere within the Wetland Complex;*
2) *Sustain significant species/communities (i.e., conservation priority bird species or, reptile/amphibian species of concern, or rare or uncommon species/communities in Ecodistrict 6E7, Ecoregion 6E, provincial or national);*
3) *Part of a wetland >2 ha in size that is fragmented by a road;*
4) *Support breeding amphibians;*
5) *Function as migratory waterfowl stopovers, summer feeding areas or waterfowl breeding areas;*
6) *Support native fish;*
7) *Support turtles;*
8) *Are headwater areas for watercourses and contribute spring base flows or serve as groundwater seepage areas that contribute base flow;*
9) *Are hydrologically connected to other wetlands;*
10) *Provide intervening wetland habitat between wetlands 2ha or greater in size that are within the complex and the adjacent Churchville-Norval Wetland Complex to the south; and,*
11) *Occur along corridors."*

The MNRF Aurora District Office applied each of these criteria to wetlands 2 hectares or less in size and 0.5 ha or less to justify their inclusion in the Wetland Complex.

According to OWES, wetland evaluations are considered 'open files' (MNRF 2014); wetland evaluation data is reflective of the site conditions at the time of the evaluation and may be subsequently updated as new information becomes available.

Wildlife Resources

Wildlife surveys were conducted in 2008, 2009, 2010, 2011, 2012, 2017, and 2018 to coincide with periods considered optimal for sampling calling frogs and toads (BSC, 2009) and breeding birds (OBBA, 2001; FBMP, 2008). Part of the northeast portion of the Study Area was surveyed for wildlife resources by Dougan and Associates from 2005-2007 as part of the HFSWS. In 2017 and 2018, Savanta performed surveys in these areas where additional effort was warranted (e.g. confirm presence / absence of rare species, or provide complete seasonal data), as well as additional surveys on newly accessible lands. Details of the various wildlife survey visits, by Savanta, Dougan and Associates, and Ages Consultants, are summarized below in **Table 4.4.3**.

Table 4.4.3. Summary of Survey Dates – Wildlife Resources

Date	Staff	Purpose
2006 Survey Dates		
April 28, May 3 and 5, 2006	Dougan and Associates	Early spring bird area searches
June 1, 6, 8, 12, 13, 15, 16, 24, 2006	Dougan and Associates	Breeding bird area searches
April 18 and 25; May 24 and 25; June 30, 2006	Dougan and Associates	Breeding amphibian area searches
2008 Survey Dates		
March 2, 6, 7, 2008	S. Phelps	Winter Wildlife surveys conducted along selected transects 12-24 hours after fresh snowfall.
April 13 & 15, May 14 & 24, June 13, 22 & 28, July 18, 2008	N. Litwin	Breeding bird surveys, area search and point counts according to the Ontario Breeding Bird Atlas (OBBA) protocols.
April - June 2008	N. Litwin	Early bird and breeding bird surveys, area search and point counts according to the Ontario Breeding Bird Atlas (OBBA) protocols.
April 13, May 14, June 13, September 20, October 24, November 6 & 23, 2008	N. Litwin	Waterfowl surveys, assessed waterfowl breeding function and stopover habitat in open water features.
April 17 & 18, May 8 & 9, June 12, 2008.	H. Whitehouse	Amphibian call count survey using Bird Studies Canada Marsh Monitoring Program protocol.
April 16, May 5 & 7, June 13, 2008	H. Whitehouse	Amphibian call count survey using Bird Studies Canada Marsh Monitoring Program protocol.
2009 Survey Dates		
April 7, 2009	S. Phelps	Winter Wildlife surveys conducted along selected transects 12-24 hours after fresh snowfall.
April through June 2009	N. Litwin	Breeding bird surveys and waterfowl surveys according to the Ontario Breeding Bird Atlas (OBBA) protocols.
April 24 & 29, May 21 & 22, June 19 & 23, 2009	H. Davis H. Whitehouse	Amphibian call count survey using Bird Studies Canada Marsh Monitoring Program protocol.
April 17, 18 & 23, May 19 & 27, June 18, 2009	H. Davis H. Whitehouse	Amphibian call count survey using Bird Studies Canada Marsh Monitoring Program protocol.
March 27, 2009	Ages Consultants Ltd.	Wildlife habitat assessment, winter and early spring wildlife survey

Date	Staff	Purpose
April 8, 2009	Ages Consultants Ltd.	Breeding Owl Survey
June 1 and 26, 2009	Ages Consultants Ltd.	Breeding Bird Survey
April 13, May 6, June 16, 2009	Ages Consultants Ltd.	Amphibian Call Count Survey
July 28, 2009	Ages Consultants Ltd.	Reptile Survey and Butterfly and Odonata Survey
2010 Survey Dates		
March 5 & 6, April 14, May 30, June 11, 12 & 26, July 3, 2010	D. Mcrae	Early Bird and Breeding Bird surveys according to the Ontario Breeding Bird Atlas (OBBA) protocols.
April 14, May 30, June 10, 2010	D. Mcrae H. Whitehouse	Amphibian call count survey using Bird Studies Canada Marsh Monitoring Program protocol.
2011 Survey Dates		
February 8 & 9, March 24 & 25, 2011	D. Mcrae G. Buckton	Winter Wildlife surveys conducted along selected transects 12-24 hours after fresh snowfall.
June 21, 22 & 23, 2011	D. Mcrae	Bobolink and Eastern Meadowlark Breeding Surveys, targeted searches within fields and grasslands.
July 14 & 15, 2011	G. Buckton	Headwater Assessment using CVC/Toronto Region and Conservation Authority's (TRCA) *Interim Guidelines for the "Evaluation, Classification, and Management of Headwater Drainage Features*" (2011)
2012 Survey Dates		
Mar 22, Apr 15 & 18, May 2, 4 & 8, June 18, 27 & 31, 2012	H. Davis H. Whitehouse G. Buckton M. Adamson	Amphibian call count survey using Bird Studies Canada Marsh Monitoring Program protocol.
June 18-21, July 5-7, 2012	L. Foerster	Breeding Bird surveys according to the Ontario Breeding Bird Atlas (OBBA) protocols; and Bobolink and Eastern Meadowlark Breeding Surveys, targeted searches within fields and grasslands where these species were observed in 2011.
June 20, 2012	R. Hubbard G. Buckton	Headwater Assessment using CVC/Toronto Region and Conservation Authority's (TRCA) *Interim Guidelines for the "Evaluation, Classification, and Management of Headwater Drainage Features*" (2011)
September 28, October 4, 2012	M. Adamson	Autumn basking reptile surveys (pond surveys for turtles and opportunistic wildlife observations)
2017 Survey Dates		
April 10, 2017	J. Leslie S. Male	Amphibian egg mass surveys; Amphibian call count survey using Bird Studies Canada Marsh Monitoring Program protocol; Turtle Basking Survey using MNRF Survey Protocol for Blanding's Turtle (2016)
April 13, 2017	L. Williamson C. Zoladeski, R. Lee E. Lee	Amphibian call count survey using Bird Studies Canada Marsh Monitoring Program protocol.
April 26, 2017	J. Leslie	Amphibian egg mass surveys
April 27, 2017	R. Lee M. Green	Snake Visual Encounter Survey using OMNRF Survey Protocol for Ontario's Species at Risk Snakes (2016); Turtle Basking Survey using MNRF Survey Protocol for Blanding's Turtle (2016)

Date	Staff	Purpose
April 28, 2017	E. Lee L. Williamson	Snake Visual Encounter Survey using OMNRF Survey Protocol for Ontario's Species at Risk Snakes (2016); Turtle Basking Survey using MNRF Survey Protocol for Blanding's Turtle (2016)
May 3, 2017	J. Leslie P. Burke	Amphibian egg mass surveys
May 10, 2017	E. Lee R. Lee	Snake Visual Encounter Survey using OMNRF Survey Protocol for Ontario's Species at Risk Snakes (2016)
May 12, 2017	E. Lee R. Lee	Snake Visual Encounter Survey using OMNRF Survey Protocol for Ontario's Species at Risk Snakes (2016); Turtle Basking Survey using MNRF Survey Protocol for Blanding's Turtle (2016)
May 16, 2017	L. Williamson C. Zoladeski R. Lee E. Lee	Amphibian call count survey using Bird Studies Canada Marsh Monitoring Program protocol.
May 17, 2017	L. Williamson E. Lee	Turtle Basking Survey using MNRF Survey Protocol for Blanding's Turtle (2016)
May 18, 2017	E. Lee R. Lee	Snake Visual Encounter Survey using OMNRF Survey Protocol for Ontario's Species at Risk Snakes (2016); Turtle Basking Survey using MNRF Survey Protocol for Blanding's Turtle (2016)
June 8, 2017	S. Male	Breeding Bird surveys according to the Ontario Breeding Bird Atlas (OBBA) protocols
June 14, 2017	S. Male	Breeding Bird surveys according to the Ontario Breeding Bird Atlas (OBBA) protocols
June 28, 2017	L. Williamson C. Zoladeski R. Lee E. Lee S. Male	Amphibian call count survey using Bird Studies Canada Marsh Monitoring Program protocol; Breeding Bird surveys according to the Ontario Breeding Bird Atlas (OBBA) protocols
June 29, 2017	S. Male	Breeding Bird surveys according to the Ontario Breeding Bird Atlas (OBBA) protocols
July 4, 2017	L. Williamson M. Green R. Lee E. Lee	Deployment of acoustic bat monitors (SM3/SM4)
July 16, 2017	L. Williamson M. Green R. Lee E. Lee	Deployment of acoustic bat monitors (SM3/SM4)
2018 Survey Dates		
May 2, 2018	L. Williamson	Amphibian call count survey using Bird Studies Canada Marsh Monitoring Program protocol.
May 10, 2018	R. Lee L. Williamson	Amphibian egg mass surveys; Turtle Basking Survey using MNRF Survey Protocol for Blanding's Turtle (2016)
May 15, 2018	L. Williamson	Amphibian call count survey using Bird Studies Canada Marsh Monitoring Program protocol.
May 22, 2018	L. Williamson R. Lee	Snake Visual Encounter Survey using OMNRF Survey Protocol for Ontario's Species at Risk Snakes (2016); Turtle Basking Survey using MNRF Survey Protocol for Blanding's Turtle (2016)
May 24, 2018	L. Williamson O. Park R. Lee	Snake Visual Encounter Survey using OMNRF Survey Protocol for Ontario's Species at Risk Snakes (2016)
May 25, 2018	L. Williamson R. Lee	Snake Visual Encounter Survey using OMNRF Survey Protocol for Ontario's Species at Risk Snakes (2016); Turtle Basking Survey using MNRF Survey Protocol for Blanding's Turtle (2016)
June 12, 2018	L. Williamson	Amphibian call count survey using Bird Studies Canada Marsh Monitoring Program protocol.

Date	Staff	Purpose
June 15, 2018	L. Williamson M. Green	Turtle Nesting Survey
June 18, 2018	L. Williamson	Amphibian call count survey using Bird Studies Canada Marsh Monitoring Program protocol.

Amphibian surveys

Breeding Amphibian call count surveys - Amphibian breeding call surveys were conducted within the Study Area over a period of six years: 2008, 2009, 2010, 2012, 2017 and 2018. The 2012 surveys included additional stations from those visited 2008-2010 to provide thorough survey effort across the Study Area. Two years of data were sought for each survey station. Surveys were designed to detect calling frogs and toads and included road-side call count stations and walk-in stations (where access was granted by landowners). Surveys in 2017 and 2018 collected one year of data and targeted newly accessible lands within the Study Area.

Locations were determined through inspection of orthophotography, vegetation communities, and ground observation including where tributaries crossed roads. Surveys were conducted at night, in accordance with Environment Canada's Marsh Monitoring Program (2004) protocol. All locations were surveyed three times (early spring, mid-season, late spring) during optimal weather conditions (low wind levels, no heavy rain). Where noise from plane, train, or road traffic was present, monitoring did not begin until there was a quiet period. All calls heard within the Study Area were recorded as well as any incidental call observations on adjacent lands. The provincial and global status of species identified within the Study Area, were referenced in the NHIC, 2012 database.

Amphibian call survey locations and survey dates are listed in Table 4.4.3, above. Survey stations and results are depicted on Figures T3 and T4 (Appendix D), respectively.

Amphibian road-crossing surveys - Amphibian road-crossing surveys were conducted in May and June 2008, and between March and June 2009 where suitable breeding habitat was confirmed or suspected in order to develop a better understanding of amphibian movement patterns across the landscape. The study served to determine if frogs or toads were moving across roads at night during the breeding season, the level of species mortality, and if roads are crossed as part of movement patterns by frogs and toads.

Surveys were conducted at night, just after a rain evening, or during a light rain / mist when roads were still wet. Frogs and toads were typically more active during these weather conditions. Roads were driven slowly (5-10 km/hr) along the perimeter and within the Study Area, to look for frogs or toads on the road pavement or shoulder. Amphibian occurrences were recorded dead or alive, and if possible, the sex, age, and direction they were headed. The amphibians were processed, and then released in the direction they were headed, but placed away from the road for their safety. The provincial and global status of species identified through this study were referenced in the NHIC database (2012).

Specific survey dates are provided in Table 4.4.3. Survey results are shown on Figure T5 (Appendix D).

Amphibian egg-mass survey – An amphibian egg mass survey (EMS) was conducted on April 10, 2017 and May 10, 2018 for pool-breeding salamanders and early spring frogs that rely on woodland habitats (namely Wood Frog and Western Chorus Frog) during daylight hours. EMS was conducted within suitable woodland amphibian breeding habitat (i.e. pools with suitable hydroperiod within woodlands and within 120 m of woodland). Survey effort included walking the perimeter of the vernal pool/wetland while scanning for egg masses and tadpoles. Any submerged sticks or shrubs standing in the water, to which eggs might be attached, were carefully checked with minimal intrusion into the vernal pool / wetland. For each EMS station, the survey was deemed to be completed when a complete check of locations where egg masses or tadpoles had occurred or within a 30-minute allotment, whichever was less.

The number of individuals of each amphibian species was recorded and the life stage was noted (e.g., egg mass, tadpole or adult). Characteristics of the breeding habitat were also noted, including: pool shape, water depth, water temperature, canopy cover, in-feature vegetation, presence of suitable egg attachment sites, and observations of predatory fish. Logs or debris in the vicinity of each pool were also checked for presence of adult salamanders (all items were returned to their original location/position to maintain microhabitat conditions).

Both the Natural Heritage Information Centre (NHIC 2020) database and the Species at Risk in Ontario (SARO) list (Ontario Regulation 230/08) were reviewed to determine the current provincial status for each amphibian species recorded in the Study Area.

Breeding bird surveys

Winter raptor, early, and breeding bird observations - Winter raptor, early, and breeding birds were surveyed in the Study Area over five years 2008–2012, and in 2017. Several means were used: formal point count surveys (methodology in accordance with the Ontario Breeding Bird Atlas (OBBA)) targeted searches for elusive and nocturnal species using recorded song playback, targeted surveys for grassland Species at Risk (2011-2012), and through incidental observations collected in the course of other field work. This approach addressed the main breeding period for most species. Point count station locations for 2008-2012, and 2017 are illustrated on Figure T6 (Appendix D).

Targeted Species at Risk surveys (Bobolink, Eastern Meadowlark and Barn Swallow) - In addition to breeding bird surveys, targeted searches were performed in 2011 and 2012 for several grassland birds that were recently listed as Species at Risk: Bobolink (Dolichonyx oryzivorus), Eastern Meadowlark (Sturnella magna) and Barn Swallow (Hirundo rustica). These three species are listed as Threatened and are addressed by the Endangered Species Act, 2007 and as such, individuals and their habitat receive protection under the Act.

The survey protocol was discussed with and approved by MNR. Suitable weather conditions were essential with the key element being little or no wind. Fieldwork occurred in both the early/mid-morning and late afternoon/ early evening period (between 10:00am and 6:00pm), if displaying activity was apparent. Multiple visits to a site were not conducted unless there was ambiguity regarding the population size or breeding status, in most cases an accurate estimate of the total number of birds present and breeding evidence could be obtained on a single visit. Dates specific to each year are provided in Table 4.4.3

Reptile surveys

Basking Turtle and Snake Visual Encounter surveys were conducted in 2012, 2017 and 2018. Potentially suitable aquatic habitat for turtles (e.g., ponds, open wetlands, and riparian/lacustrine areas) was first identified using aerial photography. Surveys were conducted between 8:00 and 17:00 under sunny conditions with air temperatures between 5°C and 25°C, or alternatively under overcast conditions where air temperatures are between 15°C and 30°C. On days when afternoon air temperature exceeds 25°C surveys were conducted between 8:00 and 10:00. Binoculars were used to scan, from a distance, for thirty minutes, the edges and surface of each water body for basking turtles. If possible, the perimeter of the feature was walked and surveyed, using polarized sunglasses, after scanning with binoculars.

Snake Visual Encounter surveys were conducted during the spring emergence period (April to June), given that the probability of encountering elusive snake species is generally higher during this window. Visual Encounter Survey timing windows and survey conditions were adapted from protocols set forth by the Ministry of Natural Resources and Forestry (MNRF 2016).

Surveys were conducted between 9:00 and 17:00 under sunny conditions with air temperatures between 10°C and 25°C, or alternatively under overcast conditions where air temperatures are between 15°C and 30°C. On days when afternoon air temperature exceeds 25°C surveys were conducted between 8:00 and 12:00 or 17:00 and 20:00.

Survey stations and transects are denoted on Figure T3, Appendix D.

Winter wildlife surveys

Savanta completed winter wildlife field surveys in 2008, 2009 and 2011. Due to poor snow conditions in 2012, winter wildlife surveys could not be completed during that year. Survey dates specific to each year are provided in Table 4.4.3. The purpose of the investigation was to establish presence/absence and relative importance of winter wildlife habitat within the Study Area by recording wildlife tracks, trails, signs, species observations, and other habitat details.

Winter wildlife surveys were conducted along transects, which are depicted in Figure T7 (Appendix D). Transects were placed in areas that were determined to be used by wildlife within the Study Area. Transect locations were determined through inspection of orthophotography, vegetation communities, and ground observation and were distributed across the Study Area to ensure the ecological variability was adequately sampled. Surveys were concentrated along existing access routes, trails, forest edges, hedgerows, and streams, so long as habitat was safely accessible by snowshoes.

Wildlife tracks were recorded within 2-3 meters on either side of each transect, and all other evidence or signs of wildlife (scat, browse, nests, etc.,) were recorded. 'Trails' can be defined as numerous tracks that are difficult to discern from one another, which creates a trail system. In many cases, trails are used by many different wildlife species. The Significant Wildlife Habitat Technical Guide (OMNR 2000) and the RISC (Resources Inventory Standards Committee) species inventory methods manual were used as guidance documents for the survey. The provincial and global status of species identified in the Study Area was referenced on the NHIC (2020) database. Whenever possible, fieldwork was conducted at least 12-24 hours after moderate (less than 15cm accumulation in 24hrs) snowfall. Fieldwork was conducted 24-48 hours after larger snow events (greater than 15cm accumulation in 24hrs).

Bat Acoustic Monitoring

Survey methods were developed based on guidance from MECP, professional experience and MNRF survey guidelines as outlined in "Bats and Bat Habitats: Guidelines for Wind Power Projects" (MNR 2011).

Surveys to detect bat species were carried out in July 2017 (Table 4.4.3) and were completed using Wildlife Acoustics Song Meter SM3BAT/SM4BAT recording devices over a duration of ten consecutive evenings. The methods and results of these surveys are provided herein.

Twelve survey stations were selected based on aerial interpretation, bat habitat assessments, and ELC vegetation community types. A total of five stations were identified on the Subject Lands associated with the woodland communities, as shown on Figure T8, (Appendix D).

Passive acoustic recorders were programmed to begin recording Appendix at sunset and to end recording at sunrise. In addition, the SM3BAT/SM4BAT passive recorder microphones were elevated approximately 2 m above the ground to reduce background noise and echo.

All ultrasonic recordings were filtered to eliminate recordings with high levels of noise or with no bat calls, and then further analyzed using SonoBat's auto-classification tool. Any calls with a positive identification were manually vetted by a wildlife ecologist with training in bat species identification by sonogram. Calls that were not identifiable to species by SonoBat were manually reviewed by a wildlife ecologist with training in bat species identification by sonogram to identify those calls with characteristics of Species at

Risk bats (i.e. calls with frequencies greater than 40kHz). Where recorded, these calls are classified as Unknown Myotis calls in accordance with MECP guidance.

Both the NHIC (2020) database and the SARO list (Ontario Regulation 230/08) were reviewed to determine the current provincial status for each bat species detected.

Incidental wildlife observations

Incidental wildlife observations were recorded during all field surveys. The provincial and global status of species identified in the Study Area were obtained from the NHIC database.

Wildlife database

All wildlife species documented in the Study Area from 2008 to 2018 were entered into a database created for this study.

The database was created primarily to facilitate analysis of results but could also potentially serve as a foundation for additional observations to be added later in the planning process.

Where applicable, the following data categories were entered into the database:

- Polygon number (for Ecological Land Classification only)
- Map ID point
- Species name
- Number of individuals or evidence observed (e.g., tracks, trails)
- Observer
- Observer date
- Comments

Integration

Input was obtained from HHSWS team members to assist in the determination of various features, their functions and policy-related designations. Further interaction and discussion occurred among biologists from MNRF, CVC and Savanta Inc. Discussions with agencies and the HHSWS team contributed to a multi-disciplinary perspective on the relationships between vegetation, soils and hydrology in the Study Area, which is discussed later in this report.

4.4.4 Results

Characterization of Study Area Setting

Pre-settlement Conditions

The original surveyor records (as interpreted by Mersey and Puddister, 2003) indicate that before European settlement in the early 1800's, the Study Area had largely sugar maple deciduous forest cover with beech predominating in some areas; pine was scarce. Other accounts indicate that the Peel Plain contained a hardwood forest of high quality and "a great wealth of species" (Chapman and Putnam 1984). The lowland areas included coniferous communities, *e.g.,* white cedar, and lowland deciduous swamp (including elm) (Mersey and Puddister, 2003). Wetlands are estimated to have occurred in small swales and depressions on the clay soils; larger wetlands occurred in the level clay Etobicoke headwaters immediately north of the study area (Environment Canada, 1983). The most recent aboriginal occupants, the Mississauga's, mainly hunted and fished, clearing only small areas (Department of Planning and Development, 1956).

Minimal European settlement occurred before 1820; by 1821, the Townships of Chinguacousy and Gore (the North West Brampton Study Area is part of Chinguacousy Twp.) had only 230 cleared acres (Pope, 1877). It is possible that some of that cleared area was in or near the Study Area since the portion between Churchville and Alloa was the most densely settled part of the watershed outside of Toronto Township (Department of Planning and Development, 1956).

The rich Peel Plain soils, booming American wheat market, proximity to Port Credit and to Upper Canada's other settlements, and access to the railroads – Grand Trunk and Credit Valley - all coincided to result in an expansion of Peel's cropland to over 50% of the area in 1851, and 65% in 1861. These land improvement figures were among the highest for Ontario counties for the date. Caledon, however, was "beyond the verge of civilization" so the lands below the Escarpment, including the Study Area, would have been even more intensively farmed than those county averages.

By 1877, the Illustrated Historical Atlas of the County of Peel (Pope, 1877) indicates that almost every farm in the area had a small orchard, usually near the farmhouse. Woodlands are not shown, and atlas sketches of the countryside suggest that relatively little woodland remained. This situation is confirmed by the Census of Agriculture. By 1891, Chinguacousy retained only 10% woodland (Department of Planning and Development, 1956).

When the wheat boom ended, the Peel Plain area developed a more mixed crop and livestock type of agriculture with its chief market focused in Toronto. In the early 1900's, the area briefly made a lucrative business in hay and in alfalfa seed (Chapman and Putnam, 1973). By the mid- 1950's, dairy operations dominated the Peel Plain as part of Toronto's milkshed. Wheat, oats and mixed grains remained the largest acreage. Hay and pasture were present. Corn had reached only 2% coverage (Department of Planning and Development, 1956). Today, field crops such as corn and soybeans dominate the landscape, along with some livestock and a few pastures.

It appears that the major drainage works occurred in the general area after World War II. This is supported by drainage expenditure patterns: in Brampton, all municipal drainage expenditures in the period from 1949 to 1979 preceded 1969, in contrast to Caledon where over 90% of the expenditures were after 1969 (Bardecki, 1984). Artificial drainage manipulations may have shifted subwatershed boundaries in the flat headwater areas. Wetlands – primarily swamps - would have become drier and more prone to clearing for farm use as surface drainage features became more defined. Those wetlands remaining would offer a much-reduced level of flow moderation and water quality protection at the landscape scale.

Municipal-wide estimates suggest that the area had minimal pre-settlement wetland cover (estimated at 7.4% of current City of Brampton municipal boundary area) and lost most of this cover (88.8%) before 1967 (Snell, 1987). Chinguacousy Township's woodland extent declined to the 5-6% range by 1911 and has remained in that range to the present. Today the landscape of the Study Area is relatively devoid of woodland, a condition that has persisted for over 100 years.

General Overview of Existing Conditions

The Study Area is close to the transition area between the Great Lakes St. Lawrence (Mixed) Forest Region and the Deciduous Forest Region (also known as the Carolinian Floristic Zone) (Rowe, 1972). No designated ESA's or ANSI's occur within the immediate area. The Region of Peel has identified the Credit River and main Huttonville Creek Valley as Core Areas of their Greenlands System on Schedule 'A' of the Regional Official Plan. (See Schedule A, Appendix D). Additionally, there are Core Areas including Significant Woodlands, Significant Wetlands and Significant Wildlife Habitat throughout the West Huttonville Creek subwatershed. Most woodlands, plantations and wetlands in the Study Area have been identified as Natural Areas and Corridors in the Region's Environmental Data as supplied in GIS format for this study (Figure T9, Appendix D).

Existing cover (natural, cultural and anthropogenic) in the Study Area is summarized on Figure T2, Appendix D according to the *Ecological Land Classification System for Southern Ontario* (Lee et.al.,1998). Forty-eight ELC-based Ecosites/Vegetation Types were identified.

The low amount of forest, wetland and riparian cover favours common wildlife species such as raccoons, skunks and deer, but significantly limits the opportunities for more sensitive habitat specialists such as amphibians and 'forest interior' or other area sensitive songbirds. The relative lack of existing natural cover in the Study Area influences the quality of 'natural services' and functions present.

The amount of cultural lands (e.g., agricultural lands and cultural meadows) currently provides habitat for bird species that favour this type of habitat including SAR grassland bird species (e.g., Eastern Meadowlark, Bobolink and Barn Swallow), along with several open country and early-successional species (e.g., Savannah Sparrow, Field Sparrow and Willow Flycatcher). However, Savanta considers that the provision of adequate, larger blocks of open country habitat in urbanizing portions of a settlement area may not be reasonably achievable, nor may it be an appropriate target. This would also seem to complicate a municipality's ability to achieve other important initiatives under the new PPS (e.g., promoting cost-effective development patterns and standards to minimize land consumption and servicing costs, promoting efficient development and land use patterns).

From a functional perspective, the current landscape, which consists of limited woodland and lack of interior woodland habitat providing limited local and regional benefits to air, water and biodiversity management. The provision of a landscape that contains more functional and resilient natural system would benefit all three areas of function and would also enhance recreational functions.

A review of the disturbance data collected according to ELC criteria during field studies reveals some general patterns throughout the Study Area. Polygon-specific disturbance data was recorded on ELC data cards. Most of the sites had light noise levels that tended to be widespread throughout the polygons, with higher noise levels reported closer to roads. Evidence of deer browsing was reported in most of the treed or shrub polygons, characterized as light but widespread throughout the habitats. Non-native plant species were rated as abundant and widespread in many polygons, and in a smaller proportion of polygons, occasional, but widespread. Most of the forested communities had the invasive alien Garlic Mustard (*Alliaria petiolata*) in varying amounts. Invasive species were rated as dominant and extensive in various cultural units, such as thickets, woodlands and hedgerows. With a few exceptions, there does not appear to be a high amount of recreational use of the natural areas. Localized trails, tracks, or roads were only documented in polygons located along major waterways (e.g., Credit River and tributaries) (e.g., in polygons 209-2, 209-5, 210-4 and 188-2 (Figure T2, Appendix D).

Other more localized disturbance factors documented in habitats within the Study Area included grazing by livestock and occasional selective logging. Grazing was attributed to horses and cattle (e.g., in polygons 168-1 and 155-1).

Vegetation Resources

The Study Area contains a diverse array of vegetation types. The most important and largest forest complex is confined to the Credit River valley and its tributaries. Most other natural and anthropogenic vegetation (i.e., forests, wetlands and meadows) occurs as patches within the dominant agricultural land use matrix of crop fields, hay fields and pastures. Cultural units, such as old-field meadows, thicket and various woodlands are scattered throughout the area and often occur as edge vegetation next to higher quality natural and much less disturbed communities.

Due to the presence of the Credit River system, natural vegetation community diversity is highest (i.e. there are more vegetation community types) in the southern portion of the Study Area. Ecological Land Classification conducted as part of the HHSWS found the Heritage Heights lands are comprised of 6%

forest (FOM, FOC, FOD, CUW), 3% wetlands (SWD, SWC, SWT, MAM, MAS, SAS), 3.7% cultural vegetation (hedgerows, cultural thickets, meadows) and 0.01% ponds (most of which were dug or enlarged for agricultural irrigation purposes). In total, existing natural cover (cultural and natural vegetation types and ponds) covers 12.7% of the Study Area.

The ELC types occurring on the Study Area reflect the most recent surveys conducted by Savanta (2017-2018) and are described in **Error! Reference source not found.** below. Vegetation communities are depicted on Figure T2, Appendix D. One vegetation type, FOD7-4 (Fresh-Moist Black Walnut Lowland Deciduous Forest) is ranked by NHIC as "S2S3", which is intermediate between "S2-Imperiled" and "S3-Vulnerable".

Flora

The botanical inventory provided in Table 1, Appendix B, reflects the most recent survey work completed (i.e. vegetation surveys conducted by Savanta (2010-2012 and 2017-2018) and Ages Consultants (2009)). A cumulative total of 380 plant species were recorded on the Heritage Heights Study Area by Savanta and Ages Consultants.

Of the 380 plant species recorded in the Study Area, 224 are native (59%) and 156 are exotic (41%). Of the 224 native species, 199 or 90% are ranked S5 (Secure – common, widespread and abundant in Ontario) and 20 species or 9% are ranked S4 (Apparently Secure – uncommon, but not rare in Ontario). One species (Butternut (*Juglans cinerea*) is ranked S2? (Imperiled in Ontario), which is discussed below. Plants observed on the Study Area, by Savanta and Ages Consultants, with status at the local and regional scale are summarized in **Table 4.4.4**.

Table 4.4.4. HHSWS Locally Rare Plant Species (Savanta Inc. and Ages Consultants Ltd.)

Common Name	Latin Name	Provincial Status	Global Status	Local Status CVC/Peel	Local Status Peel	General Habitat Type
Cow parsnip	*Heracleum maximum*	*S5*	G5	RL	R4	Floodplains, wet meadows and thickets
Tall beggar-ticks	*Bidens vulgata*	S5	G5	R	R1	Swamps, marshes, ditches, and floodplains
Blue cohosh	*Caulophyllum giganteum*	S5	G	R	X	Deciduous forests
Pale Jewelweed	*Impatiens pallida*	S4	G5	L	R8	Moist forests, treed swamps, streambanks
Common Snowberry	*Symphoricarpos albus var. albus*	S5	G5T5	L	R8	Open woodlands often having dry, sandy soil
Pale dogwood	*Cornus obliqua*	S5	G5T?	L	R5	Marshes, swamps, margins of ponds, lakes, and streams and on banks of streams and rivers
Fragrant water-lily	*Nymphaea odorata*	S5?	G5T5	R	R3	Ponds and sheltered areas of lakes and rivers. Probably introduced in dug pond on south side of Bovaird
Purple-veined willow-herb	*Epilobium coloratum*	S5	G5	R	R6	Stream banks, swamps, meadows, man-made drainage features

Common Name	Latin Name	Provincial Status	Global Status	Local Status CVC/Peel	Local Status Peel	General Habitat Type
Carolina spring-beauty	*Claytonia caroliniana*	S5	G5	R	R5	Deciduous forests
Bromelike sedge	*Carex bromoides*	S5	G5	RL	R3	Swamps, moist forests, moist thickets, moist meadows, and swales
Hairy beardtongue	*Penstemon hirsutus*	S4	G4	RL	R7	Often sandy, open, dry ground, including meadows, fields, and streambanks
Swamp Rose	*Rosa palustrus*	S5	G5	RL	R3	Swamps, wet thickets, margins of streams
Sandbar willow	*Salix interior*	S5	GNR	L	R5	Wet meadows, stream margins, ditches
Shining willow	*Salix lucida*	S5	G5	L	R5	Wet meadows, thickets, sandy shorelines
Lesser Clearweed	*Pilea fontana*	S5	G5	RL	R3	River and stream banks, swamps, marshes, seeps
Eastern red cedar	*Juniperus virginiana var. virginiana*	S5	G5T	L	R5	Open deciduous woodlands, meadows, old fields
White Spruce	*Picea glauca*	S5	G5	L	R3	Coniferous swamps, mixed forests, thickets, stream borders
Red Pine	*Pinus resinosa*	S5	G5	RL	R1	Well drained sandy soil, Meadows, woodlands; often used in plantations
Swamp Dodder	*Cuscuta gronovii var. gronovii*	S5?	G5	R	R5	Parasitic plant often in marshes or swamps
Big-Fruit Hawthorn	*Crataegus macrosperma*	S5	G5	RL	R4	Frequently in dry sandy ground; deciduous forests, roadsides, hedgerows, meadows, and pastures
Necklace sedge	*Carex projecta*	S5	G5	L	R4	Swamps and moist thickets or moist areas of upland forests, wet meadows
Tuckerman's sedge	*Carex tuckermanii*	S5	G4	L	R6	Swamps and thickets, wet depressions in woodlands, stream margins
Blunt Broom Sedge	*Carex tribuloides var. tribuloides*	S4	G5	RL	R5	Marshes, swales, streambanks, swamps, shrub thickets

Table 4.4.5 lists locally / regionally rare plants that were recorded by the MNR in the Huttonville Creek and Area Wetland Complex in the Heritage Heights Study Area. These species are presumed to be present though not all were observed by Savanta during recent survey efforts.

Table 4.4.5. Locally/Regionally Rare Plants Recorded by the MNR in the Huttonville Area and Churchville-Norval Wetland Complex, Heritage Heights Study Area

Common Name	Latin Name	Provincial Status	Global Status	Local Status CVC/Peel	Local Status Peel
Rough-leaved Goldenrod	*Solidago patula*	S5	G5	RL	R4
Broad-fruited Bur-reed	*Sparganium eurycarpum*	S5	G5	L	R6
Long-leaved Chickweed	*Stellaria longifolia*	S5	G5	RL	R5
Northern Water-meal	*Wolffia borealis*	S4S5	G5	R	R2
Foxtail Sedge	*Carex alopecoidea*	S5	G5	L	R3
Bromelike Sedge	*Carex bromides*	S5	G5	RL	R3
Blunt Broom Sedge	*Carex tribuloides*	S4S5	G5	RL	R5
Wood Reed Grass	*Cinna arundinacea*	S4	G5	RL	R3
Yellow Lady's Slipper	*Cypripedium parviflorum var. pubescens*	S5	G5T	R	R5
Smooth Gooseberry	*Ribes hirtellum*	S5	G5		R2
Tall Beggar-Ticks	*Bidens vulgata*	S5	G5	R	R1
Tuckerman's Sedge	*Carex tuckermanii*	S4	G4	L	R6
Carolina Spring Beauty	*Claytonia caroliniana*	S5	G5	R	R5
Pale Dogwood	*Cornus obliqua*	S5	G5T?	L	R5
Leafy Pondweed	*Potamogeton foliosus*	S5	G5	X	R7
Alder-leaved Buckthorn	*Rhamnus alnifolia*	S5	G5	L	R6
Marsh Blue Violet	*Viola cucullata*	S5	G4G5	L	R6

One nationally and provincially endangered species was recorded in the Study Area: Butternut . The MNR recorded this species during studies of the Huttonville Creek and Area Wetland Complex. Savanta also found Butternut specimens at the same location as MNR during a site visit in July 2012. The specimens were found in good to very poor health and some were of considerable age. Savanta has not located any Butternut specimens during 2010-2012 or 2017-2018 vegetation surveys. Locations where this sensitive species were found are not presented in this report.

Significant Wetlands

Provincially significant and locally significant wetlands are present in Heritage Heights. Wetlands within the Huttonville Creek and Area Wetland Complex and the Churchville-Norval Wetland Complex are provincially significant. Evaluated wetlands, as per LIO, are those evaluated by MNRF and determined to be not significant; these evaluated wetlands are considered locally significant under the Brampton Official Plan Section 4.6.9. All ELC wetland polygons are provided in Figure T2 (Appendix D). Both provinicially significant and locally significant wetlands are presented on Figure T1 (Appendix D).

The 2018 Huttonville Creek and Area Wetland Complex was identified in 2007 as a candidate significant wetland complex. This wetland complex is situated among seven subwatersheds of the Credit River. It is centred on the Huttonville Creek subwatershed with five smaller subwatersheds on unnamed tributaries to the west and a small portion of Fletchers Creek subwatershed to the northeast. These watersheds are mainly agricultural land use with scattered tableland woodlots. Most of the wetlands occur in these woodlots and the rest in valley forests, stream valleys, riparian habitat, depressions in agricultural fields (existing and old) as well as created habitat in the Mount Pleasant Natural Heritage System. Detailed

OWES assessment by MNRF determined that the 48 wetland units formed a significant wetland complex with its score from the hydrological assessment and special features driving the significance evaluation. These palustrine wetlands, due to silty clay soil, are dominated deciduous swamps and graminoid marshes with some thicket swamps, and cattail, ground cover and broad-leaved emergent marshes and a few open water marshes. There are 31 of these wetlands within the Study Area outside of the Greenbelt Plan area and two Greenbelt Plan Area wetlands that extend into the future urban area. As of 2016, 17 of the wetlands in the Huttonville Creek & Area Wetland Complex were staked or partly staked (MNRF 2018).

The Churchville-Norval Wetland Complex, located within the Credit River Valley and seven contributing tributaries, is comprised mainly of graminoid marshes, and some deciduous treed swamps and thicket swamps. Open water aquatic, herbaceous marsh, conifer, and mixed swamps are less frequent. As this Wetland Complex, within the Study Area occurs entirely within the NHS Area of the Greenbelt, none of these wetlands have been staked.

Wildlife Resources

A combined total of 168 wildlife species were documented from the Study Area during studies completed between 2005 and 2018. Wildlife groups represented include: fingernail clam (1), fairy shrimp (1), butterflies (22), damselflies and dragonflies (18), amphibians (8), reptiles (5), birds (90) and mammals (23) (refer to Appendix D).

Amphibian Surveys

Breeding amphibian call count surveys

Six species of frog and one species of toad were heard calling within the Study Area and are listed in Table 2a, Appendix B. Survey stations are illustrated on Figure T3, Appendix D. The species and number of individuals recorded at each station are depicted in Figure T4, Appendix D (detailed results for each station are provided in Table 2b, Appendix B). Specific survey dates for each amphibian station are provided in **Table 4.4.6**.

Table 4.4.6. HHSWS Amphibian Station Survey Dates (Savanta Inc.)

Station	Dates 2008	Dates 2009	Dates 2010	Dates 2012	Dates 2017	Dates 2018	Comments
C	16-Apr, 7-May, 13-Jun	18-Apr, 27-May, 23-Jun					
D	16-Apr, 5-May, 9-Jun	17-Apr, 21-May, no third survey since dry as of April					
E	17-Apr, 8-May, 12-Jun	23-Apr, 27-May, 23-Jun					
F	17-Apr, 8-May, 12-Jun	23-Apr, 27-May, 23-Jun					
G	17-Apr, 8-May, 13-Jun	23-Apr, 27-May, 23-Jun					
H	17-Apr, 8-May, 13-Jun	23-Apr, 27-May, 23-Jun					
I	17-Apr, 5-May, 10-Jun	17-Apr, 21-May, 18-Jun					

Station	Dates 2008	Dates 2009	Dates 2010	Dates 2012	Dates 2017	Dates 2018	Comments
K	18-Apr, 8-May, 12-Jun	24-Apr, 27-May, 23-Jun					
L	18-Apr, 5-May, 12-Jun	24-Apr, 27-May, 23-Jun					
M	18-Apr, 5-May, 10-Jun	24-Apr, 27-May, 23-Jun					
N	18-Apr, 5-May, 12-Jun	24-Apr, 21-May, 23-Jun					
O	18-Apr, 5-May, 12-Jun	24-Apr, 21-May, 23-Jun					
P	18-Apr, 5-May, 12-Jun	24-Apr, 21-May, 23-Jun					
AD	16-May, 7-May, 12-Jun	18-Apr, 22-May, no third survey since dry in May					
AF	17-Apr, 8-May, 12-Jun	17-Apr, 21-May, no third survey since dry as of April	14-Apr, 30-May, 10-Jun				
AG	17-Apr, 5-May, 12-Jun	23-Apr, 27-May, 23-Jun					
AH	18-Apr, 8-May, 12-Jun			15-Apr, 04-May, 18-Jun	13-Apr, 16-May, 28-Jun		
AI	18-Apr, 5-May, 12-Jun	24-Apr, 27-May, 23-Jun					
AJ	18-Apr, 5-May, 12-Jun	24-Apr, 27-May, 23-Jun					
AK	16-April, 9-May, 12-Jun	29-Apr, 27-May, 19-Jun					
AP	18-Apr, 8-May, 12-Jun	24-Apr, 21-May, 23-Jun			13-Apr, 16-May, 28-Jun		
AQ	17-Apr, 8-May, 13-Jun	23-Apr, 27-May, 23-Jun					
AV	17-Apr, 8-May, 13-Jun	23-Apr, 27-May, 23-Jun					
AX	18-Apr, 8-May, 12-Jun	24-Apr, 21-May, 23-Jun					
AY	18-Apr, 8-May, 12-Jun	24-Apr, 21-May, 23-Jun					
BA	16-Apr, 9-May , 12-Jun	18-Apr, 21-May, 23-Jun					

Station	Dates 2008	Dates 2009	Dates 2010	Dates 2012	Dates 2017	Dates 2018	Comments
BB		29-Apr, 21-May, 23-Jun					
BE	16-Apr, 5-May, 12-Jun	17-Apr, 21-May, 23-Jun					
BJ	16-April, 9-May, 12-Jun	29-Apr, 27-May, 19-Jun					
BK			14-Apr, 30-May, 10-Jun				This roadside station was used in 2010 when no access was granted to BK2
BK2				15-Apr, 04-May, 27-Jun	13-Apr, 16-May, 28-Jun		
BL			14-Apr, 30-May, 10-Jun				This roadside station was used in 2010 when no access was granted to BL2
BL2				15-Apr, 8-May, 27-Jun			
BM			14-Apr, 30-May, 10-Jun				This roadside station was used in 2010 when no access was granted to BM2
BM2				15-Apr, 04-May, 27-Jun			
BN				22-Mar, 08-May, 12-Jun	13-Apr, 16-May, 28-Jun		
BO				22-Mar, 08-May, 12-Jun	13-Apr, 16-May, 28-Jun		
BP				22-Mar, 02-May, 12-Jun			
BQ				22-Mar, 04-May, 12-Jun		02-May, 15-May, 12-Jun, 18-Jun	
BR				22-Mar, 02-May, 18-Jun			
BS				22-Mar, 02-May, 18-Jun	13-Apr, 16-May, 28-Jun		
BT				15-Apr, 04-May, 27-Jun	13-Apr, 16-May, 28-Jun		
BU				15-Apr, 04-May, 27-Jun			
BV				15-Apr, 04-May, 27-Jun			

Station	Dates 2008	Dates 2009	Dates 2010	Dates 2012	Dates 2017	Dates 2018	Comments
BW				15-Apr, 02-May, 18-Jun			
BX				15-Apr, 02-May, 18-Jun			
BY				15-Apr, 04-May			Station removed after May survey, too far from wetland within woodlot
BZ				15-Apr, 04-May, 31-Jun	13-Apr, 16-May, 28-Jun		
CA				15-Apr, 02-May, 18-Jun	13-Apr, 16-May, 28-Jun		
CB				18-Apr, 08-May, 27-Jun	13-Apr, 16-May, 28-Jun		Roadside survey performed in June due to no landowner access (walk-in performed April and May)
CC				18-Apr, 08-May, 31-Jun			
CE				04-May, 27-Jun			Rural residence pond with frog activity found in May, no April survey
CF					13-Apr, 16-May, 28-Jun	02-May, 15-May, 12-Jun, 18-Jun	
CP					13-Apr, 16-May, 28-Jun		
DA					13-Apr, 16-May, 28-Jun		
EA					13-Apr, 16-May, 28-Jun		
EB					13-Apr, 16-May, 28-Jun		
EE					13-Apr, 16-May, 28-Jun		
EF					13-Apr, 16-May, 28-Jun	02-May, 15-May, 12-Jun, 18-Jun	
EG					13-Apr, 16-May, 28-Jun		
EI					13-Apr, 16-May, 28-Jun		
EJ					13-Apr, 16-May, 28-Jun		

Station	Dates 2008	Dates 2009	Dates 2010	Dates 2012	Dates 2017	Dates 2018	Comments
FA						02-May, 15-May, 12-Jun, 18-Jun	
FB						02-May, 15-May, 12-Jun, 18-Jun	
FC						02-May, 15-May, 12-Jun, 18-Jun	
L					13-Apr, 16-May, 28-Jun		
N					13-Apr, 16-May, 28-Jun		
O					13-Apr, 16-May, 28-Jun		

According to the NHIC (2020), all species are considered provincially and globally common (S5, G5). The only exception is American Bullfrog, which is provincially ranked S4 (apparently secure in Ontario). This species was recorded only in 2012 at station BQ (Figure T3, Appendix D), which is a large pond on a City of Brampton property. In 2009, Ages Consultants observed Red-backed Salamander under logs within the woodland (NSIU T, polygon 108-1) located on the Mount Pleasant Heights Lands (Figure T2, Appendix D).

Since amphibians are relatively more sensitive to environmental disturbance and pollution, they can be indicator species for determining relatively higher quality habitat. Lower numbers of individuals may be indicative of suboptimal breeding sites, even though some species may still make an attempt to call at these sites. According to the Marsh Monitoring Protocol (MMP), a ‘chorus’ of calling frogs or toads occurs “when there are so many males of one species calling that all the calls sound like they are overlapping and continuous”, making it difficult to reasonably count or estimate (recorded as >10 individuals but can be considerably higher than 10). Choruses of American Toads were recorded by Savanta at stations D and H (calling from racetrack pond south of station) in April 2008, and at station BW (swale east of deciduous swamp polygon 128-4) in May 2012. A Green Frog chorus was recorded by Savanta at station BQ (permanent pond) in June 2012. In 2005-2006, Dougan recorded several toad choruses in the West Huttonville Creek subcatchment on the Heritage Heights lands: (1) AD, (2) west of BX in swale within agricultural field, (3) between BX and BY in agricultural field and (4) east of BY in dug pond 121-6. Savanta recorded low numbers of toads at locations (1) - (3) and did not have access to location (4).

Unlike frog species, the American Toad (*Bufo americanus*) is known to be a more adaptable species, more tolerant to disturbance and is found in many different habitats (anywhere there is abundant moisture and insects). Low to moderate numbers (single individual up to full chorus) of American Toads were heard calling throughout most of the Study Area. Higher concentrations of American Toads were observed in a variety of wet habitats north of the CNR (open pond at BT, riparian corridor at M, swale near swamp edge at BW). A cumulative total of 205 American Toads were heard within the Study Area from 2008-2012. Prior to this study period, between 2005-2006, Dougan recorded 54 toads in the West Huttonville Creek subcatchment of the Study Area. Between 2017 and 2018, low numbers of American Toads were recorded from 11 stations within the Study Area.

Low to moderate numbers (1 to full chorus) of Green Frogs (*Rana clamitans*) were recorded from 16 locations within the Study Area. In 2012, full chorus of Green Frog was heard at stations BQ, BO and L (the latter was incidental observation during breeding bird surveys). Green frogs were heard calling in a variety of habitats ranging from watercourse channels, to ponds, patchy woodlands and marshy areas. Green Frogs require permanent water features for their tadpoles to overwinter. A cumulative total of 120 Green Frogs (30 of which were incidentally recorded during a daytime June 2012 survey) were recorded within the Study Area from 2008-2012. Between 2005-2006, Dougan recorded 13 Green Frogs in the West Huttonville Creek subcatchment of the Study Area. Eight of these frogs were recorded in the dug pond east of station BY at 121-6.

A moderate number of Gray Treefrogs (*Hyla versicolor*) were recorded in the Study Area. A cumulative total of 56 Gray Treefrogs were heard. Treefrogs were heard calling in low numbers (1 to 7 individuals) at 21 locations with habitat ranging from watercourse channels, to patchy woodland and marshy areas. This species requires permanent water to breed. In 2017, low numbers of Grey Treefrogs were recorded from six stations within the Study Area. In 2018, a chorus of Grey Treefrogs were recorded at station BQ.

Wood Frogs (*Rana sylvatica*) were heard calling in low numbers (1 to 5 individuals) at 5 locations within the Study Area. This species prefers vernal pools near moist woodlands. The highest abundance of Wood Frogs in a single year was found at stations G and BS, both of which were located within wooded swamps containing vernal pools. A cumulative total of 19 Wood Frogs were recorded within the Study Area from 2008-2012. Between 2017 and 2018, low numbers of Wood Frogs were recorded from five stations within the Study Area.

Spring Peepers (*Pseudacris crucifer*) require wooded areas close to temporary or permanent water. Peepers were heard calling within/or adjacent to watercourse channels and at three ponds within the Study Area (9 locations). A cumulative total of 10 Spring Peepers was recorded from 2008-2012. Prior to this study period, between 2005-2006, Dougan recorded one Spring Peeper south of D and four Spring Peepers at BS. Between 2017 and 2018, low numbers of Spring Peepers were recorded from two stations within the Study Area.

Northern Leopard Frogs (*Rana pipiens*) was heard at five locations, which were associated with riparian areas and a wooded swamp. This species prefers habitat containing emergent vegetation and grasses. A cumulative total of 6 Northern Leopard Frogs was recorded from 2008-2012. Between 2017 and 2018, low numbers of Northern Leopard Frogs were recorded from one station within the Study Area.

Two American Bullfrogs (*Rana catesbeiana*) were heard within the Study Area. Amphibian station BQ, (pond) was the only site where Bullfrogs were present. Bullfrogs require permanent waterbodies. In 2017, one American Bullfrog was heard calling from station EJ. No calls were recorded in 2018.

Amphibian Road-Crossing Surveys

Green Frog (*Rana clamitans*) and American Toad (*Bufo americanus*) were observed during this study (Figure T5, Appendix D). American Toad is a very common species that is highly adaptable to disturbed areas. In addition, the breeding window for this species occurred at the same time the survey was conducted. According to the NHIC (2020), both Green Frog and American Toad are considered provincially and globally common (S5/G5).

A total of 107 toads were found on the roads within the Study Area, comprised of 74 dead toads and 33 toads found alive. A total of two Green Frogs were found, both alive. , It was difficult to determine sex and age for all individuals, as some of the dead toads were unidentifiable. The direction the toads were headed was not always obvious, especially for the dead toads. The toads were headed in many different directions, some towards water features and some towards shelter. On all roads, more dead toads were found than live ones.

Within the Study Area, the northwestern portion had the most toad occurrences. The road with the highest mortality rate was Winston Churchill Boulevard (almost twice as many dead toads were found on this road compared to other surveyed roads) followed by Mississauga Road, Heritage Road and Wanless Drive. There were no mortalities observed on Mayfield Road or Bovaird Drive. The high number of mortalities observed on Winston Churchill Boulevard is likely due to the fact this road lies between the Heritage Heights lands and the Credit River and breeding amphibians are moving to and from the wooded riparian corridor associated with the Credit River.

Amphibian Egg Mass Surveys

No amphibian egg masses were observed during surveys in 2017 or 2018.

Breeding Bird Surveys

General Observations

Point count (PC) locations are shown on Figure T6, Appendix D. Table 3, Appendix B lists bird species observed from 2005-2018, which includes surveys completed by the MNR in 2006, Dougan in 2005 and 2006, Ages Consultants in 2009 and Savanta from 2008-2017. For summary purposes over the study period, the highest degree of breeding evidence is reported. Species names follow the AOU Check-list of North American Birds, 8th edition (2012) and its supplements. For each species, the NHIC (2020) database and SARO list were reviewed to consider the probability of occurrence and to determine federal and provincial status levels.

Cumulatively, 90 bird species were observed in the Study Area. Of these, 56 were confirmed breeding species, 15 additional species were considered probable breeders and 14 were considered possible breeders. The remaining 11 species were visitors, migrants or observed outside the breeding season. Ages Consultants did not provide breeding evidence for one species (Tree Swallow), which was not subsequently observed in the Study Area. All species observed in the Study Area were provincially ranked S5 (secure and common in Ontario), S4 (apparently secure in Ontario), or exotic. All native bird species are nationally ranked G5 (very common in Canada).

During completion of the adjacent HFSWS, Dougan performed ecological inventory studies in 2005 and 2006 within the West Huttonville Subwatershed within the Heritage Heights Study Area. Dougan observed three species, which showed some evidence of breeding (e.g. not migrants or visitors) that were not recorded by Savanta:

- Black-and-White Warbler (*Mniotilta varia*) was observed in mature woodland fragment ELC polygon 116-10;
- Veery (*Catharus fuscescens*) was observed in the same woodland patch as Black-and-White Warbler but was found closer to the riparian area (ELC polygon 116-7); and

Alder Flycatcher (Empidonax alnorum) was observed in small woodland fragment ELC polygon 137-5; access was not granted to survey this woodland in 2008-2012. Six Species at Risk were found in the Study Area:

- Eastern Wood-wood Pewee (Special Concern);
- Wood Thrush (Special Concern):
- Bobolink (Threatened);
- Eastern Meadowlark (Threatened);
- Barn Swallow (Threatened); and
- Chimney Swift (Threatened).

All six species are provincially ranked S5B (Secure – extensive range in Ontario) or S4B (Apparently Secure – uncommon, but not rare in Ontario) and four are designated as Threatened in Ontario and Canada, and are protected under Ontario's *Endangered Species Act, 2007*. No provincially rare species (provincially ranked S1-S3) were found during the surveys.

To understand the potential implications of the Species at Risk occurrences, the data are reviewed and compared with known and expected Ministry of Environment, Conservation and Parks (MECP) interpretations of "habitat" for these species. Recovery Strategies have not yet been developed for Barn Swallow, Eastern Meadowlark, Bobolink or Chimney Swift and it will be some time before Habitat Regulations are available. Guidance in terms of habitat assessment, which helps define the potential impact of the ESA, is therefore limited to practical experience with MECP interpretations.

SAR species are described in the Species at Risk section below.

Breeding Bird Survey Specific Observations

Species diversity was highest at woodland point count stations (#55, 59, 60 and 61; Figure T6, Appendix D). A high diversity of birds was recorded during both 2012 surveys (June and July) at point count #61. The other stations had high diversity during only one survey. The woodlot containing #61 provided a large amount of edge habitat and vegetation diversity (e.g. dense shrubs, conifers, hardwoods, sapling stands, fruiting shrubs, old-fields, riparian area). The presence of woodlands (west of the Study Area and fragments within the Study Area) in close proximity to a diversity of breeding and foraging habitats (fruiting shrub/early successional, old-field, agricultural fields, conifer plantations, backyards, other woodlands, riparian areas) contributed to higher species richness in these areas.

Based on 2012 field observations of Meadowlark, a large area of hayfields and old-field habitat adjacent to the north side of the CNR and west of Heritage Road (ELC polygons 160-1, 233, 162, 165-2, and 168-2) was identified as an area of open country and early-successional breeding bird habitat.

Species diversity was lowest at point count stations located within or at the roadside of active agricultural fields (e.g. point count stations #48 and 50) and within a low quality sugar maple forest that had limited tree diversity, understory and ground cover (point count station #54).

Regionally Significant Breeding Birds

The MNR (2000) Significant Wildlife Habitat (SWH) technical guide provides recommendations regarding what species are considered regionally significant. Additional, draft guidance is available for consideration as well from the MNRF (2015) Significant Wildlife Habitat (SWH) Criteria Table for Ecoregion 6E, which provides some interim guidance regarding regionally significant birds. Of the breeding bird species, within the Heritage Heights landscape, 23 are listed in the Province's draft eco-regional criteria as indicator species of potentially significant wildlife habitat. The presence of these species flags the potential for designation of SWH. More specific comments follow regarding the 23 species listed in the Province's draft criteria for eco-region 6E (MNR, 2012).

Four indicator species of area-sensitive woodland breeding habitat were recorded within the Study Area. In 2012, two Red-breasted Nuthatches (*Sitta canadensis*) and two Yellow-bellied Sapsuckers (*Sphyrapicus varius*) were recorded at point count station #61. This woodlot provides no interior habitat (>100m from edge), however it is located near large wooded areas west of Winston Churchill Boulevard (outside the Study Area). Ovenbird (Seiurus aurocapilla) was recorded in 2012 at point count station #55 in a remnant woodland patch with no interior habitat (>100m from edge). Dougan observed Veery in ELC polygon 116-5, a small remnant woodlot with no interior habitat. Area-sensitive species likely inhabit larger, contiguous wooded areas associated with the Credit River valley, which provide interior habitat. Red-breasted Nuthatch were also observed incidentally during 2017 targeted SAR surveys; however observations of this species did not occur in habitats of suitable size, and therefore these records do not represent occurrence of SWH.

The Province's criteria for eco-region 6E includes four raptor species believed to breed in the Study Area: Red-tailed Hawk (*Buteo jamaicensis*), Cooper's Hawk (*Accipter cooperii*), Northern Harrier (*Circus cyaneus*) and American Kestrel (*Falco sparverius*). Four nests were found for Red-tailed Hawk (#81, 83, 73, 70; Figure T6). Cooper's Hawk is a probable breeder in the Study Area and is likely a year-round resident. A single Cooper's Hawk was observed during each observation year from 2008-2012 (found at point count #61 in 2012). A targeted search of the Study Area in 2008 found Cooper's Hawk nests in the Huttonville Fletcher's Creek subwatershed east of the Heritage Heights lands. Northern Harrier (observed in the Study Area in 2008) and American Kestrel (possible breeder in 2010) are likely only present during high vole years. Habitats that support rodent populations, such as meadows with some shrubs, thickets and old fields, are limited within the Study Area. Red-tailed Hawk were also confirmed breeding during 2017 targeted SAR surveys.

Two other raptors listed in MNRF (2015) – Osprey (*Pandion haliaetus*) and Rough-legged Hawk (*Buteo lagopus)* - were observed flying over the Study Area. Osprey is a Probable breeder within the Study Area, while the Rough-legged Hawk observed was determined to be migrating through.

Though not listed in the Province's criteria for eco-region 6E, two owl species were observed in the Study Area: Eastern Screech Owl and Great Horned Owl. The Red-tailed Hawk nests found in the Study Area (described above) may also be used by Great Horned Owl, which was recorded in 2012 at #71 and 74 (Figure T6). The Heritage Heights lands likely only support one or two Great Horned Owl (*Bubo virginianus*) pairs due to low availability of suitable habitat. Eastern Screech Owl (*Megascops asio*) was recorded at #65, 69, 75 and 82 (Figure T6) and likely occurs in all forest patches with trees old enough to provide suitable nesting / roosting cavities.

Breeding evidence was recorded for four indicator species of shrubland / early successional habitat: Field Sparrow (*Spizella pusilla*), Eastern Towhee (*Pipilo erythrophthalmus*), Brown Thrasher (*Toxostoma rufum*) and Willow Flycatcher (*Empidonax traillii*). Brown Thrasher is identified as an indicator species for SWH Early Successional Bird Habitat, whereas the other species are considered more common. Brown Thrasher was observed in 2009 (point count #23), 2010 (point count #30) and 2012 (point count #61). Suitable habitat is present at the latter two point count stations. Point count 30 is located in a large area of hayfields, cultural meadows and early-successional habitat (>10ha). Habitat in the vicinity of point count 61 is considerably less than 10 ha in size. Brown Thrasher, Willow Flycatcher, and Field Sparrow were also recorded incidentally in 2017 during targeted SAR surveys. Observations of these species did not occur in habitats of suitable size and therefore these records do not represent occurrences of SWH.

Three open country habitat indicator species were observed: Savannah Sparrow (Passerculus sandwichensis), Vesper Sparrow (Pooecetes gramineus) and Northern Harrier. The Mount Pleasant Heights Lands supported two open country indicator species (Savannah Sparrow and Vesper Sparrow in 2009). This habitat patch, ELC polygon 108-2, is quite small (<10ha in size) and succession to older meadow conditions (i.e. tall forbs, raspberry brambles, and increasing number of shrubs) has decreased suitability of this patch over time. A large area of hayfields and old-field habitat adjacent to the north side of the CNR and west of Heritage Road (ELC polygons 160-1, 161-3, 162, 165-2, 168-2.; total area >10ha) provides a mixture of open country and early-successional habitat. This area supported three SAR grassland bird species (Eastern Meadowlark, Bobolink and Barn Swallow), along with several open country and early-successional species (e.g. Savannah Sparrow, Field Sparrow and Willow Flycatcher were observed at various times between 2008-2012). Savannah Sparrow was recorded in various locations throughout the Study Area in 2017, during targeted SAR surveys. Observations of these species did not occur in habitats of suitable size and therefore these records do not represent occurrences of SWH.

Two species that nest colonially in bank / cliff habitat were observed: Northern Rough-winged Swallow (*Stelgidopteryx serripennis*; 23 individuals total in 2012) and Cliff Swallow (*Petrochelidon pyrrhonota*; 11 individuals total in 2012). Nests were not found for either species. Juvenile Rough-winged Swallows were observed at the same location during both rounds of 2012 breeding bird surveys, which suggests they nested nearby (potentially along exposed banks of the Credit River). No breeding evidence was observed for Cliff Swallow. No nesting habitat was observed for one aquatic habitat colonially nesting species (Great Blue Heron; *Ardea herodias*) and one ground habitat colonially nesting species (Ring-billed Gull; *Larus delawarensis*).

Sedge Wren (*Cistothorus platensis*) was the only marsh breeding habitat indicator species observed in the Study Area (MNRF 2015). A small colony of three male Sedge Wrens was found in a wet old field in 2011 but the field was subsequently cultivated and this species was not found in 2012.

Three species that are indicative of waterfowl stopover / staging habitat were observed in low numbers: Wood Duck (*Aix sponsa)*, Mallard (*Anas platyrhynchos*) and Canada Goose (*Branta canadensis*). No stopover / staging habitat is present in the Study Area. The Credit River valley offers suitable nesting habitat for Wood Duck and Mallard may nest in a few suitable ponds in the Study Area where pairs were observed. One species indicative of shorebird stopover / staging habitat (Spotted Sandpiper; *Actitis macularius*) was observed, but no suitable stopover / staging habitat is present.

Locally Significant Breeding Birds

Bird species observed in the Study Area that are considered species of "Conservation Concern" according to the Credit Valley Conservation Authority (CVC, 2002) are identified in Table 3, Appendix B. Of the 85 species that showed some degree of breeding evidence in the Study Area (i.e. excluding migrants and non-breeding visitors), 40 are considered locally rare by CVC (2002).

Many of the locally significant birds were associated with the forested slopes and tableland of the Credit River, and the woodlot / thicket on the City of Brampton works yard (ELC polygon 211-5, 211-10). Several locally rare species were observed at a variety of locations within the Study Area (Horned Lark, Barn Swallow, Gray Catbird, Killdeer, Common Grackle). Most, however, occurred in small numbers (1-3 males or pairs) at scattered sites due to low availability of suitable habitat (e.g. Eastern Kingbird, Sedge Wren, Eastern Wood-Pewee, Pileated Woodpecker and Eastern Bluebird).

Other Species of Conservation Concern

"Species whose populations appear to be experiencing substantial declines in Ontario" is one of the criteria to be considered when assessing Significant Wildlife Habitat (OMNR, 2000). In this section of the SWH technical guideline (OMNR, 2000, p. 55), Appendix P is referenced as a resource to help identify 'rare species' (note this SWH type excludes species protected under Ontario's Endangered Species Act). Appendix P provides a list of species listed as 'at risk' by the Committee on the Status of Species at Risk in Ontario (COSSARO) or the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) that are not regulated under Ontario's ESA.

Eastern Wood-Peewee (Special Concern) - Eastern Wood-Pewees are most common in deciduous forest and woodland, but they may be found in nearly any forested habitat, even smaller woodlots, for breeding as long as it is fairly open. As migrants, these pewees can occur in nearly any woodlot or other treed area.

Eastern Wood-Pewee were recorded singing within several of the wooded areas within the Study Area (PC4, PC6, PC7, PC8, BBS1, BBS3, BBS4, BBS5, BBS6, BBS7, BBS8 BBS9, BBS10, BBS11, BBS 12, BBS 13, BBS14, and BBS15). Though nesting locations or confirmed evidence of breeding were not recorded in 2017, probably breeding evidence was noted for several locations given observations of singing males recorded on two occasions at least ten days apart. Confirmed breeding was also observed during 2012 surveys. Eastern Wood-Pewee are associated with woodland communities during the breeding season, and life processes of breeding and foraging would occur from these areas.

Wood Thrush (Special Concern) - Wood thrush live in mature deciduous and mixed (conifer-deciduous) forests. They seek moist stands of trees with well-developed undergrowth and tall trees for singing perches. These birds tend to prefer large forests, but will also use smaller stands of trees. They build their nests in living saplings, trees or shrubs, usually in sugar maple or American beech.

Wood Thrush was observed in very low numbers in 2006, 2008, 2009 and 2012. This species was recorded by Dougan as a confirmed breeder in the woodlot northeast of Heritage Road and Wanless Drive (ELC polygon 136-1) and one individual was observed in the same woodlot in 2012. Dougan also recorded Wood Thrush as a possible breeder in another woodland fragment (ELC polygon 121-2). No access was granted for the occurrence of this species to be rechecked in subsequent years. Eastern Wood-Pewee is a confirmed breeder and was observed in small numbers in several woodlots. In 2012, this species was recorded at point count stations #51, 53, 54 and 55. Ages Consultants recorded Eastern Wood-Pewee in the western portion of ELC polygon 108-1 in 2009 (Figure T2, Appendix D).

Species at Risk

Targeted SAR surveys for Bobolink, Eastern Meadowlark and Barn Swallow were conducted from June 21-23, 2011, June 18-21, 2012, July 5-7, 2012, June 8-14, 2017 and June 28-June 29, 2017. The temperature was warm during all surveys (25-33ºC), with predominant winds characterized by the Beaufort scale as light air to gentle breezes, with infrequent wind gusts up to a maximum speed of 15km/hr.

Four Species at Risk were found in the Study Area during surveys conducted by Savanta from 2008-2018. Four of these bird species are Threatened in Ontario and Canada.

- Bobolink (*Dolichonyx oryzivorus*);
- Eastern Meadowlark (*Sturnella magna*);
- Barn Swallow (*Hirundo rustica*); and
- Chimney Swift (*Chaetura pelagic*).

Species at Risk data will be reviewed with MECP. Specific locations and detailed results of SAR surveys are not provided here.

Bobolink (Threatened) - Bobolinks breed in grassland habitats ranging from abandoned pasture and grassy edges of wetlands to active hay fields. This ground-nesting species generally requires grassland habitat with moderately deep litter and vegetation that is moderate to tall in height and moderately to highly dense. This species is also known to be "area-sensitive" and prefer larger suitable fields rather than small and isolated patches.

Bobolink was observed during several years. Targeted surveys for this species were conducted in 2011 and 2012. During surveys conducted from June 21-23, 2011, a total of 130 Bobolinks were recorded within the Study Area. In 2012, a two-round targeted survey was conducted (first survey mid-June; second survey early July). During the first survey, 34 Bobolinks were observed in four main areas and a single bird was seen at a fifth location. In 2012, all of the Bobolink locations were dominated by uncut hayfields surrounded primarily by open habitats (i.e. hayfields and cash crop fields).

Targeted SAR surveys conducted in 2017 observed Bobolink within grassland areas considered to provide suitable breeding habitat within the Study Area. The majority of these observations were made from the locations along Mississauga Road, south of Bovaird Drive W.

Eastern Meadowlark (Threatened) – This species prefers moderately tall grasslands (e.g. meadows, abandoned pasture, hay fields, etc.) with abundant litter cover, high proportion of grass, moderate to high forb density, and low coverage of woody vegetation. Meadowlarks have multipurpose territories (i.e., they defend areas used for foraging, mating, and rearing young), but prefer large grassland areas to small areas for breeding.

Eastern Meadowlark was observed during several years. Targeted surveys for this species were conducted in 2011, 2012, and 2017. During surveys in 2011, a total of 6 Eastern Meadowlarks were observed in the Study Area. In 2012, two Eastern Meadowlarks were detected in round one surveys, and occurred alongside Bobolinks in two large hay fields. Six Eastern Meadowlarks were detected in round two surveys, in 2012, and occurred alongside Bobolinks in two uncut hayfields. Young were likely present in both fields. No Eastern Meadowlark were observed during 2017 targeted SAR surveys (April 27, 2017), however this species was observed incidentally during snake surveys along SN2 (Figure T4, Appendix D).

Barn Swallow (Threatened) – Barn Swallows breed mostly in open habitats across their range, including agricultural lands, abandoned pasture, all types of grassy or weedy fields, and along river systems and wetlands. They build mud nests on ledges, lips and walls both inside and outside of human-made structures, such as barns, other buildings, bridges, culverts, and occasionally in natural caves and cliffs.

Barn Swallow was observed during several years and is commonly seen foraging across the Study Area, as is typical in rural agricultural areas. Targeted surveys for this species were conducted in 2012. 110 Barn Swallows were detected across the Study Area during the first survey. During the second survey, 145 Barn Swallows were recorded. Fourteen nest sites were identified (13 on barns or other outbuildings; 1 inside a road culvert). This species was observed in habitats ranging from agricultural crop fields (soy, corn and wheat), hayfields, pasture and early successional areas of grass/shrubs. Behavior was almost exclusively foraging observations or perched birds near nesting structures.

Barn Swallow were also observed in 2017, three confirmed observations of Barn Swallow entering suitable nesting habitat was noted (Figure T6, Appendix D). Additional suitable breeding structures were observed in the Study Area, and it is considered probable that additional nesting locations are present.

Chimney Swift (Threatened) - In urban areas, Chimney Swifts breed and roost in open top chimneys for the most part. Abandoned cisterns, lighthouses and various other manmade structures are utilized in more rural areas. Natural nesting structures include suitable caves and large hollow trees in forests. This species builds simple stick nests that are adhered to the sidewalls of all of the above sites. They are usually observed foraging in-flight above the cities where they roost and breed, and near bodies of water where insects are most abundant.

Chimney Swifts were observed foraging over the Study Area during targeted SAR bird surveys in June 2012. This species was observed at two locations only 500m apart on two separate days. Pairs of birds were observed feeding and interacting together, but no suitable nesting/roosting locations were identified in and around the area between the two sightings. Chimney Swift breeding evidence was not found on the Study Area lands. AMEC (2011) noted that discussion with Ross Evans, the principal atlasser for the OBBA atlas square, revealed the only place where Chimney Swift was believed to possibly nest was in an old mill situated along Mississauga Road, between the Credit River and Embleton Road, south of the Study Area (R. Evans, pers. comm., 2010). No Chimney Swift were observed during 2017 surveys.

All other bird species observed within the Study Area are ranked S5/G5 (Secure – common, widespread and abundant in Ontario) or S4/G5 (Apparently Secure – uncommon, but not rare in Ontario).

Rare OBBA bird species

Rare OBBA bird species were previously discussed in section 4.4.2.1 and Species at Risk occurrences were discussed above.

Overall Impressions on Breeding Birds

Considering that the Study Area is dominated by agricultural uses and offers only small patches of forest, wetland, and open habitats outside the Credit River, more species were encountered than expected. Many of the species were observed in low numbers due to limited habitat available. Some species observed during earlier studies of these lands (2005-2009) have not been found since, and were indicator species of specialized habitat types (e.g. Northern Harrier and Veery). Several new species that rely on specialized habitat types were observed in 2012 that had not been previously recorded (e.g., Yellow-bellied Sapsucker, Cliff Swallow, Red-breasted Nuthatch and Ovenbird). Two of these species, Yellow-bellied Sapsucker and Red-breasted Nuthatch, are woodland area-sensitive birds found on a property where access was granted in 2012.

Considering the proposed urbanization of the Study Area, enhancement of habitat cover and quality in a Natural Heritage System (NHS), would likely help to sustain the presence of many of those species (i.e., except for some area sensitive species; those dependent upon larger blocks of habitat). Certain species will also be difficult to maintain due to sensitivity to disturbance. With the listing of three grassland Species at Risk birds (Bobolink, Eastern Meadowlark, Barn Swallow), Eastern Meadowlark and Barn Swallow may persist in smaller patches of suitably restored habitat patches.

Winter Wildlife Surveys

The locations of winter wildlife transects and survey results from 2008, 2009 and 2011 are shown on Figure T7, Appendix D. Twenty-one mammals were observed within the Study Area throughout the course of studies completed for the HHSWS. All mammals observed in the Study Area are listed in Table 4, Appendix B. None of the species observed are considered significant at the national or provincial level (NHIC, 2020). One S4 species was observed (American Mink) and North American River Otter is uncommon in the GTA (i.e. according to the Toronto Region Conservation Authority; no local rarity rank is provided by the Credit Valley Conservation Authority). Both species were observed (tracks and slides) on the Credit River during 2011 winter wildlife surveys. Two bat species were observed during 2012 evening amphibian surveys (identification was not possible since individuals were observed foraging far overhead at night). Some bat species are considered provincially rare. Winter wildlife surveys resulted in several records of “unknown small mammal” tracks and trails due to poor preservation of the prints (i.e. older print that had been impacted by freeze-thaw, wind or trampling by other prints) preventing accurate identification.

Overall, small mammal species and deer trails were abundant and wildlife diversity is typical of rural landscapes. No evidence of deer wintering (deer beds, extensive browse) were observed during winter wildlife surveys. In general, the Credit River and other smaller watercourse channels contained concentrations of species observations and diversity that indicated these areas are used by wildlife for movement within the Study Area. The next most used areas were the patchy remnant woodlots.

Bat Acoustic Monitoring

Twelve acoustic bat monitors were deployed in July 2017, however data corruption issues resulted in the loss of data from seven stations. In total, data from five unaffected stations (WOOD1, WOOD2, WOOD3, WOOD4, and WOOD5) was analyzed.

Five bat species were confirmed to be present within the woodlands surveyed: Big Brown Bat *(Eptesicus fuscus),* Silver-haired Bat *(Lasionycteris noctivagans),* Hoary Bat *(Lasiurus cinereus*), Eastern Red Bat

(*Lasiurus borealis*), and Small-footed Myotis (*Myotis leibii)*. During 50 detector evenings of acoustic surveys, 1267 calls were recorded and identifiable to species.

Of the 1267 calls that were identifiable to species, 59 were Big Brown Bat, 4 were Silver-haired Bat, 28 were Hoary Bat, 3 were Eastern Red Bat, and 1092 were Eastern Small-footed Myotis. An additional 1 call showed Myotis characteristics (i.e., call with frequencies greater than 40 kHz).

Eastern Small-footed Myotis is listed as Endangered on the Species at Risk in Ontario List. These individuals were detected at all stations except WOOD3.

Reptiles Surveys

All reptiles observed in the Study Area are listed in Table 5, Appendix B. The locations of reptile observations are provided on Figure T4, Appendix D.

Three snake species were observed in the Study Area: Ages Consultants observed Eastern Garter Snake and Dekay's Brownsnake in polygon 108 and Eastern Milksnake was observed by a local expert (P. Clarkson, pers. comm. October 15, 2012) in a cultural meadow. Gartersnake and Brownsnake are both common and widespread in Ontario and Canada. Eastern Milksnake is designated Special Concern nationally and provincially.

As stated by Ages Consultants (2010), the Ontario Herpetofaunal Summary (Oldham and Weller, 2000) indicated the presence of Eastern Milksnake in the general vicinity. This species was not found throughout studies conducted by Dougan, Ages Consultants or Savanta. A local expert (P. Clarkson, Recreation Programmer - Outdoor Education for the Brampton Wilderness Centre) observed one adult and one young-of-the-year Milksnake along with 7 hatched Milksnake eggs in a cultural meadow (2012). Since persecution and collection are threats to this rare species, specific location details are not provided.

Snake surveys conducted in 2017 and 2018 observed Eastern Gartersnake along SN1, SN18, and SN19.

Two turtle species were observed in the Study Area: Snapping Turtle and Midland Painted Turtle. A total of seven Snapping Turtles were observed (two in 2006, two in 2012, and three in 2017). Suitable overwintering and nesting habitat is present in the Study Area.

During surveys conducted by Savanta, one Midland Painted Turtle was observed in summer 2010 (station BQ), one in summer 2012 (station BO), one in fall 2012 (station BT) and fourteen (14) in 2017 (Station BT) (Figure T4, Appendix D). A local expert (P. Clarkson) observed 4-5 Midland Painted Turtles of varying sizes (age classes) in the pond at station BQ (spring 2012). Midland Painted Turtle is common and secure in Ontario. Observation of basking turtles in the spring and fall, as was the case at station BT, indicates the presence of overwintering habitat.

Turtle nesting transects surveyed in 2018 did not observe any signs of turtle nesting (i.e. predated nests, test pits, and/or turtle tracks). Suitable turtle nesting habitat was observed along TN3, TN4 and TN10, while the rest of the habitats surveyed offered poor or marginal turtle nesting suitability.

The Credit River valley may provide suitable turtle nesting and overwintering habitat for Snapping and Midland Painted Turtles.

Insects

All insects observed in the Study Area are listed in Table 6, Appendix B. Insects were observed incidentally throughout Savanta's 2008-2012 study period, with particular emphasis placed on insect observations in 2012. Ages Consultants also performed an insect survey on polygon 108 (Figure T1, Appendix D). Dougan noted a small number of insect species during fieldwork conducted in 2005. In total, 22 butterfly / moth species (lepidotpera) and 18 damselfly / dragonfly species (odonata) were recorded in the Study Area.

All species observed are ranked S5 (Secure - Common, widespread, and abundant in the province), S4 (Apparently Secure—Uncommon but not rare), or SNA (not native in Ontario). The only exception is Monarch, which is designated Special Concern provincially and nationally. Small numbers of Monarch were observed at various locations across the Study Area (Savanta recorded 13 individual during widespread breeding surveys in 2012). No congregation areas or concentrations were observed. Cabbage White (non-native) was the most abundant butterfly species followed by Clouded Sulphur. Most other butterfly species were found in much lower numbers (1-3 observations). Common Whitetail, Twelve-spotted Skimmer and White-faced Meadowhawk were the most common odonate species.

Locally rare species are identified in Table 6, Appendix D, based on the Credit Valley Conservation Authority's Natural Areas Inventory Project (2012). Two butterflies are locally rare: Common Buckeye (two individuals observed in 2012) and White Admiral (observed by Ages Consultants in 2009). All other Lepidoptera are locally common. Two odonates observed by Ages Consultants, in 2009, are locally rare: Band-winged Meadowhawk and Lance-tipped Darner. Two odonates are locally uncommon: Shadow Darner (observed by Ages Consultants in 2009) and River Jewelwing (4 individuals observed by Savanta in 2012). All other odonates observed in the Study Area are locally common.

Other Wildlife

Terrestrial Crayfish was recorded at five locations within the Study Area during the Northwest Brampton Open Space Study (2003), during field studies conducted by the MNR and Dougan in 2006 and during field surveys conducted by Savanta in 2018. Each location is described below (Figure T2, Appendix D)

- ELC polygon 108-7 - Two chimneys observed in 2003 and one observed in 2006 in a ditch heading east from the swamp wetland portion of the woodlot on the Mount Pleasant Heights Lands.
- ELC polygon 128-4 - One chimney observed in a swale draining southward from the wooded swamp.
- ELC polygon 123-2 – chimneys were observed in a small pool / puddle in the corn field (American Toad tadpoles were also present).
- ELC polygon 159-6 – Chimneys were observed in an agricultural field and adjacent to a watercourse feature.
- ELC polygon 200-1 - Chimney observed in a swale draining southward on institutional land.

Fairy shrimp, an indicator of pond water quality, was found in a large vernal pool in ELC polygon 128-4. Fingernail clam was found within large vernal pools in ELC polygons 128-1 and 128-3.

4.4.5 Interpretation

All natural features (FOC, FOM, FOD, MA, SWD and SAS) and cultural features (CU) were grouped together to provide a higher level illustration of the location of these features (alternative mapping display to detailed ELC polygons). These groupings are referred to as Natural System Integration Units (NSIU). Groupings do not imply that these are significant features as all natural and cultural features were grouped based on proximity. Assessment of natural heritage features (i.e. woodland, significant wildlife habitat) as per the PPS, ROP (2018), and City of Brampton Official Plan (2020) was applied separate of NSIUs. The NSIU mapping approach allows the reader to refer to an NSIU to find the particular ELC polygon that has been deemed significant.

The NSIUs and other natural heritage feature terminology relevant to this significance assessment (i.e., significant woodland, significant wildlife habitat, etc.) are illustrated on Figure T9, Appendix D.

Within the Greenbelt Plan Area, identification, and delineation of the natural features conform with the Greenbelt Plan (2017).

Assessment of Significance

The following is an analysis of identified features and functions for the Study Area, and the applicability of relevant provincial and municipal natural heritage policies to their significance.

Sections 4.2 to 4.7 summarize the hydrogeology, hydrology, geomorphology and ecology (terrestrial and aquatic) conditions present within the Study Area. Within terrestrial studies, vegetation community mapping (Figure T2) illustrates the location of all natural and cultural vegetation communities (ELC); and each ELC was given a unique identifier. There are over 100 ELC polygons within Heritage Heights. To assist the reader in locating a particular ELC polygon all natural features (FOC, FOM, FOD, MA, SWD, and SAS) and cultural features (CU) were grouped together as Natural System Integration Units (NSIU); groupings do not imply that these are NSIU are significant features as all natural and cultural features were grouped based on proximity. Assessment of candidate significant natural heritage features (i.e., woodland, wildlife habitat) as per PPS was assessed separate of NSIU's. A reader can refer to an NSIU to find the particular ELC polygon that has been deemed significant under a PPS policy (i.e., NSIU has a pond which provides candidate significant wildlife habitat).

Natural features and areas are protected under Section 2.1 of the PPS. The sections below summarize the candidate significant natural heritage features assessment, as per PPS. Figure T9 – Natural Features Mapping illustrates a broad picture of terrestrial and aquatic results, showing the location of stream reaches with the NSIU, the location of the Greenbelt, as well as areas that were assessed to provide/contain significant woodland, significant wildlife habitat, significant wetland and significant valleylands.

Additional studies such as the Norval Quarry Aggregate Resources Act application, the Bovaird Drive Transportation Corridor from Lake Louise Drive/Worthington Avenue to 1.45 km west of Heritage Road Class Environmental Assessment (AMEC 2013), the North West Brampton Landscape Scale Analysis (Dougan and Associates 2013) and Eastern Mainline Project: Project Description (TransCanada, 2014) were reviewed for relevant information that may affect the significance assessment.

Provincial Policy Statement (2020)

Seven types of natural heritage features are defined in the PPS:

1) Significant wetlands;
2) Habitat of endangered species and threatened species;
3) Fish habitat;
4) Significant woodlands;
5) Significant valleylands;
6) Significant Areas of Natural and Scientific Interest (“ANSIs”); and,
7) Significant wildlife habitat.

As stated in the PPS, development and site alteration (defined terms),

- shall not be permitted in significant wetlands;
- shall not be permitted significant valleylands, or significant woodlands south and east of the Canadian Shield unless it is demonstrated that there will be no negative impacts on the natural features or the ecological functions for which the area was identified;
- shall not be permitted in significant wildlife habitat or significant areas of natural and scientifici interest unless it is demonstrated that there will be no negative impacts on the natural features or the ecological functions for which the area was identified;

- shall not be permitted in fish habitat except in accordance with provincial and federal requirements; and
- shall not be permitted in habitat of endangered species and threatened species except in accordance with provincial and federal requirements.

The Ministry of Natural Resources Natural Heritage Reference Manual (NHRM 2010) was used as guidance to define and assess the potential significance of natural heritage features.

Provincial Greenbelt Plan (2017)

Greenbelt Plan policies provide long-term guidance for the management of natural heritage and water resources when addressing such matters through watershed/subwatershed and stormwater management planning, water and wastewater servicing, development, infrastructure, open space planning and management, aggregate rehabilitation and private or public stewardship programs. Protected Countryside in the Greenbelt Plan Area adjacent to the Heritage Heights lands is entirely Natural System and subject to its policies (Figure T9). The Greenbelt Natural System policies protect areas of natural heritage, hydrologic and/or landform features and their functions. The Natural System is made up of a Natural Heritage System and and Water Resource System. Development and site lateration are generally not permitted in the Natural System with the exception of forest, fish and wildlife management, conservation and flood or erosion control projects and recreational, aggregate, infrastructure and existing uses described in the Plan. The Plan protects key natural heritage features, key hydrologic features and their Vegetation Protection Zones.

Peel Regional Official Plan (Office Consolidation 2018)

The Plan has established a Greenlands System consisting of three components, i.e., Core Areas, Natural Areas and Corridors, and Potential Natural Areas and Corridors. Core Areas contain ecological features, forms and functions that provide, "*favourable conditions for uninterrupted natural systems and maximum biodiversity*". Core Areas include features with the highest importance and protection such as significant wetlands, significant woodlands, significant valleylands, significant wildlife habitat, fish habitat and habitat of endangered species and threatened species. These areas are protected in policy and are functionally supported, connected and/or buffered by Natural Area and Corridors (NAC) and Potential Natural Areas and Corridors (PNAC).

The definitions of natural heritage features (i.e. woodlands, valleylands) and assessment criteria from the Peel ROP were used in this assessment to determine significance.

City of Brampton Official Plan (Office Consolidation 2020)

The Plan provides detailed policies on identification and criteria for natural heritage features. The following are considered natural heritage features and areas in the City OP:

- Valleylands/watercourse corridors;
- Woodlands;
- Wetlands (Provincially Significant Wetlands, Locally significant and Unevaluated Wetlands);
- Environmentally Sensitive/Significant Areas;
- Areas of Natural and Scientific Interest; and
- Provincial Greenbelt.

Schedule D, of the City OP maps natural heritage features based on material provided by various agencies (CVC, TRCA, MNRF, etc). For this Subwatershed Study, MNR's Natural Heritage Reference Manual (NHRM, 2010) was used to assess significance of natural heritage features as well as the MNRF wetland evaluations and direction from the Region of Peel Official Plan.

Significant Habitat of Endangered and Threatened Species

There are four bird species present within Heritage Heights that meet the PPS definition related to significance for Endangered and Threatened Species. The species are: Bobolink, Eastern Meadowlark, Barn Swallow and Chimney Swift. All four species are provincially ranked S4B (Apparently Secure – uncommon, but not rare in Ontario) and are designated as Threatened in Ontario and Canada, and are protected under Ontario's Endangered Species Act, 2007. These species are grassland and/or open country birds, which use cultural meadow, fallow agricultural fields and active agricultural fields (i.e. hayfields, foraging over cash crops). SAR occurrences were described in the 'Species at Risk' Section of 4.4.4.3. Generally, consultation with MECP, through an Information Gathering Form (IGF), is required to assess the impact of development on these Species at Risk. Mitigation may be required through the use of replacement habitat, for example artificial nesting structures for Barn Swallow, or habitat compensation. Common avoidance practices during the construction phase, such as removing habitat outside of the active window, nest searches, or exclusionary measures, will be considered.

The Species at Risk will need to be evaluated further at the EIR stage. In order to understand the potential implications of the Species at Risk occurrences, the data will be reviewed and compared with known and expected MECP interpretations of "habitat" for these species.

One endangered plant species - Butternut - is present in portions of the Huttonville Creek and Area Wetland Complex in Heritage Heights. Specimens of varying health and age were observed along the toe of valley slope of CRT4-3 where a Hawthorn-buckthorn cultural thicket edge abuts a forb mineral meadow marsh. The butternut trees are within the Greenbelt Plan Area and a significant valleyland, located outside of the future development area.

One endangered bat species (Eastern Small-footed Bat) was observed at four acoustic bat monitoring stations (WOOD1, WOOD2, WOOD4, and WOOD5). Acoustic data was lost for the remaining seven stations; however it is likely Eastern Small-footed Bat occurs within those woodlots as well. As with the SAR bird species, MECP will be engaged to discuss impacts, mitigation and avoidance options. Common avoidance practices during the construction phase, such as removing habitat outside of the active window, nest searches, or exclusionary measures, will be considered.

Significant Wetlands

As discussed in section 4.4.4.3, there are two MNRF Wetland Complexes within Heritage Heights: Huttonville Creek and Area Wetland Complex (December 2018) and Churchville-Norval Wetland Complex (October 2012). The PPS, Peel ROP and City of Brampton Official Plans protect PSWs from development, although infrastructure is permitted.

Locally significant wetlands were also identified in the Study Area based on the criteria in the Peel OP. They are shown in Figure T1 (Appendix D).

Significant Woodlands

Table 1 from the Peel ROP specifies size criteria for significant woodland in an urban area, 4 Ha or greater, as well as other evaluation criteria for woodlands. These criteria as well as the NHRM 2010 was used to evaluate woodlands for significance.

Under the NHRM 2010 woodlands are defined as:

"*…treed areas that provide environmental and economic benefits to both the private landowner and the general public, such as erosion prevention, hydrological and nutrient cycling, provision of clean air and the long-term storage of carbon, provision of wildlife habitat, outdoor recreational opportunities, and the sustainable harvest of a wide range of woodland products. Woodlands include treed areas, woodlots or forested areas and vary in their level of significance at the local, regional and provincial levels*."

In accordance with this definition both natural (FOC, FOD, FOM, SWC, SWD, SWM) and cultural forest (CUW, CUP) communities are considered woodlands. Woodland vegetation communities that were within 20 metres of each other were considered contiguous. Based on ELC from field data and air photo interpretation it is estimated that 28.2 ha (6.1%) of West Huttonville Creek Subwatershed and 88.9 ha (7.5%) of Credit River Tributary is woodland. Based on the amount of woodland cover present in each subwatershed a minimum 40 m patch width applies when defining woodlands, in accordance with NHRM.

Table 7.2 within the NHRM summarizes evaluation criteria and thresholds for each criteria for designation as significant woodland. The criteria are:

1) Size: Where woodland cover is 5-15% of land cover woodlands 4 ha in size or larger should be considered significant;
2) Ecological Functions
    a) Woodland Interior – woodlands with any viable interior habitat, where woodland cover is less than 15% of the subwatershed, should be considered significant;
    b) Proximity to other woodlands or other habitats – where woodlands are within 30 m of candidate significant natural feature (candidate significant woodland, candidate significant valleyland, candidate significant wildlife habitat, candidate PSW) or fish habitat (high net constraint ranking), they are assumed to be likely receiving ecological benefit from the woodland and can be considered significant; in this case the proposed densely urbanizing form will diminish the relevance of this criterion (it was considered in the context of urban development);
    c) Linkages – woodlands that provide a potential connecting link between two other significant natural features (each within about 120 m) may be deemed to be significant.
    d) Water Protection – Woodlands within 50 m of sensitive (groundwater discharge, recharge, headwater, or fish habitat) stream reaches (HV3, HV4, CRT2-1, CRT2-2, CRT2-3, CRT2-4, CRT2-5 (west of Heritage Road), CRT4-1, CRT4-2, CRT4-3), could be deemed to be significant, especially where that intervening land or portions thereof could be successfully retained in the urbanizing landscape; and
    e) Woodland diversity – Where a patch contains a higher than typical diversity and/or contains vegetation community present that has declined within the ecoregion 6E-3 (FOD7-4), it may also be deemed to be significant.
3) Uncommon Characteristics – Where a woodland contains uncommon species compositions, cover type, old growth (>100 yrs) or structure.
4) Economic and Social Functional Values – woodlands that have high economic or social values.

These guidelines and criteria were applied to the treed features in the Heritage Heights landscape to assess the presence of significant woodlands. In addition to the guidance offered by the suggested NHRM criteria, our team assessed these wooded areas, informed by detailed assessments of these and other similar features within the North West Brampton area.

Table 4.4.7 summarizes which woodlands meet a given NHRM criteria for designation as significant woodland and following criteria from the Peel ROP.

Table 4.4.7. Summary of Significant Woodland Peel ROP (December 2018 Consolidation) Criteria Review

NSIU (Figure T9)	**Contiguous woodland with ELC code(s) (Figure T9)**	**Treed Area Patch Size (ha)**	**Criteria for Significance (Peel ROP December 2016 Table 1)**						**Peel ROP Woodland Category**	**Recommended as Significant Woodland**
			Size Core =>4 NAC =>2	*Age 100 yr*	*Proximity (100m of ANSI, ESA, wetland, Core / NAC woodlands that meet size criterion, Core valley / stream corridors)*	*Linkages (no distance identified, significant ecological linkage)*	*Surface Water Quality (30m of wetland, fish habitat, perm / int streams)*	*Significant Species (S1-S3, G1-G3, SAR under COSSARO or COSEWIC)*		
West Huttonville Creek Subwatershed										
J	FOD9-4, SWD2-2	0.9	No	No	Yes	No (no hydrological connection)	Yes	Yes	NAC	Not significant since size criterion is not met
J	SWD2-2 SWD2-7	4.7	Yes	No	Yes	Yes - within 100 metres of J (0.9 ha) and both patches provide Redside Dace survival habitat	Yes	Yes	CORE	Yes
K	FOD2-4, FOD5-1, SWD3-2, SWD2-2	9.9	Yes	No	Yes	Yes (Redside Dace survival habitat)	Yes	Yes	CORE	Yes
M	FOD4-2	3.4	Yes	No	Yes	Yes (links seasonal fish habitat and Redside Dace survival habitat)	Yes	Yes	NAC	Yes
N	FOD5-2, FOD7	3.8	Yes	No	Yes	Yes (links seasonal fish habitat and Redside Dace survival habitat)	Yes	Yes	NAC	Yes
T (west)	FOD5-2, FOD9, SWD1/SWD3	4.5 ha	Yes	No	Yes	Yes (hydrological connection	Yes	Yes	CORE	Yes

NSIU (Figure T9)	**Contiguous woodland with ELC code(s) (Figure T9)**	**Treed Area Patch Size (ha)**	**Criteria for Significance (Peel ROP December 2016 Table 1)**						**Peel ROP Woodland Category**	**Recommended as Significant Woodland**
			Size Core =>4 NAC =>2	*Age 100 yr*	*Proximity (100m of ANSI, ESA, wetland, Core / NAC woodlands that meet size criterion, Core valley / stream corridors)*	*Linkages (no distance identified, significant ecological linkage)*	*Surface Water Quality (30m of wetland, fish habitat, perm / int streams)*	*Significant Species (S1-S3, G1-G3, SAR under COSSARO or COSEWIC)*		
		(0.96 ha piece to southeast is >20 m away)				between the two woodland patches of NSIU T)				
T (east)	CUW FOD9	0.96 (larger piece to the northwest is >20 m away)	No	No	Yes	Yes (hydrological connection between the two woodland patches of NSIU T)	Yes	Yes	NAC	Not significant since size criterion is not met
Credit River Tributaries Subwatershed										
U	SWD3-5*	3.5	Yes	No	Yes	No	Yes	Yes	NAC	Yes
W	SWD2-2, SWD3-3	3.3	Yes	No	Yes	No	Yes	Yes	NAC	Yes
Z	CUP1-11*, FOD4-4*, FOD5-3, FOM2, CUW	5.4	Yes	No	Yes (candidate Core valleyland, other wetland)	Yes – <20m from large contiguous forest block west of Winston Churchill Blvd	Yes	Yes	CORE	Yes
EE (east of Heritage Road)	FOD5-2, SWD2-2/SWD4-1	2.2	Yes	No	Yes (PSW, candidate Core stream corridor)	No	Yes	Yes	NAC	Yes
BB	FOD5-1	3.0	Yes	No	No	No	Yes	Yes	NAC	Yes
CC	CUP, FOD	3.2	Yes	No	No	No	Yes	-	NAC	Yes
DD	FOD, SWD2-2	2.1	Yes	No	Yes	No	Yes	No	NAC	Yes

NSIU (Figure T9)	**Contiguous woodland with ELC code(s) (Figure T9)**	**Treed Area Patch Size (ha)**	**Criteria for Significance (Peel ROP December 2016 Table 1)**						**Peel ROP Woodland Category**	**Recommended as Significant Woodland**
			Size Core =>4 NAC =>2	*Age 100 yr*	*Proximity (100m of ANSI, ESA, wetland, Core / NAC woodlands that meet size criterion, Core valley / stream corridors)*	*Linkages (no distance identified, significant ecological linkage)*	*Surface Water Quality (30m of wetland, fish habitat, perm / int streams)*	*Significant Species (S1-S3, G1-G3, SAR under COSSARO or COSEWIC)*		
EE (west of Heritage Road)	SWD3-2	0.7 ha	No	No	Yes	No	Yes	No	NAC	Not significant since size criterion is not met
EE (east of Winston Churchill)	FOD, FOD7-4,	15.6	Yes	No	Yes (candidate Core valleyland, other wetland)	Yes - <20m from large contiguous forest block west of Winston Churchill Blvd	Yes	Yes	CORE	Yes
EE (CUW patch)	CUW, FOD	1.3	No	No	Yes (candidate Core valleyland, other wetland)	No	Yes	No access to determine whether significant species present	NAC	Not significant since size criterion is not met
HH	FOD9-2, SWD3-5*	5.9	Yes	No	Yes	No	Yes	Yes	CORE	Yes
GG (CUW patch)	CUW	0.7	No	No	Yes	No	Yes	No	NAC	Not significant since size criterion is not met
GG/JJ (contiguous woodland west of Heritage Road)	CUW, CUW/FOD, FOC4-1, FOD, FOD2-5*, FOD5-8, FOD7-4,	31.1	Yes	Yes	Yes (candidate Core valleyland)	Yes - <20m from large contiguous forest block / floodplain habitat of Credit River valley; secondary	Yes	Yes	CORE	Yes

NSIU (Figure T9)	**Contiguous woodland with ELC code(s) (Figure T9)**	**Treed Area Patch Size (ha)**	**Criteria for Significance (Peel ROP December 2016 Table 1)**						**Peel ROP Woodland Category**	**Recommended as Significant Woodland**
			Size *Core =>4* *NAC =>2*	*Age* *100 yr*	*Proximity (100m of ANSI, ESA, wetland, Core / NAC woodlands that meet size criterion, Core valley / stream corridors)*	*Linkages (no distance identified, significant ecological linkage)*	*Surface Water Quality (30m of wetland, fish habitat, perm / int streams)*	*Significant Species (S1-S3, G1-G3, SAR under COSSARO or COSEWIC)*		
	FOM3-2, SWD, SWD4-1					corridor along Credit River				
II/JJ (contiguous woodland east of Heritage Road)	FOD	15.0	Yes	Yes	Yes (PSW, candidate Core valleyland)	Yes - <20m from large contiguous forest block / floodplain habitat of Credit River valley; secondary corridor along Credit River	Yes	Yes	CORE	Yes

Significant Valleylands

The Region's and City's Official Plan valleyland mapping was reviewed, in the context of the definition of valleylands in the NHRM, our detailed field studies, and terrain analysis. Our evaluation included the criteria and thresholds in Table 2 of the Peel ROP. There were minor variations in the extent of the valleyland but there was consensus on where and the extent of the significant valleyland features. Based on this review, refined Significant Valleylands are shown on Figure T9.

Under the NHRM, valleylands are defined as:

"… a natural area that occurs in a valley or other landform depression that has water flowing through or standing for some period of the year"

Table 8.1 within the NHRM summarizes recommended criteria for identifying significant valleylands, which includes features and functions related to hydrology, hydrogeology, terrestrial ecology, fish habitat, and geomorphology. CRT2-west of Heritage Road, CRT4-1, CRT4-2, CRT4-3, and HV3 are valleylands that have some groundwater discharge, and as such would reasonably meet suggested groundwater criteria for the designation of features as significant valleylands. From a geomorphology perspective, the main Credit River and tributaries CRT1-1, CRT2-1, CRT2-2, CRT2-3, CRT2-4, CRT2A-1, CRT3-3, CRT4A-1, CRT4-1, CRT4-2, and CRT4-3 meet criteria for designation as significant valleylands.

Reaches HV3 and HV4 are designated by MNR as occupied Redside Dace (END) habitat and meet criteria under the Endangered and Threatened species policy – their presence reinforces the labeling of these features as significant valleyland. Portions of tributaries CRT2-2 and CRT2-3 have an uncommon vegetation community, Fresh-Moist Black Walnut Lowland Deciduous Forest (S4), which would meet NHRM criteria for designation as significant wildlife habitat and reinforces the significant valleyland designation.

Significant Wildlife Habitat

Significant Wildlife Habitat (SWH) was assessed using the MNR (2000) SWH Technical Guide and MNRF (2015) Significant Wildlife Habitat Criteria Schedules for Ecoregion 6e. Table 4.4.9 below summarizes the presence of SWH in the Study Area.

ANSIs

There are no Areas of Natural and Scientific Interest within the HHSWS Study Area.

Fish Habitat

Section 2.1.5 of the PPS states that, "Development and site alteration shall not be permitted in fish habitat except in accordance with provincial and federal requirements". As described within Section 4.7 of this report, the quality and extent of the aquatic resources within the West Huttonville Creek and Credit River Tributary subwatersheds was assessed using the current 2014 guidelines from the TRCA/CVC to characterize headwater drainage features. This information has been used in conjunction with knowledge of terrestrial and groundwater conditions to identify those watercourse reaches that provide direct and indirect habitat and where aquatic functions are most significant.

Table 4.4.8. Significant Wildlife Habitat Criteria Review

Feature of Function	ELC # (Figure T1) NSIU (Figure T7)	Comments
Seasonal concentrations of animals		
A1. Deer wintering area	-	**None detected.**
A2. Colonial bird nesting sites	-	**None detected.** Though some of the indicator species were observed foraging / flying over the Study Area (i.e. Northern Rough-winged Swallow, Sedge Wren, Cliff Swallow) no nests were found in sufficient quantity to meet this criterion.
A3. Waterfowl nesting habitat	-	**None detected.** None of the indicator species were observed within the Study Area.
A4i. Migratory landbird / stopover areas	-	**Not applicable.** Subject Lands are too far from the Lake Ontario shoreline (> 5 km).
A4ii. Migratory bat stopover areas	-	**Not applicable.** This is not considered an SWH type under the Province's ecoregional criteria (MNRF 2015).
A4iii. Migratory butterfly stopover areas	-	**Not applicable.** Subject Lands are too far from the Lake Ontario shoreline (> 5 km).
A4iv. Migratory shorebird stopover and/or staging	-	**None detected.** No evidence of flooded fields were identified during spring headwater drainage feature investigations in 2018.
A4v. Migratory waterfowl stopover and/or staging	-	**None detected.** No aquatic area were identified that are considered suitable to support large numbers of migratory waterfowl. Further, there are no records of migratory stopover areas within the Study Area,
A4vi. Migratory shorebird stopover areas		**None detected.** No suitable areas for shorebird migratory stopover areas were identified within the Study Area.
A5. Raptor wintering areas (hunting, roosting)	-	**None detected.** There are no open fields, with no recent farming activity, that are > 15 ha and adjacent to woodlands.
A6. Snake hibernacula	-	**None detected.** Targeted surveys conducted in 2017 and 2018 did not meet the Province's (MNRF 2015) ecoregional criteria for 6E. Only one individual of Eastern Gartersnake was observed in a few separate locations despite three rounds of survey effort in 2017 and 2018.
A7. Bat maternal roosts and hibernacula	-	**Not detected.** Indicator species were not observed in sufficient number to indicate that Bat Maternal roosts and hibernacula is present within the Study Area.
RA8. Bullfrog concentration areas	-	**Not applicable.** The Peel-Caledon SWH Study (2009) incorporated this SWH type into criterion B8ii. This is not considered an SWH type under the Province's ecoregional criteria (MNRF 2015).
A9. Wild turkey winter range	-	**Not applicable.** No threshold recommended, as Wild Turkey is no longer of conservation concern in Ontario, the Region of Peel or Town of Caledon. This is not considered an SWH type under the Province's ecoregional criteria (MNRF 2015).
A10. Turkey vulture summer roosting areas	-	**None detected.** Insufficient information to suggest specific threshold for this criterion; most preferred roosting areas would be protected through SWH Criteria B1 (rare vegetation communities) and B6 (cliffs and caves). This is not considered an SWH type under the Province's ecoregional criteria (MNRF 2015).
Rare Vegetation Communities or Specialized Habitat for Wildlife		
B1. Rare vegetation types	NISU EE (191-3, 184-1, 186-2, 187-1, 188-2), GG (215-1)	**One rare vegetation community detected:** Fresh-Moist Black Walnut Lowland Deciduous Forest (FOD7-4), which is ranked S2S3 in Ontario and Regionally Rare. All patches of this ELC type are ≥ 0.5 ha and are found in NSIU EE (191-3, 184-1, 186-2, 187-1, 188-2) and NSIU GG (215-1).
B2. Forests providing a high diversity of habitats (captured by significant woodlands)	-	**Not applicable.** It is assumed that all forests providing a high diversity of habitats will be captured by the suite of significant woodland criteria. This is not considered an SWH type under the Province's ecoregional criteria (MNRF 2015).
B3. Old-growth or mature forest stands (captured by significant woodlands)	-	**Not applicable.** It is assumed that all old-growth and mature forests will be captured by the significant woodlands criteria.
B4. Foraging areas with abundant mast	NSIU H, T, J, K, JJ	**Several vegetation communities (FOD1, FOD2, FOD9) identified in the Peel-Caledon SWH Study were detected:** FOD9-2 in NSIU H (86-1, 89-1); FOD9 in NSIU T (108-3, 108-5); FOD9-4 in the smaller wooded patch of NSIU J (137-5); FOD2-4 in NSIU K (128-3); and various FOD2-5* patches along the Credit River valley (i.e. NSIU JJ). This is not considered an SWH type under the Province's ecoregional criteria (MNRF 2015).
B5. Highly diverse areas	-	**Not applicable.** The Caledon-Peel SWH study consultant team provided a map to the Town for review regarding the most diverse patches in Caledon / the Region. This is not considered an SWH type under the Province's ecoregional criteria (MNRF 2015).
B6. Cliffs and caves	-	**None detected.**

Feature of Function	ELC # (Figure T1) NSIU (Figure T7)	Comments
B7. Seeps and springs (captured by significant valleyland and significant woodland mapping)	NSIU EE, N, T, JJ	**Several groundwater discharge areas detected.** Groundwater discharge areas are known to occur that contribute to tributaries within the Study Area. These features are already identified through the ROPA 21B significant valleyland designation and include: NSIU EE east and west of Heritage Road (CRT2-5 and eastern portion of CRT2-4); NSIU N (HV3, HV4); NSIU T (HV81b); and NSIU JJ (CRT2A-1, CRT2-1); and NSIU JJ (MAM2 adjacent to the north of CR1).
B8i. Amphibian breeding habitat – woodland sites	NSIU M	**Detected within NSIU M pond 121-6** Pond 121-6 within NSIU M met the Peel-Caledon (2009) threshold for this SWH type since two indicator species were recorded in 2018 (Wood Frog and American Toad) with a combined total of 21 calling individuals (threshold is 20 calling individuals). This is also in line with the provincial threshold for this SWH type (i.e., 20 calling individuals total of two of the listed species, or two listed species with call code 3 recorded) (MNRF 2015).
B8ii. Amphibian breeding habitat – wetland (non-woodland) sites	NSIU FF (211-6), NSI	**Detected within NSIU FF pond 211-8** To meet the Peel-Caledon (2009) threshold for this SWH type, at least two of the listed calling amphibian species must be recorded with a combined total of 20 calling individuals. This SWH type is also triggered by the presence of Bullfrog regardless of the number of individuals. The Peel-Caledon (2009) SWH threshold is crossed only by amphibian station BQ (NSIU FF pond 211-8). This pond supported calling Bullfrogs in 2012 and in 2018, though Bullfrog was not recorded during three-round call count surveys, two of the listed species were present (Green Frog and Gray Treefrog) with a combined total of > 20 calling individuals. Based on the 2012 and 2018 data, the NSIU FF pond would also meet provincial ecoregional criteria for this SWH type (MNRF 2015). Provincial ecoregional criteria requires that call code 3 or a total of 20 individuals be recorded for two listed species). None of the other amphibian stations passed the requirement for a combined total of 20 calling individuals (Peel-Caledon SWH and MNRF SWH threshold). At amphibian station N (a marsh within NSIU EE), 19 calling individuals were recorded in 2009 however low numbers were recorded in 2008 and this wetland was dry in late-spring 2018. As such, it does not provide viable amphibian breeding habitat and does not meet this SWH type.
B9. Turtle nesting habitat and turtle overwintering areas	NSIU FF , Y, II, M	**Turtle overwintering SWH is present in NSIU FF (pond 211-8), NSIU Y (pond 161-4), NSIU II (pond 96-4 / 93-1), NSIU M (pond 121-6),** NSIU FF pond 211-8 and NSIU Y pond 161-4 had more than 5 Midland Painted Turtles during spring emergence surveys. Snapping Turtles was recorded in several ponds: • NSIU FF pond 211-8 – recorded during Phase 1 Subwatershed Study surveys, this pond also met this SWH type due to presence of > 5 Midland Painted Turtle so turtle surveys were not repeated; • NSIU M pond 121-6 – recorded during Phase 1 Subwatershed Study surveys, the presence of this species could not be confirmed in 2017 or 2018 as access was not granted; • NSIU II pond 96-4 / 93-1 – recorded during 2017 spring emergence turtle basking survey and observed again in 2018 during June turtle nesting survey, low numbers of Midland Painted Turtle were also recorded in this pond during Phase 1 Subwatershed Study surveys; and • NSIU Z pond 167-3 – one individual recorded during Phase 1 Subwatershed Study surveys, however this pond does not provide suitable overwintering habitat (too shallow in even early spring), three spring emergence turtle basking surveys conducted at this pond in 2018 did not record any turtles, as such this SWH types is not present at pond 167-3. **Turtle nesting SWH may be present at NSIU FF (strong suitability) and at NSIU Y (moderate suitability)** A potential nest site was observed in an area of exposed sand / gravel within NSIU FF (east of the pond 211-8 and substrate provides suitable nesting habitat for turtle species (due to sandy soils no claw marks / test dig sites are retained in this substrate). This was the only location with strong suitability for turtle nesting habitat on participating lands. Moderately suitable turtle nesting habitat was noted at several other locations, namely in the vicinity of NSIU Y pond 161-4 (silty clay loam substrate). Pond 161-4 contained moderate numbers of Midland Painted Turtles (8 individuals in 2018) and evidence of turtles exiting the pond was observed during 2018 surveys. No direct turtle nesting evidence was recorded during a turtle nesting survey in June 2018. The farm field margin provides areas with exposed mineral soil (silty clay loam) otherwise vegetation was continuous around the pond itself without gravel or sand shores for nesting.
B10. Habitat for area-sensitive forest interior breeding bird species		**None detected.** The woodland areas associated with NSIU Z and NSIU JJ are located within 20m of the large, off-site forested areas west of Winston Churchill Blvd, which likely provide interior patch size (>100m from edge) that would meet the Peel-Caledon (2009) requirements or, potentially >200m from edge that would meet the Province's ecoregional criteria (MNRF 2015). However, indicator species were not observed in sufficient quantity to meet this SWH type (only one indicator species was observed at each of the breeding bird survey point count stations located in NSIU Z and JJ). NSIU Z woodland patch was resurveyed in 2017 and confirmed that indicator species are not present in sufficient quantity to meet this SWH type.
B11. Habitat for open country and early successional breeding bird species		**None detected.** Open fields that are > 10 ha existed in NSIU Y and NSIU J at the time of the preparation of the Phase 1 Subwatershed Study. Farm activity has occurred with the past 5 years including during recent years. As such habitat criteria are not met for this SWH type.
B12. Habitat for wetland breeding bird species		**None detected.** Indicator species are not present in sufficient quantity to meet this criteria.
B13i. Raptor nesting habitat – wetlands, ponds, rivers	-	**None detected.** No Northern Harrier or Osprey nests were detected within the Study Area (indicator species from the Peel-Caledon study). The habitat size criteria (MNRF 2015) are also not met (i.e., woodland > 30 ha with > 10 ha interior that is 200m from the woodland edge).
B13ii. Raptor nesting habitat – woodlands		**None detected.** One indicator species (Cooper's Hawk) was recorded within the Study Area however no nests were found. The habitat size criteria (MNRF 2015) are also not met (i.e., woodland > 30 ha with > 10 ha interior that is 200m from the woodland edge).

Feature of Function	ELC # (Figure T1) NSIU (Figure T7)	Comments
B14. Mink, River Otter, Marten and Fisher feeding and denning sites		**None detected.** River Otter and Mink tracks were recorded on the Credit River banks south of ELC polygon 128-1 (NSIU JJ), however no den sites were detected. This is not considered an SWH type under the Province's ecoregional criteria (MNRF 2015).
B15. Mineral licks	-	**Not applicable.** Mineral licks are not recommended as an SWH type for the Region of Peel or the Town of Caledon. This is not considered an SWH type under the Province's ecoregional criteria (MNRF 2015).
Species of Conservation Concern		
C1. Species identified as nationally Endangered of Threatened by COSEWIC, which are not protected in regulation under Ontario's Endangered Species Act	NSIU J	**Two species detected.** Wood Thrush was observed (possible breeding evidence) within the larger wooded patch of NSIU J and is listed as Special Concern in Ontario and Threatened in Canada. This species is addressed further under C2. Monarch was observed (13 individuals in total across the Subject Lands during Phase 1 Subwatershed Study surveys), which is listed as Special Concern in Ontario and Endangered in Canada. This species is addressed further under C2. This is not considered an SWH type under the Province's ecoregional criteria (MNRF 2015).
C2. Species identified as Special Concern based on Species at Risk in Ontario List that is periodically updated by OMNR	NSIU FF, J, EE, BB, HH, N, T, U, W	**Five Special Concern species were recorded within the Study Area:** • Eastern Wood-Pewee rare wildlife SWH is present in the woodland patches of NSIU FF, J, EE, BB, HH, N, T, U and W. • Wood Thrush (NSIU J) • Snapping Turtle occurrences are described in B9 Monarch Butterfly (13 individuals observed throughout Study Area during Phase 1 Subwatershed Study surveys, no concentrations were recorded)
C3. Species that are listed as rare (S1-S3) or historical in Ontario based on records kept by the NHIC in Peterborough	-	**All S1-S3 and SH species are addressed in C2.**
C4. Species whose populations appear to be experiencing substantial declines in Ontario	-	**Not applicable.** The Peel-Caledon SWH Study (2009) does not provide a threshold for this criterion due to insufficient information. This is not considered an SWH type under the Province's ecoregional criteria (MNRF 2015).
C5. Species that have a high percentage of their global population in Ontario and are rare or uncommon in the Region of Peel	-	**Not Applicable** The Peel-Caledon SWH Study (2009) does not provide a threshold for this criterion due to insufficient information. This is not considered an SWH type under the Province's ecoregional criteria (MNRF 2015).
C6. Species that are rare within the Region of Peel even though they may not be provincially rare	-	**29 Locally Rare species; 8 Locally Uncommon species (Varga, 2005)** The Peel-Caledon SWH Study (2009) does not provide a regionally rare wildlife list due to lack of sufficient information. The unpublished plant list produced by Varga et al., 2005 and Credit Valley Conservation, 2002, are to be used to identify regionally rare plants. Locally rare and locally uncommon species, according to Varga et al. (2005), are listed in Table 4.4.5.
C7. Species that are subjects of recovery programs (captured in Endangered and Threatened species portion of PPS analysis)	-	**Final Recovery Strategies are available for five species recorded in the Study Area:** Bobolink, Eastern Meadowlark, Barn Swallow, Butternut, Redside Dace, and Eastern Small-footed Bats. These species are addressed separately from SWH under the PPS. According to this SWH criterion, habitat identified for SAR with final Recovery Strategies is also cross-designated as Regional SWH. This is not considered an SWH type under the Province's ecoregional criteria (MNRF 2015).
C8. Species considered important to the Region of Peel based on recommendations from the Conservation Advisory Committee	-	**Not applicable.** No Conservation Advisory Committee currently exists in the Region or the Town of Caledon. This is not considered an SWH type under the Province's ecoregional criteria (MNRF 2015).
Animal Movement Corridors		
D. Animal Movement Corridors	Main corridor NSIU JJ, M, K, N, FF, Y, II	Several movement corridors present: NSIU JJ connects to the Greenbelt and provides a continuous, broader natural cover area that would serve as a primary movement corridor along part of the western boundary of the Study Area.When amphibian breeding SWH (woodland or wetland) is present, the identification of amphibian movement corridors is recommended to ensure amphibians using the breeding habitat are able to access the habitat types that support their other life processes (i.e., overwintering, foraging, dispersal).Woodland amphibian breeding SWH is present (according to regional criteria) in pond 121-6 within NSIU M. Three species have been recorded within this pond based on Phase 1 Subwatershed Study surveys and 2018 surveys: Green Frog, American Toad and Wood Frog. Green Frog would overwinter within the pond (provided the bottom does not freeze) and forages within moist woodlands and riparian areas (i.e., stream corridor to north and south of the pond). The pond is surrounded by upland forest that provides appropriate overwintering and foraging habitat for Wood Frog and American Toad. Maintaining a riparian connection, via the existing natural or realigned stream corridor, between this pond and NSIUs K and N to the north and south, respectively, is recommended. NSIU K contains the only other woodland amphibian breeding wetland (amphibian station BS) that approached the Peel-Caledon (2009) SWH threshold. The same species recorded in NSIU M were also recorded in NSIU K. Maintaining a viable movement corridor between NSIUs M and K will provide dispersal opportunities and avoid isolation of either amphibian population. It is recommended the existing natural or realigned stream corridor be at least 30 m wide to serve as an amphibian movement corridor.

Feature of Function	ELC # (Figure T1) NSIU (Figure T7)	Comments
D. Animal Movement Corridors	Main corridor NSIU JJ, M, K, N, FF, Y, II	Wetland amphibian breeding SWH (according to regional and provincial criteria) is present within NSIU FF pond 211-8 due to the presence of Bullfrogs. Several other species were also recorded within this pond including Gray Treefrog, Green Frog and American Toad. This pond is located on City property and the pond itself is directly surrounded by a variety of habitat types including cultural meadow, shrubland and mature forest that connects to the Greenbelt. Bullfrog and Green Frog would both overwinter in the pond (since it does not freeze through), while American Toad and Gray Treefrog overwinter and forage terrestrially in adjacent woodland or shrubland. Bullfrog does not stray far from the pond for foraging purposes; this species has a small home range closely tied to the breeding pond. The existing natural vegetation within NSIU FF is to be retained, no additional movement corridor is required. Turtle overwintering SWH (according to regional and provincial criteria) was also identified in both of these ponds (211-8 and 121-6) and within ponds 161-4 (NSIU Y) and 96-4 / 93-1 (NSIU II). The movement corridors described previously for amphibians would also provide suitable movement corridor functions for turtle species utilizing the ponds within NSIUs M and FF. Maintaining existing natural cover within NSIU FF will also sustain the connection between the pond and turtle nesting SWH located several meters from the pond in an area of exposed gravel and sand (regular maintenance would be required to keep the turtle nesting habitat in an open, unvegetated condition). The pond within NSIU II is located immediately north of and hydrologically connected to the Greenbelt, this riparian connection should be maintained as a movement corridor for turtle species. Under existing conditions, the NSIU Y pond is situated adjacent to a headwater drainage feature that likely provides some movement corridor functions. If the NSIU Y pond is retained, the realignment of the adjacent drainage feature should be planned to continue to provide a connection to this pond. The proposed realigned watercourse in this part of the Study Area would eventually connect to the Greenbelt which is beneficial for longer term dispersal of turtle species within the local landscape.
Terrestrial Crayfish		
New SWH type present in the MNRF (2015) ecoregional criteria for 6E	NSIU K	Terrestrial crayfish chimneys were recorded at three locations: • Eighteen crayfish chimneys were recorded at reach CRT2-7; • Numerous crayfish chimneys were recorded at reach HV8; and • One crayfish chimney was recorded in a farm field margin west of the NSIU K woodland Habitat criteria are met (1 or more chimneys located in a MAM or moist terrestrial site) at CRT2-7 and HV8, therefore this SWH type is present. This SWH type is not present in Peel-Caledon (2009) SWH study.

4.5 Fluvial Geomorphology

4.5.1 Importance/Purpose

Fluvial geomorphology is the study of river processes and form. The processes, which determine the form and stability of a stream system, are dependent on numerous underlying controls including climate, land use, topography, geology, vegetation, and other natural and anthropogenic influences. A watercourse can achieve stability once it reaches a state of dynamic equilibrium with these controls. Land use alterations, such as urbanization, can impact watercourses by altering the availability of water and sediment in a catchment. Watercourses respond to changes in flow and sediment supply through adjustments in channel form and position by way of erosion and depositional processes. To understand, predict and mitigate potential impacts of a proposed development plan on a watercourse system, geomorphic assessments are required to support appropriate planning decisions.

To characterize existing geomorphic conditions and assess the potential impacts of land use change on stream morphology within the Heritage Heights Study Area, a geomorphic assessment was completed. In support of this assessment, the following tasks were undertaken:

- Review of available background information with specific emphasis on the North West Brampton Phase 2 Urban Expansion Area Study, Environmental Open Space Study, and the HFSWS;
- Preliminary assessment or refinement of basin morphometrics and subcatchment boundaries using topographic mapping, digital drainage layers and current ortho-aerial photographs to determine parameters such as stream order, sinuosity and gradient;
- Identification or refinement of existing channel reaches based on channel form, gradient, local geology, degree of valley confinement, and land use;
- Update the historic analysis that was completed for the North West Brampton Phase 2 Urban Expansion Area, Environmental Open Space Study at tributary level (the historical assessment will determine the degree of channel alteration, planform adjustment or land use change that may have occurred over the available historic record (i.e. 1954, 1978, 1999 and 2004)), where possible;
- The rapid assessment of existing geomorphic conditions on a reach basis using RGA, RSAT and Down's methods;
- Detailed collection of geomorphic data along those reaches which are deemed most sensitive to alterations in land use/flow regime;
- Application of a variety of sediment transport equations to determine the mobility of the bed material and (as applicable) erodibility of banks for each detailed site to establish erosion thresholds; and,
- Based on the background review, an overall categorization of reaches based on physical characteristics will be developed and used to draw preliminary inferences with respect to reach sensitivity (these inferences will be verified through the field inventory).

4.5.2 Background Information

Prior to initiating the geomorphic field assessment, a review of available relevant background information was completed. The following section provides an overview of previous study findings, and their relevance to geomorphic conditions and constraints within the Heritage Heights lands, as well as an assessment of historic trends in land use and drainage networks over the available record, dating to 1954.

Previous Studies

Available information pertaining to the Credit River tributary and West Huttonville Creek watersheds within the general study area was reviewed to provide insight into underlying geomorphic controls affecting the system. This included a review of available topographic and geological mapping, aerial photographs, geotechnical reports, and any previous reports that were compiled for the study area. The following sections provide a summary of available background documentation relevant to the fluvial geomorphology of the Heritage Heights lands.

Gateway West Subwatershed Study Draft Update (CVC, 2007)

The Gateway West Subwatershed Study Draft Update (CVC, 2007) identified three main categories of drainage systems in the study area: primary, secondary and tertiary. Primary drainage systems take the form of a well-defined and mature valley, containing older and younger alluvium. Secondary drainage systems are less well-defined, and flow within a smaller valley. Tertiary drainage systems occur as drainage patterns established on Halton Till and, to a lesser degree, on surficial sands. These systems usually manifest on the landscape as agricultural swales and other minor surface drainage channels that are typically dry, conveying runoff during peak storm events or during spring freshet conditions (CVC, 2007). The study generally characterized the Credit River valley as a primary drainage system. However, a review of the topographic mapping for the study area indicated that many of the delineated reaches within the watershed could have been classified as tertiary drainage systems, as many of these occurred as small agricultural swales with intermittent to ephemeral flow. This desktop evaluation was confirmed through field investigation. The lower reaches of West Huttonville Creek (HV3, HV4, and HV5) were identified as secondary drainage systems.

A review of the available mapping indicated that surficial soils in the study area were dominated by alluvium and Halton Till, which has a clayey-silt texture. The Halton Till formation is characterized by low permeability; as a result, there is little infiltration of precipitation, with the majority of water flowing overland through agricultural swales into primary and secondary drainage systems (CVC, 2007). The underlying bedrock, consisting of Queenston Shale, is exposed along the bed and valley walls at several locations in the study area, particularly within the Credit River valley. In general, valley slopes were characterized as steep; the formation of alluvial terraces was documented along the Credit River valley floor.

Mississauga Road Widening Class Environmental Assessment (TROW, 2006)

In 2006, Trow Associates Inc. completed an Environmental Study Report (ESR) for the Mississauga Road widening Class Environmental Assessment. The ESR study area corridor consisted of the length of Mississauga Road between Bovaird Drive and Queen Street in the City of Brampton and captured portions of both the Credit River and the Huttonville Creek watersheds. In support of regulatory requirements, a meander belt width assessment was undertaken for a portion of Huttonville Creek east of Mississauga Road, immediately downstream of Bovaird Drive (Highway 7). The purpose of this assessment was to delineate the erosion hazard limits associated with Huttonville Creek within the identified study area in order to evaluate any potential implications on the proposed road widening and requirements for mitigative measures. Using a desktop-based approach, the report identified a recommended meander belt width of 32.8 m for the Huttonville Creek reach. This dimension was delineated tangential to governing meander bends along the reach, and incorporated the average bankfull width as well as a 100-year migration rate. Given the proximity of the future road alignment to Huttonville Creek, bio-engineering measures were recommended to address potential long-term maintenance issues associated with channel erosion.

Design Brief: Unnamed Tributary of the Credit River. Mississauga Road Widening (Geomorphic Solutions, 2010)

In 2009, Geomorphic Solutions completed a geomorphic assessment of a tributary to the Credit River immediately west of Mississauga Road (CRT5) in support of the proposed widening of Mississauga Road between Ostrander Boulevard and Queen Street West. The purpose of this study was to assess the fluvial geomorphology of the tributary within the identified study limits and recommend an appropriate set of offset protection measures to mitigate long-term risk to the road in the form of channel erosion and migration processes. Any proposed measures would also need to function as enhancements to the existing terrestrial and aquatic habitat within the tributary corridor.

Through the geomorphic assessment, existing conditions along the tributary were characterized on a reach basis. Results from the rapid assessment tools indicated that, immediately downstream of Ostrander Drive, the tributary (*Reach CRT5-3 - upstream section*) was relatively poorly defined, taking the form of a wet meadow feature. An RGA score of 0.28 characterized the reach as being in a transitional or stressed state. The dominant mode of active adjustment was identified as aggradation (sedimentation); as evident through poor longitudinal sorting of bed materials, siltation in pools and medial bar formation. Evidence of planimetric form adjustment and degradation were also documented at the time of survey. RSAT results indicated a good overall degree of ecological health, with physical instream and riparian habitat identified as limiting factors. The Down’s (2004) method characterized the system as ‘D - Depositional’ due to consistent decreases in channel width and/or depth due to sediment deposition.

With distance downstream, the tributary transitioned to a well-defined channel with riffle-pool morphology (*Reach CRT5-3 - downstream section*). An RGA score of 0.52 characterized the reach as being in a state of active adjustment. The dominant mode of adjustment was identified as widening; as evident through fallen/leaning trees, exposed tree roots and basal scour through more than 50 percent of the reach. Evidence of planimetric form adjustment, aggradation and degradation were also documented at the time of survey. RSAT results indicated a good overall degree of ecological health, with physical instream and riparian habitat identified as limiting factors. The Down’s (2004) method characterized the system as ‘M – Lateral Migration’ due evidence of migration at most bends, in combination with the observed preservation of cross-sectional dimensions along the reach.

In order to inform the requirement for erosion protection measures in relation to the future road alignment, meander belt widths were delineated for the tributary within the study limits. **Table 4.5.1** presents the belt width dimensions as determined based on governing meander amplitudes, then incorporating the bankfull channel width and a 10% factor of safety to account for long-term adjustments in channel form. Recommended belt width dimensions ranged from 24.8-33.5 m for *Reach CRT5-3*.

Table 4.5.1. Meander Belt Width Delineation – Credit River Tributary Reach CRT5-3

Reach	Meander Belt Width (including bankfull width and factor of safety)
Reach CRT5-3 (Upstream Section)	24.8 m
Reach CRT5-3 (Downstream Section)	33.5 m

In addition to the rapid assessments, detailed geomorphic data collection was completed along *Reach CRT5-3* on May 7, 2009 (data summarized in Table 4.5.2). The detailed assessment included a level survey (along the channel thalweg and 10 cross-sections) and a detailed site sketch. Bankfull cross-sectional dimensions were determined using standard protocols and accepted field indicators. At each cross-section, bank characteristics were noted, including root density and depth and bank angle and height. A modified Wolman (1954) pebble count was also completed at each cross-section in order to determine the grain size distribution. The results of the survey and subsequent calculations of bankfull flow conditions are summarized in **Table 4.5.2**.

An erosion threshold was also presented in the form of critical shear stress for *Reach CRT5-3*. Given the degree of bedrock control on bed incision and erosion processes along the reach, the governing erosion threshold for the tributary was established in relation to the less resistant bank materials. This approach was supported by the rapid assessment findings, which identified channel widening as the dominant mode of channel adjustment.

Table 4.5.2. Summary of Detailed Assessment – Mississauga Road Widening (Reach CRT5-3)

Parameter	Reach CRT5-3
Channel Gradient (%)	3.52
Bankfull Gradient (%)	3.52
D_{50} (m)	0.014
D_{90} (m)	0.120
Average Bankfull Width (m)	3.0
Average Bankfull Depth (m)	0.2
Manning's 'n'	0.040
Calculated Bankfull Discharge (m^3/s)	0.91
Calculated Bankfull Velocity (m/s)	1.58
Critical Shear Stress (N/m^2)	10.2

Environmental Implementation Report and Functioning Servicing Report Four X Lands, Brampton, Ontario (Beacon Environmental, 2016)

In 2016, Beacon Environmental Ltd. completed an Environmental Implementation Report and Functioning Servicing Report (EIR/FSR) in support of the proposed Draft Plan of Subdivision application by Four X Developments Inc. The study area included a 42.75 hectare (ha) parcel located on Part of Lot 7, Concession 5, west of Hurontario Street in the City of Brampton (Subject Property), as well as 40 ha of Additional Lands immediately to the north and the adjacent lands. The EIR/FSR identifies a number of opportunities to protect and enhance the recommended Natural Heritage System (NHS) which includes the Credit River woodlands, valleylands, and associated ephemeral drainage features, Provincially Significant Wetland (PSW) Unit #46, and the intermittent tributary CRT5-5 valley and associated PSW Unit #45.

Management recommendations include the restoration of the riparian areas and naturalization of buffer zones associated with CRT5-5 and PSW Unit #45, as well as the creation of a wetland in the CRT5-5 valley a bioretention feature draining into it. Ephemeral drainage features CRT4A-1, CRT4B-1, and CRT4B-4 will also be retained and buffered. Plantings and naturalization are also recommended around the two stormwater management ponds and the tableland portions of CRT4A. Infrastructure and stormwater management practices, including a range of Low Impact Development measures are recommended to replicate the function of the upstream reaches of CRT4 and CRT5 that are proposed for removal on the Subject Property (CRT4A-2, CRT4A-3, CRT4B-2, CTR4B-3, CRT4B-5, and CRT5-6). While it was not explicitly mentioned in the report, removal of CRT5-6 will result in the removal of upstream reach CRT5-7 as well.

Effectiveness Monitoring Strategy, North West Brampton 2003 Report, Gartner Lee, January 2005

As a continuing component of the Effectiveness Monitoring Program implemented by the Credit Valley Conservation Authority, PARISH Geomorphic Ltd was retained in 2004 to continue the fluvial geomorphology component of the study. As part of the 2004 instalment of the monitoring study, previously established control sites located on Fletcher's Creek, Huttonville Creek and Springbrook Creek were revisited and available control points were re-measured. Additional sites were also established in the headwaters of Fletcher's Creek and on Springbrook Creek. In 2005 and 2006, these sites were revisited to assess channel change. There was one detail site located on Huttonville Creek that fell with the North West Brampton Study Area boundary. In 2003, a detailed site (EM7) was established west of Mississauga Road, just north of Highway 7. From 2003 to 2004, an increase in cross-sectional area of 0.3% was ascertained. The cross-section showed a drop in the channel bed and some scour of the right bank. This was offset by the accumulation of material on the floodplain area on the right side. 2 out of 3 erosion pins established in the area showed only 1 cm change while 1 pin showed 23 cm change, which was credited to local scour. Due to the small scale of the channel, these adjustments were attributed to measurement technique and/or typical channel evolution. In 2005, Site EM7 was moved to east of Mississauga Road, north of Highway 7 due to landowner issues (ref. Figure SM1). According to the cross-sectional analysis, this section of Huttonville Creek had experienced a 2.6% increase in area since the establishment of the new location. The erosion pins that had been installed in the area had very little change, with an average rate of bank erosion calculated was 1.3 cm/year. These changes were attributed to an increase in stream power created from seasonal changes in flow regime.

Credit River Tributary Monitoring Program 2008 Report (CVC and Parish, 2009)

From 2007-2009, Credit Valley Conservation (CVC) conducted a fluvial geomorphic monitoring study of three tributaries to the Credit River within the Heritage Heights lands. The geomorphic study, completed by PARISH Geomorphic Ltd. entailed the collection of detailed geomorphic field data at three stations along individual headwater tributaries (CRT1, CRT2 and CRT4). Note these sites are located within the Greenbelt. The location of these geomorphic monitoring sites is provided in Appendix 'E' (E-4). Each fluvial geomorphic station included the establishment of long-term monitoring stations which allowed re-sampling of channel bed substrate, erosion pins, a control cross-section and longitudinal bed profile.

Credit River Tributary CRT1

The CRT1 geomorphic monitoring site was established within Heritage Heights *Reach CRT1-1*. Within the surveyed extent, the tributary exhibited evidence of active erosion, including basal scour, headcutting due to knickpoint migration, exposed tree roots, formation of scour pools and incision into the underlying shale bedrock. Over the 3-year monitoring period, Site CRT1 displayed an overall decrease in cross-sectional area of 5.95%; however, an increase of 0.20% was noted between 2008 and 2009. Repeated erosion pin measurements indicated an average bank migration rate of 0.19 m/yr.

Credit River Tributary CRT2

The CRT2 geomorphic monitoring site was established within Heritage Heights *Reach CRT2-1*, downstream of Bovaird Drive West. Within the surveyed extent, the tributary exhibited evidence of morphologic adjustment in the form of medial bar and chute formation. Over the 3-year monitoring period, Site CRT2 displayed an overall increase in cross-sectional area of 2.89%. Repeated erosion pin measurements indicated an average bank migration rate of 0.11 m/yr.

Credit River Tributary CRT4

The CRT4 geomorphic monitoring site was established within Heritage Heights *Reach CRT4-1*, upstream of the tributary confluence with the Credit River. Within the surveyed extent, the tributary exhibited evidence of active erosion in the form of basal scour, exposed tree roots and formation of scour pools. Over the 3-year monitoring period, Site CRT4 displayed an overall increase in cross-sectional area of 7.48%; however, a decrease of 2.18% was noted between 2008 and 2009. Repeated erosion pin measurements indicated an average bank migration rate of 0.07 m/yr.

Overall, the report recommended that future monitoring be undertaken to determine longer-term trends in channel adjustment in order to establish whether the rates of adjustment observed were reflective of natural channel processes, or were a reflection of local changes in hydrologic and sediment regime conditions.

Mount Pleasant Huttonville and Fletcher's Creek Subwatershed Study (HFSWS)

The HFSWS characterized resources associated with the subwatershed study area, identified potential impacts to these resources based on a series of possible future land use scenarios, and established a set of management solutions for consideration into the Secondary Planning process. A long-term monitoring initiative to evaluate the effectiveness of management and implementation strategies was also undertaken.

Surficial Geology

Surficial geology within the HFSWS lands included a significant fine grained (silt and clay of the Halton Till) component as well as sand, gravel or larger stones. The texture and reddish brown colour of the Halton Till reflects the underlying Queenston shale. Glacial melt water left behind eroded sand and gravel as older alluvium, while within glacial lakes, silt and clay (glaciolacustrine) deposits remain. Along portions of the Credit River and tributaries, erosion through both the glaciolacustrine and Halton Till deposits has exposed the underlying shale bedrock within stream valleys, which may also contain sand and gravel deposits. More significant deposits of sand and gravel are observed in vicinity of the confluence of tributary valleys with the Credit River valley system.

Fluvial Geomorphology

In order to assess potential impacts of the proposed development on stream morphology within the North West Brampton Study Area, a detailed fluvial geomorphic study was undertaken. Tasks completed in support of this study included a review of available background information, delineation of reaches, rapid field assessment on a reach basis and detailed geomorphic data collection at representative sites. The field program was based on reaches originally delineated for the North West Brampton Environmental Open Space Study (Dougan & Associates *et al.*, 2005). Minor refinements to reaches *HV19, HV23, F18 and F22* were then identified, based on available mapping and agency review.

The geomorphological inventory of the channel system was developed based on fieldwork conducted between May 2005 and November 2007. As part of the North West Brampton Environmental Open Space Study (Dougan & Associates *et al.,* 2005), field reconnaissance had already been completed for defined channel reaches. This work consisted of a synoptic-level survey that was intended to confirm the findings of the 2005 report, qualitatively assess any reach-specific problems, and assess overall reach stability and sensitivity. As part of the HFSWS geomorphic assessment, reaches that were not assessed in 2005 (i.e. agricultural swales) were evaluated in 2007 to document channel characteristics.

Two different channel assessment techniques were applied to reaches with a defined channel; the Rapid Geomorphic Assessment (RGA) and the Rapid Stream Assessment Technique (RSAT). The geomorphological aspects of the "Evaluation, Classification and Management of Headwater Drainage Features: Interim Guidelines" were released by CVC and Toronto and Region Conservation (TRCA) in March, 2007 were originally applied as part of the 2007 field assessments. Subsequent to completion of the fieldwork in 2007, updated guidance was issued in the form of the publication in March 2009. This guidance was applied retrospectively to provide an updated, integrated reach characterization.

To gain further insight into geomorphic processes occurring within the Study Area, detailed field sites were established in May 2006 along Reaches *HV6, HV24* of Huttonville Creek and F15 of Fletchers Creek. The locations of these sites were selected to provide good representation of the overall watershed. At each of the detailed sites, cross-sections were measured at ten locations, including pools, riffles and transitional areas. At each transect, bankfull widths and depths, entrenchment, as well as low flow dimensions were recorded. Substrate was sampled using a modified Wolman (1954) pebble count. Sub-pavement was also characterized at each cross-section. Bank assessments included measurements of height, angle, composition, in-situ shear strength, vegetation and rooting depths. Each geomorphic field site included one control cross-section and erosion pins to permit re-measurement. A level survey of the site was also conducted, including bankfull elevations, maximum pool depths, top and bottom of riffles and any obstruction to flow.

Based on the field reconnaissance work, four monitoring sites were established in May 2005 at Huttonville Creek Reaches *HV2, HV3(a/b)* and *HV9*, with a fifth site established at HV29 in November 2005. A further three monitoring sites were established in May 2006 along Reaches *HV6, HV24* (Huttonville Creek) and *F15* (Fletcher's Creek).

Through extensive discussions with CVC, erosion thresholds were determined for both Huttonville and Fletcher's Creek. At the request of CVC, erosion thresholds were calculated for sites EM10 and SW4, due to their sensitivity to changes in land use and flow regime. These erosion thresholds were then used to inform stormwater management strategies for the study area.

The HFSWS stormwater management strategy proposed that in-stream erosion impact mitigation be addressed through the incorporation of extended detention storage within stormwater management facilities. The HFSWS determined unit storage and release rates for use in sizing the erosion control portion of the SWM facilities to meet erosion mitigation targets, assuming no LID measures were in place. Referring to Table 2.7 from the HFSWS Phase 3 Report (June 2011), the following criteria were identified for Huttonville Creek (Site EM10):

- Extended Detention/Erosion Storage: 200 m^3/imp ha
- Extended Detention/Erosion Release Rate: 0.00052 m^3/s/ha

It should be noted that the unitary release rates provided for Site EM10 were calculated using empirical methods at the subwatershed study scale (i.e., a high level). Field verification over a range of flow conditions and further detailed review of the reported release rate is, therefore, required in order to support these values.

Headwater Swale Assessment

In order to further understand the contributive role of headwater systems within the study area, a detailed headwater swale assessment was undertaken. The study utilized field-based flow regimes and sediment yields to calibrate sediment transport models such that they can better predict entrainment conditions within poorly defined headwater systems. The headwater field sites established for this project consisted of three small groups of low-order channels located in the headwaters of Huttonville and Fletcher's Creek. Both the Western and Central swale sites referenced within this assessment are captured within the Heritage Heights lands.

Each site consisted of two first order swales that fed into a second order channel. Two monitoring transects with two sediment traps per transect were installed on each swale and the channel; a pressure transducer was installed at the downstream limit of each site. Sediment traps were also installed on each bank adjacent to in-stream locations to assess the source of sediment in the channel. Longitudinal profiles of all channels were completed to determine local gradients and monitoring adjustments in swale profile. Erosion pins were installed in several banks at each site to provide a direct measure of lateral channel migration. Spot flow measurements were then used to calibrate the pressure transducer data and develop rating curves for each site. All sites were monitored to capture localized storm events from 2006- to 2007.

Results of the study indicated that the effects of zero order streams must be included to properly characterize the drainage patterns, and the flow regimes of headwater swales. Total measured volumes and rates of sediment delivery within the headwater systems confirmed that these systems were producing significant volumes of sediment to downstream reaches, with suspended load identified as the most likely mode of transport. Study findings emphasized the importance of addressing to what degree headwater streams must be replicated in order to maintain downstream channel health.

The headwater assessment recommended that subwatershed management strategies should not only consider the replication of flow delivery rates, but also management, sediment delivery rates from headwater systems. Indeed, every attempt should be made to maintain headwater systems that are producing large volumes of sediment as they are the most influential in maintaining aquatic habitat in the lower portions of the watershed. In conjunction with implementing stormwater management practices that focus on mimicking pre-development hydrographs, this strategy should offer the highest probability of maintaining stream health in a post-development scenario.

Historical Aerial Photographs

Historic land cover, land use, and planform adjustments were examined using black and white aerial photographs from 1954 (1:15,840), 1971 (1:15,840), 1978 (1:10,000), 1982 (1:30,000) and 1990 (1:30,000) from the University of Waterloo Map Library, and colour digital photographs from 2005 and 2009 (Google Earth Pro®) to obtain a simple qualitative assessment of the degree of channel change over time (Appendix 'E' (E-1)). The resultant historical assessment represents an update to the historic analysis that was completed for the North West Brampton Phase 2 Urban Expansion Area, Environmental Open Space Study. Observations have been subdivided into an overall description of land use change over the available historic record, as well as a more detailed summary of historic conditions on a tributary basis.

In 1954, land use within the study area was primarily agricultural (orchards, pasture and crop). Mature tree cover was limited to hedgerows lining agricultural fields, along with isolated woodlots, and the Credit River valley system. All of the major roads present within the study area (i.e., Mississauga Road, Embleton Road, Heritage Road, Winston Churchill Boulevard and Mayfield Road) had been constructed prior to 1954. Residential development was limited to the Town of Norval; scattered rural residential dwellings were observed along the major roads and intersections. A dam structure was present upstream of Mississauga Road, south of River Road. Upstream of the dam, an extensive backwater condition was observed, along with numerous medial bars. Evidence of relic channel locations (oxbow features) could also be observed along what is now Embleton Road.

By 1971, the Town of Norval had expanded eastward and the density of rural residences had increased along each of the major roadways. Winston Churchill Boulevard was extended south from Old Pine Crest Road. Two race tracks were observed west of Mississauga Road, south of Bovaird Drive West and east of Winston Churchill Boulevard, immediately south of Wanless Drive. Orchards dominated the tablelands along the Credit River valley at Heritage Road. Overall, however, the extent of agricultural fields and woodlots remained consistent relative to 1954. Between 1954 and 1971, the development of a well-defined channel within the dam backwater zone along the main Credit River represented the most obvious change in channel planform.

By 1978, Mississauga Road had been widened and residential development had extended along River Road. Embleton Road had also been constructed. Between 1971 and 1978, residential homes could be observed lining River Road, as well as the Mississauga Road and Embleton Road intersection, reducing forest cover within that area. The Town of Norval had expanded to the south, along Winston Churchill Boulevard, south of Bovaird Drive. The breach in the Credit River dam was captured through this year of aerial coverage.

By 1982, the Town of Huttonville expanded north, and Ostrander Boulevard and Huttonville Drive had been constructed. The density of residential dwellings had also increased along the major roads, especially at Embleton Road and Bovaird Drive. Overall, with the exception of minor reductions in forest cover along the Credit River valley, minimal change in land use was evident by 1991.

Between 1991 and 2009, residential development had expanded substantially outside of the study area, most notably east of Mississauga Road along Huttonville Creek. The breached dam upstream of Mississauga Road was still observed, with the main branch of the Credit River exhibiting a well-defined active channel. Residential development in association with the Town of Huttonville had also expanded to the southwest along Heritage Road and Embleton Road. Commercial development could now be observed to the north east of the Mississauga Road and Queen Street intersection.

Huttonville Creek Tributaries

Between 1954 and 2009, minimal changes in channel planform and characteristics were observed. The most notable modification to the Huttonville Creek watershed has occurred in recent years, with the development of Blocks 3 and 5, east of Mississauga Road. Medium and low density residential development has expanded in these areas since 2006. This includes Blocks 1 and 2, and the Credit Valley Secondary Plan area located adjacent to Huttonville Creek, between Bovaird Drive and Creditview Road and north of Queen Street. Block 3 is to the east, and includes the lands adjacent to the main Springbrook Creek, as well as the west (SV7) tributary to Springbrook Creek, immediately west of Creditview Road, as well as the East Tributary to Springbrook Creek and Tributary 8B, north of Queen Street. Block 5 includes the lands east of Creditview Road, south of Queen Street and east of Chinguacousy Road and include the main Springbrook Creek and Tributary 8B.

Note that sections of East Huttonville Creek through the Mount Pleasant lands, which include the Clark drain (HV29) and Rowntree drain (HV24, HV22, and portions of HV19 to the CNR) were subject to channelization under Drainage Act authorizations. These are outside the Heritage Heights Study Area.

Credit River Tributary 1 (CRT1)

CRT1 originates as a small headwater swale through an agricultural field north of Mayfield Road. The swale transitions to a more defined channel south of Mayfield Road, where numerous swales drain into the tributary. North of the CN Rail Line, the tributary exhibited evidence of extensive modification (channelization) to support adjacent agricultural land use. There was a noticeable increase in channel width and sinuosity with distance downstream of the CN Rail crossing. Further downstream, CRT1 transitions to a confined, forested valley system prior to crossing Winston Churchill Boulevard. Between 1954 and 2009, minimal change in channel planform or dimension was observed downstream of the Rail Line.

Credit River Tributary 2 (CRT2)

In 1954, tributary CRT2 appeared as a series of agricultural swales between Mayfield Road and Wanless Drive. Downstream of Wanless Drive, the feature exhibited a greater degree of definition. This definition, however, appeared to be associated with active maintenance (excavation) over time. Downstream of the rail line, a sinuous channel situated within a well-defined floodplain could be observed, particularly in the

1978 coverage. The presence of meander scars provided evidence of planimetric adjustment. Overall, the degree of forest cover within the tributary corridor has increased between 1954 and 2009.

Credit River Tributary 2A (CRT2A)

In 1954, CRT2A originated as a headwater swale flowing through an agricultural field south of Bovaird Drive. The tributary then transitioned to a more defined feature as it entered the Credit River valley. In 1978, grading activities were observed. In the 1982 aerial coverage, an office building and existing offline pond with associated diversion channel had been constructed. By 2009, a pond at the western edge of the residential property had been implemented. Due to forest cover, changes in channel planform and characteristics could not be identified downstream of the pond. Upstream of the pond, minimal evidence of planimetric adjustment was observed between 1954 and 2009.

Credit River Tributary 3 (CRT3)

Between 1954 and 1971, land use along the tablelands south of CRT3 in vicinity of the Credit River valley transitioned from crop-based agriculture to orchards. By 1978, these orchard fields had expanded, along with the farm located west of Heritage Road. Grading activities associated with an informal crossing of the tributary could be observed within *Reach CRT3-4* in 1978. This crossing had been completed by 1982. Beyond these minor changes in land use activity, little planform adjustment or land use modification was discernible between 1954 and 2009.

Credit River Tributary 4 (CRT4)

In 1954, land use surrounding tributary CRT4 consisted of both crop and orchard agriculture. CRT4 originated north of Bovaird Drive and flowed southward towards the Credit River. The existing online pond at *Reach CRT4-4* was evident as early as 1971. In 1954, prior to the construction of the pond, tributary CRT4 *Reach CRT4-5* took the form of a defined, sinuous channel. Evidence of active geomorphic processes were observed in the form of bank erosion and multiple flow path formation. Following construction of the pond, little discernible form could be observed along the upstream reaches of tributary CRT4. By 2009, however, riparian vegetation had increased and upstream channel form could be discerned along *Reach CRT4-5*; however, the feature location had shifted position to occupy a former high-flow path to the east. The relic channel to the west can be observed in the 2009 coverage.

Credit River Tributary 4A (CRT4A)

In 1954, CRT4A appeared as a small headwater swale flowing through an agricultural field, prior to draining into the Credit River valley. Due to forest cover, changes in channel planform were difficult to observe over the historic record.

Credit River Tributary 4B (CRT4B)

In 1954, CRT4B took the form of two agricultural swales that confluenced along the Credit Valley top of slope into a single gully feature. Major modifications to the tributary included the development of a residential community along River Road and Ostrander Boulevard between 1991 and 2009. In association with this development, *Reach CRT4B-2* was converted to a rear yard swale.

Credit River Tributary 5 (CRT5)

In 1954, land use within the general study area consisted primarily of agriculture, with numerous orchards observed; residential dwellings were isolated. Mature tree cover was largely observed in relation to the Credit River valley, with hedgerows delineating agricultural fields. *Reach CRT5-5* was lined with trees within the exiting cattle pasture and a small online pond was observed at the downstream extent of the property limit. Between 1954 and 1971, tributary CRT5 was no longer tree-lined and the entire portion of the tributary immediately downstream of the subject lands appeared to have been straightened. A second pond was observed upstream of the existing farm laneway. River Road had been constructed and residential development had begun to establish along the road. By 1978, Mississauga Road had been widened and residential development had extended along River Road. Embleton Road had also been constructed. Downstream of the study limits, tributary CRT5 exhibited evidence of active adjustment through bank erosion and channel migration. Between 1978 and 1982, Ostrander Boulevard had been constructed and preliminary grading, along with additional residential development south of the study area, was observed.

By 1990, Huttonville Drive had been constructed and residential development had expanded along Mississauga Road and Embleton Road. Little change was observed within the study limits with respect to land use or channel planform. Between 1990 and 2009, residential development had expanded substantially outside of the study area, most notably east of Mississauga Road along Huttonville Creek. The two online ponds previously observed along CRT5 were no longer present, and riparian vegetation had begun to re-establish along the downstream corridor.

Summary

Based on the findings of the historic assessment, it is apparent that the study area has been heavily modified by historic land use. Activities, such as on-going agricultural land use, have resulted in degraded morphology (channel definition and degree of diversity). This, in turn, holds implications with respect to the quality of aquatic and terrestrial habitat. Topography within the subject lands is sufficiently steep such that, over time, one could expect headwater features to gradually achieve a degree of definition over time. However, farming practices have continued to re-work the features on a seasonal basis. More defined drainage features, such as the Credit River tributary west of Mississauga Road, lack diversity in form due to historic straightening and loss of riparian buffer to facilitate drainage of the adjacent lands. From a function perspective, the overall active nature of the land use within the site as well as individual drainage features would result in greater sediment production potential for delivery to downstream reaches, as the systems attempted to adjust to anthropogenic perturbations. Given the extensive length of time over which these land practices and modifications have occurred, the resultant morphologic adjustments to historic activities (and any future proposed land use change) along the downstream receiving systems would be expected to continue well beyond the 100-year planning timeframe.

4.5.3 Methods

The field-based geomorphic assessment involved the following key tasks:

- Reach delineation;
- Rapid assessments;
- Detailed geomorphic data collection;
- Preliminary development of erosion thresholds;
- 2017 field assessment to confirm geomorphic conditions.

An overview of the methods employed in support of each task has been provided below.

Basin Morphometrics

Every watershed possesses a quantifiable set of geomorphic properties that define the topographic characteristics of the watershed. These variables obey statistical relations and can be used to describe drainage network characteristics. Such parameters include stream order, basin length, total catchment relief, and drainage density. To provide a context for the field-based geomorphic observations, an analysis of basin morphometrics including stream order and drainage density was undertaken on a catchment and subcatchment basis for the Heritage Heights lands.

Stream Order

Stream order describes the composition of a drainage network through varying levels of magnitude and expresses this magnitude in mathematical terms. Each stream segment within a catchment is assigned a particular order which indicates its relative importance to the overall network. Low order streams represent minor tributaries (headwater features), while higher order streams represent the main branch (trunk) of the river. A stream segment with no upstream contributing tributaries is designated as a first-order stream. Where two first-order stream segments confluence, they form a second order segment; where two second-order segments confluence, a third-order segment is formed, and so forth. Obviously, the scale at which stream order analysis is undertaken will greatly influence the results of the assessment. The larger the scale, the more headwater (first order stream) will be mapped. For the purposes of this study, stream ordering was based on available digital drainage network mapping (CVC, 2012).

Reach Delineation

The planimetric form of a watercourse is fundamentally a product of the channel flow regime and the availability and type of sediments (i.e., surficial geology) within the stream corridor. The 'dynamic equilibrium' of these inputs governs channel planform. These factors are influenced on smaller systems by physiography, riparian vegetation and land-use. In order to facilitate a systematic evaluation of the study area and to account for all these factors, channels are separated into reaches. Reaches are homogenous sections of channel with regards to form and function, with consideration to channel gradient, hydrology, surficial geology, land use, and vegetative controls (Montgomery & Buffington, 1997; Richards et al., 2007). Each reach is therefore expected to adjust in a generally uniform manner along its full length to changes in hydrology and sediment supply, as well as other modifying factors.

Reach delineation was completed using the available series of aerial photographs (Google Earth Pro, 2009), topographic mapping, and drainage network mapping (CVC, 2012) for the study area. Field observations were used to confirm and refine the limit of reaches delineated through the desktop assessment to reflect any observed transitions in land use, riparian cover, valley confinement, or channel modification that were not reflected in the available mapping. Some reaches were divided to reflect existing field conditions. In consultation with the City of Brampton and CVC, a ground-truthing field evaluation was undertaken in April 2012 to confirm the presence and absence of low order drainage features within the study area. As a result of this assessment, minor revisions were made to the drainage network mapping. The reach enumeration for HHSWS was established such that it was consistent with both the HFSWS, as well as the CVC Credit River tributary nomenclature.

Rapid Assessments

In addition to the desktop assessment, existing geomorphic conditions were characterized for the reaches in the study area. Two rapid assessment tools, the Rapid Geomorphic Assessment (RGA) and Rapid Stream Assessment Technique (RSAT) were used to assess the watercourse. The RGA documents observed indicators of channel instability (MOE, 2003) 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 in regime (score <0.20), in transition/stressed (score 0.21-0.40), or in adjustment (score >0.41). The RSAT offers a slightly different approach by using an index to quantify overall stream health and includes the consideration of biological indicators. Observations concerning channel stability, channel scouring/sediment deposition, physical instream habitat, water quality, and riparian habitat conditions are used in an index to produce values that indicate whether the channel is in poor (<13), fair (13-24), good (25-34), or excellent (35-42) condition. The Down's (2004) classification was also used as an indicator of morphological adjustment. This classification scheme categorizes channels based on adjustment processes and changes in channel form. For example, streams are characterized as stable, laterally migrating, enlarging, undercutting, aggrading, or recovering.

Detailed Field Investigation

Building upon the findings of the rapid field assessments, detailed geomorphic field sites were selected in consultation with the study disciplines. The location of the detailed sites was governed by the need to reflect those reaches most sensitive to alterations in land use and flow regime, while also providing the data necessary to perform erosion analysis in support of future stormwater management recommendations. With this in mind, five detailed field sites were selected: Reaches *CRT2-4, CRT3-5, CRT4-5, HV4* and *HV9*.

Detailed data collection included measurements of bankfull/active channel dimensions, characterization of bed materials using a modified Wolman (1954) pebble count, evaluation of bank characteristics including composition, degree of vegetative cover and in situ shear strength, and sub-pavement characterization using bulk samples and standard sieve and hydrometer techniques. A longitudinal survey was conducted at each site in order to document bed morphology and estimations of bankfull stage in order to identify the local energy gradient.

The assessments documented a number of key geomorphological parameters, including basic planform geometry, longitudinal profiles, and cross-sectional morphology. Five to eight cross-sections were surveyed at each site, depending on the degree of geomorphic diversity and scale of the drainage feature. Each cross-section surveyed extended beyond the active (bankfull channel) to include the adjacent floodplain. Where possible, bankfull dimensions were quantified within each cross-section using standard protocols and field indicators (e.g., changes in bank slope, vegetation, and soil type; mineral stain lines on boulders and bedrock, top of point bars and bank undercuts). At each cross-section, bank characteristics were also noted, and a modified Wolman (1954) pebble count was also completed to determine the substrate grain size distribution.

Long-Term Monitoring

Following CVC protocols, long-term monitoring stations were established at detailed geomorphic field sites, where appropriate. Monitoring cross-sections were established by installing monumented pins along the channel top of bank; erosion pins were also installed horizontally in the face of several banks to provide a method of quantifying any migration of the channel at these locations. It should be noted that, due to the poorly-defined nature of the majority of the detailed geomorphic field sites, the installation of erosion pins was not feasible.

Erosion Thresholds

Heritage Heights Detailed Field Sites

Erosion thresholds determine the magnitude of flows required to potentially entrain and transport sediment in the channel. An erosion threshold provides a depth, velocity, or discharge at which sediment of a particular size class (usually the median or averaged stone size) may potentially be entrained. This does not necessarily mean systemic erosion (i.e., widening or degradation of the channel); it simply indicates a flow, which may potentially entrain sediment (i.e., initiation of motion of boundary materials). Given the variability within reaches, this approach provides a planning-level approximation of reach-scale erosion thresholds. Nevertheless, it offers an effective overview of the overall sensitivity of the system

Erosion threshold analyses were undertaken for all five detailed geomorphic field sites, using representative cross-sections from each site. The location of these sites is provided in Appendix ‘E’ (E-4). The calculations performed to determine critical discharge (discharge at which entrainment could potentially occur) were completed using sediment entrainment models based on both a critical shear stress (Miller *et al*., 1977) and permissible velocity (Komar, 1987) approach. A discharge was then back-calculated to determine the erosion threshold using the appropriate model. The recommended critical discharge is reflective of observed convergence between modelled results for the individual surveyed cross-section.

Credit River Tributary Monitoring Program Sites

In addition to the five detailed geomorphic field sites surveyed through this study, erosion threshold analyses were also undertaken for the three long-term geomorphic monitoring sites established through the Credit River Tributary Monitoring Program (CVC/PARISH Geomorphic Ltd.). The location of these sites is provided in Appendix 'E' (E-4). Detailed geomorphic data as provided by CVC was analyzed for *Reaches CRT1-1*, *CRT2-1* and *CRT4-1* of the Heritage Heights lands using representative cross-sections from each site. Calculations were then performed to determine critical discharge (discharge at which entrainment could potentially occur) were completed using sediment entrainment models based on both a critical shear stress (Miller *et al*., 1977) and permissible velocity (Komar, 1987) approach. A discharge was then back-calculated to determine the erosion threshold using the appropriate model. The recommended critical discharge is reflective of observed convergence between modelled results for the individual surveyed cross-section.

2017 Field Assessment

An updated field assessment was conducted in 2017 given the amount of time that has elapsed since the initial field assessments in 2011. A "wind shield" reconnaissance type of assessment was completed to confirm that there had not been any significant geomorphic changes to the watercourses since the 2011 field assessments as recommended by CVC. During the 2017 assessment the accessible main branches of the watercourses outside of the Credit River NHS Block were walked and the watercourses at the main road crossings along Wanless Drive and Bovaird Drive were visited and photographed. This included 8 road crossings, 3 C.N. railway crossings, and 8 reaches or sections of reaches. A figure illustrating the reaches and crossings visited is provided in Appendix 'E' (E-7). A photographic record of existing conditions was prepared, and any new significant geomorphic issues were documented.

4.5.4 Results

Basin Morphometrics

Stream Order

Appendix 'E' (E-2) provides an overview of the stream order classification process undertaken in support of the Subwatershed Study. Results of the analysis clearly illustrate the prevalence of first and second order streams within the study area. The highest order of stream classified through the exercise was the portion of Huttonville Creek, just east of Mississauga Road within the neighbouring Mount Pleasant lands. Within the study limits, third order streams were the highest order characterized along both Huttonville Creek and the Credit River tributaries.

Reach Delineation

A summary of general reach characteristics (length, gradient, sinuosity) for Huttonville Creek and the Credit River tributaries has been provided in Appendix 'E', Table E-1. Results of this analysis indicate that gradients within the study area range from 0.06-28%, reflecting the marked disparity in topography between the lower order tableland reaches and downstream gully draining into the Credit River valley. The reach-averaged slope of the study area was 2.3%. Sinuosities ranged from 1.0-1.5, with an average of 1.12. The low degree of sinuosity on average within the study area reflects both the degree of channel modification to facilitate drainage practices, as well as the relatively steep nature of the topography. A figure illustrating the extent of delineated reaches for the Heritage Heights study area is provided in Appendix 'E' (E-3).

Rapid Assessments

The majority of the reaches evaluated through the rapid field assessment were characterized as headwater drainage features, for which rapid assessment protocols could not be applied. It was noted, however, that the degree of feature definition within these headwater systems was heavily influenced by active agricultural practices, such as excavation, planting of crops or clearing of vegetation. Rapid assessment results for defined reaches has been provided in Appendix 'E' (Table E-2), while a figure illustrating rapid assessment results within the Heritage Heights lands has been provided in Appendix 'E' (E-4). A photographic record of all surveyed reaches within the accessible land parcels has been included in Appendix 'E' (E-5).

Credit River Tributaries

The morphology of the Credit River tributaries was generally governed by headwater swales and valleyland gullies. Selected defined channel reaches displaying moderate gradients and maintaining a degree of sinuosity were observed at the transition between these two archetypes. The headwater reaches of the Credit River tributaries had been heavily modified by historical and on-going land use practices, largely in the form of straightening, excavation and planting of crops. The few defined reaches along the tablelands appeared to occur at the point at which the tributaries had incised through the Halton Till overburden, into the underlying shale bedrock. These reaches also tended to exhibit a degree of valley confinement. These reaches were typically characterized as being in a transitional or active state of adjustment, exhibiting evidence of widening and planimetric adjustment (e.g., *CRT2-4* and *CRT2-5*). The remaining gully features were characterized as high-gradient systems with minimal sinuosity. These systems offered varying degrees of definition, largely in relation to their associated upstream drainage area. All of the gully features were situated within deeply incised confined valley settings, with bed materials reflecting the exposed shale surface.

West Huttonville Creek

The headwaters of West Huttonville Creek were dominated by actively farmed drainage swales, which occasionally gained a minor degree of definition through hedgerows or isolated woodlots. Through the portions of West Huttonville Creek accessible through this study, a defined channel was observed along *Reaches HV3, HV4* and *HV5*, all of which scored as being in a transitional or 'stressed' state. Widening and planimetric adjustment generally represented the dominant morphologic processes observed along these reaches. These processes are consistent with systems that have been modified (straightened) to support land use activities. RSAT scores for these reaches were typically 'fair', with ecological health largely limited by a lack of riparian and aquatic habitat diversity. All of the defined reaches along Huttonville Creek scored as being in a state of planform adjustment (lateral migration) using the Down's tool.

Detailed Field Investigation

A summary of general channel characteristics for each detailed site is provided in Table 4.5.3, while a detailed summary of data collection results has been provided in Appendix 'E' (E-6). The locations of the five detailed field sites established through the HHSWS was determined based on a number of objectives, including spatial representation of the study area, permission to enter agreements, location of existing long-term monitoring sites (i.e., CVC CRT monitoring sites) and future stormwater servicing requirements for the lands. Given the overall lack of channel definition within the study area, four of the five surveyed field sites were established within headwater drainage features. While every effort was made to identify active channel dimensions within each of these sites, the majority of the sites had been heavily modified and lacked bankfull indicators.

Erosion Thresholds

Results of the erosion threshold analysis in support of the HHSWS are presented in **Table 4.5.3** and **Table 4.5.4**. These critical flows will be used to determine future conditions for proposed development within the study area and, ultimately, provide guidance for the preliminary sizing of stormwater management facilities. For clarification, an erosion threshold provides a discharge at which sediment may potentially be entrained. This does not necessarily mean systemic erosion (i.e., widening or degradation of the channel); it simply indicates a flow which may potentially entrain sediment (i.e. initiation of motion of materials).

In natural systems, erosion thresholds are exceeded regularly, ensuring the downstream delivery of sediment. As such, the key to maintaining natural channel function of a system is not to prevent exceedence of the threshold but to ensure that the frequency and duration of time for which it is exceeded does not increase under the post-development conditions. Thus, existing rates of erosion should not be exacerbated under the future land use scenario.

Given the poorly defined nature of the majority of the detailed field sites, the erosion threshold should be considered preliminary and highly conservative in nature. Additional field verification of these thresholds is required in order to ensure that the sediment entrainment models are providing an appropriate and representative target. It is anticipated that, through these further verifications, the erosion threshold targets could be increased.

Heritage Heights Detailed Field Sites

Results presented below of the HHSWS detailed field sites reflect parameters averaged over a set of representative cross-sections. For *Reaches CRT3-5, CRT4-5, HV4* and *HV9*, channel dimensions were estimated based on factors such as inflection points in floodplain topography. At the time of survey, *Reach HV9* has recently been ploughed, resulting in a poor degree of confidence in any estimate of critical discharge. All of the surveyed field sites for which erosion thresholds were derived indicated a high degree of sensitivity to altered flow regimes, as the calculated critical discharge represented only a small fraction of the bankfull flow. Again, these values should be considered highly conservative and would benefit from a level of field verification.

Table 4.5.3. Existing Channel Parameters and Erosion Thresholds – North-West Brampton Heritage Heights Lands

Parameter	CRT2-4	CRT3-5#	CRT4-5#	HV4#	HV9#
Bankfull Width (m)	5.5	2.2	1.9	4.9	1.82
Average Bankfull Depth (m)	0.2	0.06	0.12	0.2	0.07
Channel Gradient (%)	0.74	1.11	0.94	0.42	0.16
Bed Material d_{50} (m)	0.017	<0.002	<0.002	<0.002	<0.002
Bed Material d_{84} (m)	0.073	<0.002	0.0025	<0.002	<0.002
Manning's n*	0.045	0.045	0.045	0.045	0.045
Bankfull Velocity (ms^{-1})	0.72	0.36	0.54	0.5	0.15
Bankfull Discharge (m^3s^{-1})	0.85	0.05	0.11	0.5	0.02
Flow competence** (ms^{-1}) for d_{50}	0.7	NA	NA	NA	NA
Flow competence** (ms^{-1}) for d_{84}	1.4	NA	0.3	NA	NA
Critical Shear (Nm^{-2})*** for d_{50}	12.4	4	5	4	3
Critical Shear (Nm^{-2})*** for d_{84}	53.2	4	5	4	3
Critical Shear (Nm^{-2})*** for bank material	5	4	4	4	3
Critical (maximum) depth (m) for entrainment	0.13	0.09	0.08	0.15	To be determined

Parameter	CRT2-4	CRT3-5[#]	CRT4-5[#]	HV4[#]	HV9[#]
Critical discharge (m^3/s) for entrainment	0.098	0.028	0.013	0.071	To be determined
Critical velocity (m/s) for entrainment	0.37	0.25	0.29	0.28	To be determined
Critical discharge/bankfull discharge	0.12	0.56	0.12	0.14	To be determined

**based on visual estimate and checked using technique outlined in Chow (1959)*
***according to Komar (1987)*
****according to Miller et al. (1977) or from tables in Chow (1959)*
[#] *Note that these reaches were swales and channel dimensions were only estimates.*

Credit River Tributary and Monitoring Sites

In support of the HHSWS, erosion thresholds were also quantified for the three Credit River tributary monitoring sites, using field data provided by PARISH Geomorphic Ltd. All three of the field sites exhibited well defined channels with riffle-pool bed morphology. Representative cross-sections from each site were selected for analysis. A comparison of critical discharge to bankfull flows indicates that the majority of bed materials have the potential to become entrained under bankfull conditions at all three sites. Erosion thresholds presented for Credit River tributary CRT5-3 were identified by Geomorphic Solutions (2010) through a previous study.

Table 4.5.4. Existing Channel Parameters and Erosion Thresholds – Credit River Tributary and Monitoring Sites

Parameter	CRT1-1[+]	CRT2-1	CRT4-1	CRT5-3#
Bankfull Width (m)	8.7	4.3	3.86	3.0
Average Bankfull Depth (m)	0.38	0.34	0.40	0.29
Channel Gradient (%)	2.6	1.4	3.0	3.5
Bed Material d$_{50}$ (m)	0.023	0.017	0.0083	0.0034
Bed Material d$_{84}$ (m)	0.074	0.053	0.073	0.064
Manning's n*	0.045	0.038	0.050	0.040
Bankfull Velocity (ms^{-1})	1.79	1.43	1.77	2.07
Bankfull Discharge (m^{3}s^{-1})	6.0	2.17	2.93	1.79
Flow competence** (ms^{-1}) for d$_{50}$	0.85	0.73	0.52	0.50
Flow competence** (ms^{-1}) for d$_{84}$	1.43	1.25	1.42	1.14
Critical Shear (Nm^{-2})*** for d$_{50}$	17.4	12.5	6.04	10.20
Critical Shear (Nm^{-2})*** for d$_{84}$	54.1	40.0	52.9	33.14
Critical Shear (Nm^{-2})*** for bank material	72.6	9.29	70.8	11.5
Max Critical depth (m) for entrainment	0.25	0.15	0.10	0.15
Critical discharge (m^3/s) for entrainment	0.20	0.16	0.076	0.0100701007
Critical velocity (m/s) for entrainment	0.84	0.62	0.51	0.50535053
Critical discharge/bankfull discharge	0.033	0.073	0.025	0.04

**based on visual estimate and checked using technique outlined in Chow (1959)*
***according to Komar (1987)*
****according to Miller et al. (1977) or from tables in Chow (1959)*
[+] *values based on a single, top of bank cross-section, for which bankfull was estimated*
[#] *threshold identified through a previous study (Geomorphic Solutions, 2010)*

2017 Field Assessment

Appendix 'E', Table E-3 presents the observations from the 2017 field assessment for *Reaches CRT1-1, CRT1-2, CRT2-4, CRT 2-5, CRT2-5a, CRT2-6, HV3, and HV4*. A photographic record of all surveyed reaches and crossings has been included in Appendix 'E' (E-8). Overall, no new significant geomorphic issues were observed during this assessment. Stream reaches that were previously undergoing adjustment were still undergoing adjustment and reaches that were 'in regime' in 2011 still appeared to be stable. One local notable exception was the crossing at CRT2-2 where the upstream side of the crossing was recently restored and stabilized with vortex rock weirs during culvert works. Note that this was only a small portion of the overall reach.

4.5.5 Interpretation

The key findings of the fluvial geomorphic characterization of the HHSWS Study Area are summarized below:

- Reaches within the study area can be divided into those with a defined channel and headwater drainage features which lack a discernible active channel;
- The degree of definition within headwater features is heavily influenced by land use practices (both historic and present activities likely generate high volumes of fine sediment);
- The majority of well-defined reaches within the subject lands were characterized as being in either an active state of adjustment, or transitional/stressed state (active geomorphic process observed at the time of survey were largely indicative of widening and channel migration);
- Detailed data collection undertaken through this study was largely limited to headwater features for which the determination of bankfull dimensions, as well as erosion thresholds was challenging; and
- Erosion thresholds derived for both headwater and downstream monitoring sites indicated that the reaches within the study area are sensitive to altered flow;
- Supplementary field monitoring confirmed that the geomorphic condition of the reaches assessed in 2017 was similar to their condition in 2011.

4.6 Surface Water Quality

4.6.1 Importance/Purpose

The purpose of the water quality assessment for the Huttonville Creek Subwatersheds and the Credit River Tributaries has been to characterize the aquatic health of the subwatersheds and tributaries with respect to contaminant loadings under existing land use conditions, and to establish a baseline condition which would be used for the impact assessment during the next Study Phase.

4.6.2 Background Information

Background Information

Background information for the CRTs has not been available from the CVC's Integrated Watershed Monitoring Program and the CRT Monitoring Program, as noted within the 2011 Study Terms of Reference. A continuous water quality sampling program has not been implemented Based on the available water quality monitoring within West Huttonville Creek and Huttonville Creek. As the land use and soils are considered to be largely homogeneous with the adjacent Huttonville Creek, the data from the water quality field program for Huttonville Creek from the Mount Pleasant Community Subwatershed Study, 2011, provides a significant understanding that can be applied to the Heritage Heights area and the CRTs

The water quality characterization for the Huttonville Creek Subwatershed has been completed previously as part of the Mount Pleasant Community Subwatershed Study (AMEC et al, June 2011) based upon the information collected during the 2006 and 2007 Monitoring Program. Full details regarding the methodology and conclusions of the Water Quality Monitoring Program are provided in that report and Appendix F of this report. As a summary of the field program, the following water quality monitoring was conducted within Huttonville Creek.

- Dry weather flow grab samples at Sites H1, H2 and H3
- Wet weather flow automated continuous sampling for ten events at the Sites H1, H2, and H3 and five continuous sampling events at CVC site H5.
- Continuous flow data obtained at three gauge locations Sites H1, H2 and H3
- Sites H5 flow data was provided by CVC.

The following water chemistry parameters of concern had been monitored under the 2006 and 2007 Water Quality Monitoring Program:

➢ Dissolved Calcium (Ca)	ug/L	• Orthophosphate (P)	mg/L
➢ Dissolved Magnesium (Mg)	ug/L	• Sulphate (SO$_4$)	mg/L
• Total Metals	ug/L	• Total Kjeldahl Nitrogen (TKN)	mg/L
• *Escherichia Coli (E.Coli)*	*cfu/100 ml*	• Alkalinity (CaCO$_3$)	mg/L
• *Total Dissolved Solids (TDS)*	*mg/L*	• Conductivity	uS/cm
• *Total Suspended Solids (TSS)*	*mg/L*	• PH	--
• Carbonaceous BOD$_5$	mg/L	• Total Phosphorus (P)	mg/L
• Hardness (CaCO$_3$)	mg/L	• Nitrate (NO$_3$ –N)	mg/L
• Chloride (Cl) –	wg/L	• Nitrite (NO$_2$ -N)	mg/L
• Ammonia (NH$_3$ –N)	mg/L		

Metals

Total Aluminum (Al)	ug/L	Total Molybdenum (Mo)	ug/L
Total Antimony (Sb)	ug/L	Total Nickel (Ni)	ug/L
Total Arsenic (As)	ug/L	Total Potassium (K)	ug/L
Total Barium (Ba)	ug/L	Total Selenium (Se)	ug/L
Total Beryllium (Be)	ug/L	Total Silicon (Si)	ug/L
Total Bismuth (Bi)	ug/L	Total Silver (Ag)	ug/L
Total Boron (B)	ug/L	Total Sodium (Na)	ug/L
Total Cadmium (Cd)	ug/L	Total Strontium (Sr)	ug/L
Dissolved Calcium (Ca)	mg/L	Total Tellurium (Te)	ug/L
Total Calcium (Ca)	ug/L	Total Thallium (Tl)	ug/L
Total Chromium (Cr)	ug/L	Total Thorium (Th)	ug/L
Total Cobalt (Co)	ug/L	Total Tin (Sn)	ug/L
Total Copper (Cu)	ug/L	Total Titanium (Ti)	ug/L
Total Iron (Fe)	ug/L	Total Tungsten (W)	ug/L
Total Lead (Pb)	ug/L	Total Uranium (U)	ug/L
Total Lithium (Li)	ug/L	Total Vanadium (V)	ug/L
Dissolved Magnesium (Mg)	mg/L	Total Zinc (Zn)	ug/L
Total Magnesium (Mg)	ug/L	Total Zirconium (Zr)	ug/L
Total Manganese (Mn)	ug/L		

Tables 4.6.1 to 4.6.3 provide the results for the water quality monitoring completed for Mount Pleasant Community Subwatershed Study for Huttonville Creek at sites H1, H2 and H3.

Table 4.6.1. Comparison of Event Mean Concentrations for Site H2 with Literature Values from Water Quality Models (mg/L unless otherwise noted)

Contaminant	2006-2007 Field Monitoring Results			Water Quality Models	
	Range	Mean	Median	TWWF[1]	RHCWP[2]
BOD/CBOD	0.0 – 4.8	1.6	1.2		2
E.coli (#/100mL)	70 - >20,000	>12,726	>16,179	100,000	
TKN	1.0 – 6.0	1.7	1.5	1.0	2.8
Total P	0.2 – 2.0	0.4	0.3	0.2	0.5
TSS	54 – 920	206	135.4	100	400
Copper	0.009 – 0.073	0.016	0.011	0.008	0.005
Zinc	0.023 – 0.190	0.048	0.038	0.018	0.01
Lead	0.003 – 0.063	0.008	0.005	0.004	
Nitrate+Nitrite	0.9 – 12.0	6.5	6.2	2.5	

1. Toronto Wet Weather Flow Management Master Plan
2. Red Hill Creek Watershed Plan

Table 4.6.2. Comparison of Event Mean Concentrations for Site H3 with Literature Values from Water Quality Models (mg/L unless otherwise noted)

Contaminant	2006-2007 Field Monitoring Results			Water Quality Models	
	Range	Mean	Median	TWWF[1]	RHCWP[2]
BOD/CBOD	0.0 – 5.4	2.7	2.4		2
E.coli (#/100mL)	120 - >20,000	>10,905	>10,348	100,000	
TKN	1.0 – 8.0	2.0	1.8	1.0	2.8
Total P	0.1 – 1.3	0.45	0.45	0.2	0.5
TSS	11.5 – 860	106	88.2	100	400
Copper	0.005 – 0.057	0.015	0.012	0.008	0.005
Zinc	0.024 – 0.091	0.042	0.032	0.018	0.01
Lead	0.001 – 0.025	0.006	0.004	0.004	
Nitrate+Nitrite	0.9 – 10	3.2	2.6	2.5	

1. Toronto Wet Weather Flow Management Master Plan
2. Red Hill Creek Watershed Plan

Table 4.6.3. Comparison of Event Mean Concentrations for Site H3 with Literature Values from Water Quality Models (mg/L unless otherwise noted)

Contaminant	2006-2007 Field Monitoring Results			Water Quality Models	
	Range	Mean	Median	TWWF[1]	RHCWP[2]
BOD/CBOD	0.0 – 5.4	2.7	2.4		2
E.coli (#/100mL)	120 - >20,000	>10,905	>10,348	100,000	
TKN	1.0 – 8.0	2.0	1.8	1.0	2.8
Total P	0.1 – 1.3	0.45	0.45	0.2	0.5
TSS	11.5 – 860	106	88.2	100	400
Copper	0.005 – 0.057	0.015	0.012	0.008	0.005
Zinc	0.024 – 0.091	0.042	0.032	0.018	0.01
Lead	0.001 – 0.025	0.006	0.004	0.004	

Contaminant	2006-2007 Field Monitoring Results			Water Quality Models	
	Range	Mean	Median	TWWF[1]	RHCWP[2]
Nitrate+Nitrite	0.9 – 10	3.2	2.6	2.5	

1. Toronto Wet Weather Flow Management Master Plan
2. Red Hill Creek Watershed Plan

The results in Tables 4.6.1 to 4.6.3 indicate the following:

- Observed mean and median Carbonaceous Biological Oxygen Demand (CBOD) concentrations at certain locations within the Huttonville Creek Subwatershed were slightly higher than literature values cited, suggesting slightly higher loadings of carbonaceous biodegradable material for agricultural lands.
- E. coli concentrations for agricultural lands within the Huttonville Creek Subwatershed could be lower than literature values; although it is difficult to fully qualify this conclusion, given that the upper detection limit for E. coli used the approach prescribed in the 2006 Terms of Reference is significantly lower than literature values (i.e. 20,000 counts/100mL upper detection limits compared to 100,000 counts/100mL literature value).
- Observed mean and median concentrations of Total Kjeldahl Nitrogen (TKN) and Total Phosphorus generally correspond to literature values.
- Observed mean and median concentrations of TSS varied within the Huttonville Creek Subwatershed.
- Observed mean and median concentrations of copper and zinc within the Huttonville Creek Subwatershed were between two and three times literature values for agricultural land uses; observed mean and median concentrations of lead were comparable to literature values. This suggests potentially high loadings of certain metals under existing land use conditions.
- Observed mean and median concentrations of nitrate+nitrite within the Huttonville Creek Subwatershed were up to 2 times the literature values for agricultural land use conditions.

Based on the comparison of contaminant of concern observed loadings versus the Provincial Water Quality Objectives, the following was determined for the Huttonville Creek Watershed.

- Concentrations of Nitrate within the Huttonville Creek Subwatershed frequently exceed current water quality standards under both dry and wet weather flow conditions.
- Concentrations of E. Coli are consistently above current water quality standards at all locations during both dry and wet weather flow conditions.
- Concentrations of cobalt and copper frequently exceed current water quality standards during wet weather flow conditions.
- Concentrations of iron frequently exceed current water quality standards during wet and dry weather flow conditions.
- Concentrations of zinc during wet weather flow conditions frequently exceed current water quality standards during wet weather flow conditions at all sites.

4.6.3 Methods

In accordance with the Terms of Reference for the Subwatershed Study, HSP-F water quality model which has been applied previously for the Mount Pleasant Community Subwatershed Study, 2011, has been used for the current study. Details regarding the methodology which has been applied for the development and calibration of the HSP-F Water Quality model are provided in the Mount Pleasant Community Subwatershed Study, 2011.

Table 4.6.4. Event Mean Concentration by Contaminant and Land Use as per CRWMSU (mg/l unless otherwise noted)

Land use	Contaminant						
	Total P	Nitrate + Nitrite	TKN	Copper	Zinc	E.Coli (#/100 ml)	TSS
Residential	0.36	1.75	1.92	0.025	0.123	25,000	91
Commercial	0.25	0.67	0.71	0.022	0.127	5,000	70
Industrial	0.30	1.16	1.06	0.027	0.220	1,138	67
Educational/Institutional	0.36	1.75	1.92	0.025	0.123	8,360	63
Open Space	0.12	0.54	0.97	0.016	0.098	4,100	70
City Parks	0.36	1.75	1.92	0.025	0.123	10,000	63
Golf/Cemetery	0.70	1.75	3.30	0.025	0.123	4,100	63
Agricultural	0.45	4.00	1.90	0.014	0.039	100,000	132
Highway	0.39	0.76	2.00	0.052	0.302	3,070	331

The Event Mean Concentrations (EMC's) which have been applied previously for the Water Quality analyses for the HFSWS, 2011, (ref. Table 4.6.4 have been used along with the simulated average annual runoff volumes for the various land use conditions, in order to determine the mass loadings of water quality indicators at key locations within the study area. The water quality analyses for the Huttonville Creek Subwatershed have applied the future land use conditions with stormwater management and Low Impact Development within the Mount Pleasant area (as per the HFSWS, 2011) and existing land use conditions for the balance of the subwatershed. The analyses for the Credit River Tributaries have been based upon the existing land use conditions within the tributaries. The existing land use contaminant of concern loadings will be used during the impact assessment for the proposed land use to determine stormwater quality management requirements.

The results for the surface water modelling are presented in Table 4.6.5.

Table 4.6.5. Area Annual Loading Based on Mass Balance Modelling for Existing Land Use Conditions (kg unless otherwise noted)

Reference Node/Location	Nitrogen Species		Total P	Chloride	Metals		Pesticides		TSS	E.coli. (#/ 100 mL)
	Nitrates +Nitrites	TKN			Copper	Zinc	Diazinon	Simazine		
Huttonville Creek Subwatershed										
Gauge H1	2666	1322	310	88773	10.69	34.25	143	476	91431	6.56E+8
Gauge H5	12691	7878	1593	2680970	73.04	291.52	1409	2073	482504	2.84E+9
Credit River Tributaries										
CRT1	3409	1619	383.48	0.00	11.93	33.23	162	622	112486	8.52E+08
CRT2	6511	3093	732.53	0.00	22.79	63.49	309	1188	214876	1.63E+09
CRT2A	390	185	43.92	0.00	1.37	3.81	19	71	12884	9.76E+07
CRT3	1663	790	187.12	0.00	5.82	16.22	79	304	54888	4.16E+08
CRT4	2460	1168	276.74	0.00	8.61	23.98	117	449	81178	6.15E+08
CRT4A-e	298	142	33.56	0.00	1.04	2.91	14	54	9845	7.46E+07
CRT4A	354	168	39.78	0.00	1.24	3.45	17	65	11669	8.84E+07
CRT4B	348	165	39.16	0.00	1.24	3.39	17	64	11486	8.70E+07
CRT5	1672	794	188.10	0.00	5.85	16.30	79	305	55176	4.18E+08

4.7 Aquatic Resources

4.7.1 Purpose

Aquatic resources are key components of a holistic vision for our communities. Investigating and clearly communicating the types of habitat present and the biota they support is essential for landscape scale discussions. The following section characterizes the aquatic habitat of West Huttonville and Credit River Tributary subcatchments within the Heritage Heights Subwatershed Study Area, referred to in this text as the Study Area. Biotic data (i.e., benthic invertebrates and fish) was obtained from previous studies and field assessments conducted by the subwatershed study team consultants, as well as other agencies (e.g., CVC). Field assessments were conducted by Savanta ecologists in 2007, 2008, 2009, 2012, 2018 and 2019.

4.7.2 Background Information

The background information that has been reviewed for the Subwatershed Characterization is documented in Section 2.3.

The current mapping for fish habitat in the Study Area is provided in Figure F1 (Appendix G). Additional relevant data was obtained through discussions with staff of CVC (L. Marray, per. comm.). CVC staff provided a summary of known fish collection data from both the Ministry of Natural Resources and Forestry (Aurora District) and CVC, as well as qualitative observations of fish at various locations throughout the subwatersheds. These data are discussed in more detail and the information depicted on Figure F2 within Appendix G. Of the various background sources identified in Section 2.3, the following are most relevant to an understanding of the aquatic resources within the West Huttonville and Credit River Tributary subcatchments:

- Credit River Fisheries Management Plan (2002);
- Huttonville and Fletcher’s Creeks Subwatershed Study (AMEC, 2011);
- The Credit Valley Subwatershed Study and Servicing Plan – Huttonville Creek (7), Springbrook Creek (8a), and Churchville Tributary (TSH et al, 2003);
- Environmental Report (prepared for the Osmington Inc. lands within the lower West Huttonville Creek subwatershed (Ages Consultants Limited (February 2010);
- Credit River Tributary Monitoring Program (CVC, 2008 Report).

The MNRF has designated the West Huttonville Creek as “direct” or “occupied” habitat for the endangered Redside Dace from Mississauga Road upstream to the top end of Reach HV4, and contributing habitat north of this point (M. Heaton, pers. comm., 2012). DFO’s Species at Risk mapping of Redside Dace confirmed the “occupied” reaches.

A summary of the relevant information from these sources as they relate to the West Huttonville Creek and the Credit River Tributaries is provided below.

4.7.2.1 Aquatic Habitat

The *Credit Valley Conservation Report (Department of Planning and Development, 1956)* classified watercourses in the Credit River watershed based on their flow characteristics (permanent flow, dries to standing pools, or dries up completely during most summers), and fish communities (cold – favourable for Brook Trout (*Salvelinus fontinalis*), large temperature variations – unfavourable for Brook Trout but suitable for Brown Trout (*Salmo trutta*); and warm – suitable for centrarchids, primarily Rock Bass.

The West Huttonville Creek, from the Credit River upstream to approximately Highway 7, was classified as “permanent cold flow” (suitable for Brook Trout). As noted in the HFSWS (Phase 1 Characterization report), the reason for this classification “cold water” designation was not provided. From Highway 7 to just north of the Canadian National Railway (CNR), the West Huttonville Creek is classified as "dries to standing pools", and the remainder of the watercourse shown to rise just north of Wanless Road is classified as "dries up completely (in most summers)".

Within the Credit River Tributaries portion of the Study Area, three watercourse reaches are noted that correspond to CVC's present-day nomenclature CRT1, CRT2, and CRT4. In the CVC's 1956 Report, watercourse CRT2 is depicted as rising immediately south of the CNR (just to the east of Heritage Road). For the first approximately 200m to a point downstream of Heritage Road, the watercourse is noted as "dries to standing pools", and downstream of this point was classified as "permanent cold flow" downstream to its confluence with the Credit River, approximately 150m south of Highway 7. The two other tributaries (i.e., CRT1 and CRT4) are both classified in their entire reaches as "dries up completely (in most summers)". The Credit River itself was classified as "permanent flow warm" adjacent to the southern portions of the Study Area (i.e., from approximately south of Highway 7). To the north of Highway 7, the Credit River was classified as having "permanent flow with large temperature variations (such that it was not suitable for Brook Trout but would be favourable for Brown Trout).

The *Phase 1 Characterization Report for the Huttonville Fletchers Creek Subwatershed Study* (HFSWS) included some aquatic habitat assessment within the West Huttonville Creek subwatershed (AMEC, 2009). C. Portt and Associates (Portt) completed spring flow observations at 10 headwater locations within the West Huttonville Creek and two locations further downstream along Mississauga Road (south of the CNR). Observations occurred during spring conditions in 2005, 2006, and 2007 and the West Huttonville Creek data are summarized on **Table 4.7.1**. Portt noted that the results of the spring field investigations revealed minor differences in flow conditions between the years and suggests that this finding was not unexpected because year-to-year differences in precipitation affects the duration of flow in these low-infiltration settings. Regardless of the year, by late April, the watercourses at Mayfield Road were either exhibiting very slight flows, were reduced to areas of standing water or were dry.

Table 4.7.1. Flow Conditions Observed Observed in Spring 2005, 2006, and 2007 for Stations within the West Huttonville Creek Subcatchment (Plus Biota Observed and Preliminary Headwater Classification Based on April 30, 2007 Observations with CVC): From AMEC, 2009

Station #	April 19th, 2005		April 20-21, 2006		April 30, 2007			
	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Biota Observed	Preliminary Classification
529 (Mayfield Road)	dry	dry	dry	dry	dry	flow	mosquito larvae	simple contributing
528 (Mayfield Road)	dry	dry	dry	dry	dry	pools	mosquito larvae	simple contributing
527 (Mayfield Road)	dry	pools	dry	pools	dry	flow		simple contributing
524 (Mayfield Road)	Station Shown In HFSWS Report, But No Data Shown In Associated Table							
525 (Heritage Road)	dry	pools	dry	flow	flow	flow		simple contributing
523 (Wanless Drive)	flow	flow	flow	flow				
522 (Wanless Drive)	flow	flow	flow	flow				
521 (Wanless Drive)	flow	flow	flow	flow	flow	flow		simple contributing
518 (Mississauga Road)	pools	pools	flow	flow				
520 (Mississauga Road)	dry	dry	dry	puddles				

Station #	April 19th, 2005		April 20-21, 2006		April 30, 2007			
	Upstream	Downstream	Upstream	Downstream	Upstream	Downstream	Biota Observed	Preliminary Classification
501 (Mississauga Road)	flow	flow	flow	flow				
500 (Mississauga Road)	flow	flow	flow	flow				

4.7.2.2 Aquatic Habitat

The CVC and TRCA have formulated guidelines to assist in evaluating and classifying headwater drainage features, entitled "Evaluation, Classification, and Management of Headwater Drainage Features: Interim Guidelines". These were released initially in 2007 and were revised in 2009, 2011 and 2014. Starting in 2007-2008 Savanta collected fish habitat and flow data. Additional data was collected in 2009. This data was supplemented in 2012 by spring/summer flow surveys and site walks. Savanta collected additional data in 2017, 2018 and 2019 to improve the evaluation of the headwater drainage features and to facilitate use of the 2014 guidance document which is significantly different from the initial version of the guidelines.

During the preparation of the draft Phase 1 Characterization Report (2012), Savanta was requested by the CVC to apply the updated 2011 guidelines to the 2012 field assessment of headwater features. Field walks during spring 2012 occurred throughout the Heritage Heights subwatersheds (i.e., both the West Huttonville Creek and Credit River Tributaries) and were intended to survey representative reaches of various drainage features. R. Hubbard (Savanta) and A. Labbe/L. Marray (CVC) examined most of the features either via observations at, and adjacent to road crossings (where landowner access was not granted), but more often via actual walking of entire sections of drainage features to resolve the differences in application of the 2011 guidance document.

As part of this updated Phase 1 Characterization Report, the Evaluation, Classification and Management of Headwater Drainage Features Guideline (2014) was applied to all HDFs. The 2014 guidelines are closest to the 2011 version and generally similar to the 2007 and 2009 iterations. There is an increased level of detail required for each headwater feature and the revised 2014 guidelines require that the role of existing land use activities (such as modifiers like agricultural tilling) in influencing the functions of headwater features is to be factored in to the overall Management Recommendations. The 2007 and 2009 guidelines tended to orient around the assessment of four types of fish habitat (i.e., "permanent", "seasonal", "contributing" and "not direct or indirect habitat (i.e., not fish habitat)", whereas the 2014 and 2011 guidelines broadened the perspective by including hydrologic and biological characteristics that influence the final classification of each reach. Specifically, the "Classification" portion of the 2014 Guidelines requires the assessor to rank the individual reaches based on:

1. Hydrology (i.e., whether the reach exhibits "Important Functions – Permanent", "Valued Functions – Intermittent", "Contributing Functions – Ephemeral", "Recharge Function – Dry or Standing Water" or "Limited Functions – Dry or Standing Water")
2. Riparian Classification (i.e., Ranked Important Functions, Valued Functions, Contributing Functions and Limited Functions base on riparian habitat OSAP Codes)
3. Fish and Fish Habitat Classification (i.e. Ranked Important Functions – Permanent Fish habitat and occupied species-at-risk habitat, Valued Functions – Seasonal fish habitat or contributing habitat for species-at-risk, Contributing Functions – Contributing fish habitat)
4. Terrestrial Habitat Classification (i.e., Ranked Important Functions – amphibian breeding habitat, Valued Functions – general amphibian habitat, Contributing Functions – movement corridors, and Limited Functions – no terrestrial habitat).

Using the flow chart from the guideline, the accessor uses the four ranks to determine the appropriate management recommendation. Possible management recommendations include “protection”, “conservation”, “mitigation” and “no management required’. Management recommendations are discussed in greater detail in section 4.7.4.1.

4.7.2.3 Benthic Invertebrates

Benthic Sampling as Part of HFSWS

Regarding the West Huttonville Creek subwatershed, one benthic sampling station was sampled over the course of several dates (with in a two-week period) in 2006 and 2007. That station was located on the West Huttonville Creek, upstream of the confluence of the East Huttonville Creek and West Huttonville Creek (identified as Site 4 within the Phase 1 HFSWS, June 2011). Though not explicitly stated in the HFSWS, Savanta assumes that this station would correspond to EM8 (as part of the CVC’s Effectiveness Monitoring Program/Integrated Watershed Monitoring Program – i.e., the reach of West Huttonville Creek that flows southward along the east side of Mississauga Road before becoming confluent with the East Huttonville Creek). The 2007 samples were collected between May 22 and July 16, 2007.

The West Huttonville Creek benthic data are described within **Table 4.7.2** below.

Table 4.7.2. Number of Samples (n), Means, and Standard Deviations (s.d.) of Taxa Richness, Shannon’s Diversity and the Hilsenoff Biotic Index (HBI) Calculated from Base Line Data Collected in 2006 and 2007, and the Water Quality Implied by those Indices.

				Taxa Richness		Shannon’s Diversity		HBI		EPT
Station	**Habitat**	**Year**	**N**	**Mean**	**s.d.**	**Mean**	**s.d.**	**Mean**	**s.d.**	**Mean**
4 (West Huttonville Creek, on east side of Mississauga Road)	Pool	2007	5	25	8.0	3.37 (clean)	0.32	6.73 (fairly poor)	0.19	1 (severely impacted)
	Riffle	2006	5	32	6.5	3.79 (clean)	0.28	6.43 (fairly poor)	0.43	2 (moderately impacted)
		2007	5	30	4.1	3.82 (clean)	0.14	6.31 (fair)	0.24	3 (moderately impacted)

The HFSWS summarizes the overall quality of the benthic results as follows:

- Although the habitat quality classification indicated by HBI changes from “fairly poor” in 2006 to “fair” in 2007, there is in fact little difference in the scores between the years;
- The indices for the “pool” habitat indicate slightly poorer water quality in the pools than in the riffles which is more a reflection of differences in physical habitat. Intuitively, one would not anticipate real differences in water quality as the samples were collected within metres of each other;
- Shannon’s diversity indicates “clean” conditions for both the “pool” and “riffle” substrates, while the other two indices indicate “impacted” conditions. This may occur because Shannon’s diversity is based solely on the relative abundance of taxa, whereas the HBI and EPT both are strongly influenced by the type of taxa present, and the taxa that indicate better water quality for those indices tend to be those that prefer higher dissolved oxygen concentrations and cooler water temperatures.

Benthic Sampling as Part of the CVC's Effectiveness Monitoring Strategy / Integrated Watershed Monitoring Program

West Huttonville Creek:

Of the 12 EMS stations established within the Huttonville and Fletcher's Creek watersheds, only two (EM7 and EM8) relate to the West Huttonville Creek. Station locations are shown on Figure F2, Appendix G. EM7 has been sampled for benthic invertebrates once each summer between 2004 through 2019 skipping 2012. Based on data provided by CVC in 2021, EM8 has been sampled for benthic invertebrates in 2013 through 2019.

- *CVC's Effectiveness Monitoring Strategy*
    - In the 2009 5-Year Review (AECOM, 2009), the results from benthic sampling at Station EM7 are summarized for the sampling years 2004 through 2007. While Station EM7 is located north of Bovaird Drive (and hence, represents the combined effects of both West Huttonville and East Huttonville Creek), these data are provided for background information purposes. Station EM8 is located on West Huttonville Creek just downstream of Mississauga Road outside of the Study Area.
- *CVC's Integrated Watershed Monitoring Program*
    - The *Integrated Watershed Monitoring Program* is the evolution of the CVC's monitoring program. There are monitoring reports dating back to 2014. Only the most recent report was reviewed.
    - The Integrated Watershed Monitoring Program Biennial Report 2016 and 2017 (CVC 2019) provides data for EM7 and EM8. In 2016, EM7 was shown as having a poor benthic community rating based on the Hilsenhoff Family Index and maintain that rating in 2017. Whereas, in 2016, EM8 had a fair rating but dropped down to a poor rating in 2017.

Credit River Tributaries

Of the 92 IWMP stations established within the Credit River watershed, three (CRT2, CRT4 and CRT3) relate to the Credit River Tributaries within the Study Area. IWMP monitoring station locations are shown on Figure F2, Appendix G. Although monitoring data is collected yearly, not all stations are sampled every year. CRT2 is located a short distance upstream of Bovaird Drive (Hwy 7) and this watercourse enters the Credit River approximately 400m downstream of this monitoring site. CRT4 is located at the eastern portion of the Study Area and is approximately 75m upstream of the confluence with the Credit River. All these stations are on tributaries that drain ephemeral/intermittent drainage features on the agricultural tablelands that extend up to Mayfield Road. Based on data provided by CVC in 2012 and 2021, CRT2 has been sampled for benthic invertebrates once each summer in 2008, 2013, 2015, 2017, and 2019. CRT4 has been sampled for benthic invertebrates once each summer in 2008, 2016, 2017, and 2019. CRT3 has been sampled for benthic invertebrates once each summer in 2015, 2017, and 2019.

- Macrobenthic invertebrate communities were sampled at CRT2 and CRT4 in 2008 during the mid-summer season. See Figure F2 for locations. CVC notes that a third site (CRT3) was not sampled in 2008 due to insufficient flow. The issue of adequate stream flow is an important one in collecting meaningful benthic samples. Intermittent flow conditions dominate the mid- and upper reaches of the Credit River Tributary portion of the Study Area.
- Macrobenthic invertebrate communities at CRT2, CRT3, and CRT4 since 2008 have been variable and contain tolerant species reflective of the variable flow conditions and upstream agricultural land use.

Environmental Report for Osmington Inc. (Ages Consultants, 2010)

- Benthic invertebrates were sampled at three stations on West Huttonville Creek, all located downstream of the CNR and upstream of Mississauga Road (see Figure F2 for locations). A section of West Huttonville Creek was divided into three reaches and the report states that samples were collected from three riffles within the reaches.
- Analysis of the benthic data for total organism density, taxa richness, Hilsenoff Biotic Index (HBI), BioMAP Water Quality Index, and Ephemeroptera, Plecoptera, and Trichoptera (EPT) index was performed for each of the three stations as per **Table 4.7.3** below:

Table 4.7.3. Results from Benthic Invertebrate Sampling of Lower West Huttonville Creek (CNR to Mississauga Road) – Samples Collected May 5th, 2009 (Ages Consulting, 2010)

Parameter	Station 3 (immediately D/S of CNR	Station 2 (mid-way)	Station 3 (immediately U/S of Mississauga Road)
Mean Density (organisms/sample)	7156	2150	8191
Mean Taxa Richness	31	34	34.5
Pooled Taxa Richness	57	56	64
HBI	6.51	6.34	5.42
HBI Interpretation	Fairly Poor	Fair	Good
BioMAP	6.47	9.4	10.39
BioMAP Interpretation	Impaired	Impaired	Impaired
EPT Taxa Richness	10	10	9

The Ages report provided the following summary comments:

- Both HBI and BioMAP use the relative sensitivity of each organism found to pollutants or poor water quality and their relative abundance to derive an index of water quality which can be compared among benthic stations. The interpretation of water quality based on HBI and BioMAP for these three stations suggests that water quality is generally poorer at the upstream Station 3 (i.e., “fairly poor – significant organic pollution), and better at the downstream Station 2 (i.e., “good – with some organic pollution);
- Based on an overall assessment of the composition of the benthic organisms at the three stations (i.e., the relative proportion of oligocheates and chironomids), the low % of these invertebrates at each station suggests that water quality “was not extremely poor”.

The report provides an overall conclusion that this section of West Huttonville Creek exhibits poorer water quality upstream which becomes relatively better with distance downstream. However, regardless of improvements in a downstream direction, it is impaired throughout the entire length based upon the benthic analyses.

4.7.2.4 Fish

The existing fish communities were designated in the *Credit River Fisheries Management Plan (2002)*. Figure F1, Appendix G, presents the Credit River Fisheries Management Plan (CRFMP) findings. A portion of the Credit River that is immediately upstream from the confluence with Huttonville Creek has a mixed cold/cool fish community. This fish community includes Brown Trout (*Salmo trutta*) and Rainbow Trout (*Oncorhynchus mykiss*), and Rainbow (*Etheostoma caeruleum*) and Fantail Darters (*Etheostoma flabellare*) among others. Downstream from its confluence with the main Huttonville Creek, the Credit River supports a cool/warm fish community. This section of the Credit River fish community includes seasonal use by Rainbow Trout and salmon. The Endangered Redside Dace (*Clinostomus elongatus*) is also associated with this habitat type but are limited to portions of the West Huttonville Creek subcatchment and are not found within any of the Credit River Tributaries.

The lower reaches of the main Huttonville Creek support a coldwater fish community from the Credit River upstream to a migration barrier at Queen Street. Brook Trout (*Salvelinus fontinalis*) is the indicator species for a coldwater fish community, but the CRFMP states that in Huttonville Creek, potential Brook Trout habitat is utilized by Rainbow Trout. The main Huttonville Creek from Queen Street upstream to the confluence with the East and West Huttonville Creeks, just north of Highway 7, is designated as "warmwater fish community dominated by Cyprinids", as is the West Huttonville Creek upstream to approximately Wanless Road. The remainder of the headwater tributaries in the West Huttonville Creek are not assigned a fish community in the CRFMP. Within the western portion of the Study Area (i.e., in the Credit River Tributaries), none of these watercourses have been assigned a fish community classification in the CRFMP.

The CRFMP also identifies fish community management zones, which are based upon the fish communities that are present and on actual or potential habitat conditions. The lower reach of Huttonville Creek, below approximately Queen Street is to be managed for a mixed warm/cool community. The remainder of the Huttonville Creek watershed (including all the West Huttonville subcatchment) is to be managed for a "small warmwater fish community", and this classification also applies to the Credit River Tributaries.

Portt completed fish sampling as part of the Phase 1 Characterization report within the HFSWS (AMEC, 2011). Sampling occurred within the West Huttonville, East Huttonville, and Fletcher's Creek subwatersheds as depicted on Figure F6 from the HFSWS Phase 1 report. Those sites that are relevant to the West Huttonville Creek are the following and are described in **Table 4.7.4**: Stations 1, 23, 15, 16, and 17. Location descriptions are provided in the table as well. Portt reported that drainage feature crossings that were not sampled by electrofishing were dry by late May, and indicated that the fish species that were captured in the headwaters are common warmwater fish species (Brook Stickleback - *Culaea inconstans*, Fathead Minnow - *Pimephales promelas*, Creek Chub - *Semotilus atromaculatus*, Blacknose Dace - *Rhinichthys atratulus*, and Pumpkinseed - *Lepomis gibbosus*). The Portt report had no sampling data in any of the Credit River Tributaries.

Table 4.7.4. Fish Sampling was by Electrofishing Unless Otherwise Noted. Sampling Locations are Shown on Figure F2-. (Only data pertaining to West Huttonville Creek are shown)

Site	Date	Catch	Electrofishign seconds	Comments
1 (Mayfield Road)	5/11/2005	no catch	45	puddle at end of culvert
15 (Mississauga Road@ Wanless Drive)	5/13/2005	no catch	316	140m
16 (Wanless Drive)	5/13/2005	no catch	277	35m
17 (Wanless Drive)	5/13/2005	1 creek chub	262	60m
23 (Heritage Road)	15/11/06	2 brook stickleback	1050	340m
23 (Heritage Road)	1/06/07	no catch	na	210m (remainder was dry)

In terms of the West Huttonville Creek sampling, Portt notes that station 23 (Heritage Road) was of particular interest as this was where Brook Stickleback were caught in the fall of 2006 in a sediment trap installed as part of the fluvial geomorphology investigations. When Portt electrofished this station (located on the downstream side of Heritage Road) on November 15, 2006, two Brook sticklebacks were captured in 340m of stream. However, no fish were observed in a subsequent visual assessment completed during the spring of 2007 (April 30, 2007). A little more than a month later (on June 1, 2007), Portt noted standing water within a 210m reach of this drainage feature and the entire length was electrofished and no fish were captured. Portt speculated that the likelihood of fish migrating into this headwater drainage feature is probably correlated with the length of time that these features are flowing in spring and fall. October 2006 was particularly wet, and hence, the opportunity for fish to enter the headwaters is thought to have been greater than usual. Savanta has viewed this location (HV9d) on several occasions during the summer/fall of 2011, as well as spring/summer of 2012. No additional fish observations have been recorded in this reach. Water was not observed in this reach during the 2011 site visits, and only limited water was noted during the April 3, 2012 orientation site visit with CVC and City staff.

Summary of Fish Capture Data and Fish Observations During Field Visits – Discussion with CVC

Savanta met with CVC staff on May 10, 2012 to discuss and review background fisheries information within the Study Area. These data were provided by L. Marray and were a compilation of historic MNR Fish Collection Records (FCRs), CVC electrofishing data, and various visual observations of fish presence during field visits.

Summary of Fish Capture Data from the CVC's Effectiveness Monitoring Strategy / Integrated Watershed Monitoring Program

A fundamental assumption in the assessment of the health of fish communities is that changes in watershed hydrology and water quality (including chemical and biologic factors) and channel morphology will affect fish community dynamics cumulatively (in a positive or negative manner). As such, fish communities are recognized as integrative indicators of the environmental integrity of a watershed (CVC, 2008).

West Huttonville Creek:

As part of the CVC's Effectiveness Monitoring Program / Integrated Watershed Monitoring Program, annual fish community monitoring has occurred at several stations throughout the Huttonville and Fletcher's Creek subwatersheds. Station EM8 is located on West Huttonville Creek, immediately downstream of Mississauga Road (on the east side of Mississauga Road), and this station has been sampled annually during the following years: 2001, 2002, 2004, 2005, 2006, 2007, 2009, 2010, 2012, 2013, 2015, 2016, and 2020. Station EM7 is located on West Huttonville Creek, immediately downstream of Hwy 7 (on the east side of Mississauga Road), and this station has been sampled annually during the following years: 2001, 2002, 2004, 2005, 2006, 2007, 2009, 2010, 2013, 2015, 2016, and 2020. CVC IWMP fish species capture data for 2012 to 2020 is presented in Table 4.7.6.

Table 4.7.5. CVC IWMP Data (2012 – 2020): Fish Species Caught within Huttonville Creek (EM8 and EM7) and Credit River Tributaries #2 and #4 (CRT2 and CRT40 by Year

Sampling Year	Rainbow Trout	Coho Salmon	Chinook Salmon	Brown Trout	Brook Stickleback	Western Blacknose Dace	Creek Chub	Fathead Minnow	Fantail Darter	Longnose Dace	Northern Redbelly Dace
Huttonville Creek @ Mississauga Rd (upstream of EM 8)											
2012	x				x	x	x				x
2013	x				x	x	x				
2015					x	x	x	x			
2016					x	x	x				
2020					x	x	x				
Huttonville Creek @ Hwy 7 (downstream of EM 7 and tributary)											
2013	x				x	x	x				
2015					x	x	x	x			
2016	x				x	x	x				
2020	x				x	x	x	x			
Credit River Tributary #2 (upstream of Hwy 7)											
2015					x	x	x				
2017	x				x	x	x				
2019					x	x	x				
Credit River Tributary #4 (upstream of Credit River)											
2017	x	x		x		x		x	x	x	
2019	x		x								

The Five-Year Review of the Effectiveness Monitoring Program (AECOM, 2008) provided a summary of the preliminary trends at all stations, including EM7. The catch at each location was used to estimate an Index of Fish Health. The Index was based on species' weighting factors (either a 1, 2, or 3) designed to reflect each species' sensitivity – sensitive fish species are given a score of 3 (most sensitive) and tolerant species assigned a score of 1 (least sensitive) – this is termed the Station Health Index. In the case of small-bodied fish, sensitive fish would include species such as Redside Dace, Longnose Dace, Spottail Shiner, Mottled Sculpin among others, and less sensitive species would include fish such as Common Shiner, Fathead Minnow, and Brook Stickleback. The fish data from EM7 characterize the fish community as being "good to excellent" quality based upon the relatively high proportion of three species (Western Blacknose Dace, Brook Stickleback, and Creek Chub). The Five-Year Review suggests that the trends over time show improvement in the quality of surface water or habitat.

CVC completed additional electrofishing surveys in 2009 and 2010. A total of 201 and 506 fish being captured at the two stations, respectively. Most of these captures were Fathead Minnow, Brook Stickleback, and Western Blacknose Dace. This trend continued in subsequent monitoring years, as shown in Table 4.7.6, with Creek Chub, Brook Stickleback, and Western Blacknose Dace accounting for most of the fish community with Rainbow Trout being captured in the most recent studies. The West Huttonville Creek continues to provide "good to excellent" quality fish community results.

Credit River Tributaries

With approval of land development within the Mount Pleasant Secondary Plan, the original Effectiveness Monitoring Strategy / Integrated Watershed Monitoring Program (IWMP) was expanded to include additional monitoring sites within this area. In partial fulfillment of this initiative, to help characterize the current physical environment, terrestrial ecology and aquatic ecology within this area, the Credit River Tributary Monitoring Program was established in 2007 has continued through 2020, though not all stations are sampled annually.

CVC IWMP fish community surveys were completed at CRT2 and CRT4. Electrofishing locations are shown on Figure F2, Appendix G. The number of fish species collected ranged from 1 to 7. Current data suggest that CRT2 has "good" fish community and CRT4 has "excellent" fish community.

In 2008, only one species was caught at CRT2 (87 specimens of Western blacknose Dace). The fish community of CRT2 was previously impacted by a perched culvert immediately downstream that acted as a barrier to fish movement. This barrier was removed in 2015 when Highway 7 was widened. Fish surveys in 2015, 2017 and 2019 have consistently had at least three fish species present including Rainbow Trout in 2017 (Table 4.7.6).

Salmonids, including young of the year, are consistently found at CRT4 (Table 4.7.6), and CVC confirmed spawning of salmonids in the vicinity of their monitoring station (M. Rizwan, Per. Com. 2021). In addition, the fish found at CRT4 may be using this tributary as a place of refuge as the station is close to the confluence with the Credit River.

4.7.3 Methods

4.7.3.1 Headwater Drainage Features

Headwater drainage features (HDF) within the Study Area were initially identified in 2006-2007. Savanta completed initial field investigations and preliminary stream reach classifications in July 2011 based on the CVC/TRCA's 2009 Evaluation, Classification, and Management of Headwater Features. Additional field assessments occurred during the spring and summer of 2012 following the revision of CVC/TRCA's guidelines. Additional assessments were then completed in the spring and summer of 2017, 2018 and 2019 to update the classifications to meet requirements of the most recent version of the updated HDFA guidance issued in 2014 (CVC and TRCA, 2014). Table 4.7.7 summarizes the field activities that have occurred in 2011, 2012, 2017, 2018 and 2019.

A series of field walks were completed in April and May 2012 that included various staff from the CVC, City of Brampton, the MNR and members of the Heritage Heights study team. During some walks, individual landowners also participated. Following is a summary of these efforts and findings:

- July 18, 19, and 22, 2011 – Spot observations for surface water flow and preliminary classification of tributaries through application of the CVC/TRCA's document entitled "Evaluation, Classification, and Management of Headwater Features, Revised 2011). Flow status was classified as "dry", "flowing" or "standing pools present" and a photo log was maintained of all locations where flow or pools were noted. During July 2011, little flowing water was noted in the middle/upper reaches of the Credit River Tributaries as well as the West Huttonville Creek, except for "standing water" within historic irrigation ponds.
- During the spring 2012 season, Savanta staff as well as team members from other disciplines conducted site visits documenting field conditions within both the West Huttonville Creek and Credit River Tributaries. Savanta staff viewed a number of these reaches during the last week of March in preparation for the several agency/City site walks that were to take place in April. The purpose of these site visits was to gain a general understanding of watershed conditions within the Study Area during the spring season, as well as to reassess the West Huttonville Creek tributaries since the original site investigations between 2005-2007 (which were completed as part of the HFSWS).
- In 2017 and 2018, Savanta completed Headwater Drainage Feature Assessment (HDFA) for drainage features identified for reassessment due to the updated HDFA guidance issued in 2014.
- Investigation determined there were features mapped based on aerial imagery that were not present on the landscape and these features are not included in the HHSWS mapping or HDF assessment.

Table 4.7.6. Summary of Headwater Drainage Feature Site Investigations and Field Walks Within the Heritage Heights Subwatershed Study Area, 2011-2019

Year/Date		Key Activity/Purpose of Visit	Staff/Agency/Landowner(s) Present	Comments/Observations
2011	07/18 07/19 07/20	• Initial summer Headwater Drainage Feature classification of Heritage Heights watercourses. • Spot flow observations.	Savanta staff (George Buckton/Rick Hubbard)	Summer dry weather was predominant. Only standing water at a limited number of locations. Permanent flow observed at downstream reaches of CRT 2, with presumed flow at downstream portion of CRT4.
2012	03/20	• Early spring assessment of headwater features.	Savanta staff (George Buckton/Rick Hubbard)	Flowing conditions generally observed throughout the headwater and mid-reach areas in Heritage Heights.
	04/03	To obtain general appreciation for site conditions in both West Huttonville and Credit River Tributaries. Initial review of Savanta's preliminary Headwater Classification.	***CVC*** - (A. Labbe, L. Marray, J. Campbell, R. Haq) ***City*** – (M. Hoy, J. Hogan, S. Jorgenson) ***Heritage Heights Team*** – (R. Hubbard, H. Whitehouse, S. Gorenc, J. Shaw, N. Mather, B. Blackport).	Roadside visit of HV14 and HV31 Roadside visit of CRT2-9a, CRT2-9b and HV13a and HV13b Visit of CRT2-8, CRT2-8a, CRT2-8b, CRT2-8c and CRT2-8d
	04/05	Further assessment of specific reaches of Credit River Tributaries	***CVC*** - (A. Labbe, L. Marray, J. Campbell, R. Haq) ***City*** – (M. Hoy,) ***Heritage Heights Team*** – (R. Hubbard, H. Whitehouse, S. Gorenc, J. Shaw, N. Mather, B. Blackport).	Field walked CRT1-3, CRT1-3a and CRT1-1 Brook sticklebacks observed in reaches of CRT1-3a – Savanta to undertake further investigation via minnow traps (took place on 04/10th
	04/10	Five minnow traps established at two locations (four in irrigation pond on CRT1-3a) and one in CRT2-6)	Savanta-R. Hubbard	• Traps set for 24hrs; • Approximately 70 brook stickleback observed in CRT1-3a pond • Six stickleback observed at upper reach of CRT2-6
	04/16	• Specific attention on the Reed lands (i.e., CRT2-4 and 2-5). Riparian mineral marsh around CRT2-4, 2-5 is associated with MNR Wetland #43. • Visited various reaches of CRT4 located on east side of Heritage Road.	***Landowners –*** (James & Bruce Reed) ***CVC*** - (A. Labbe, L. Marray, J. Campbell, R. Haq) ***City*** – (M. Hoy, J. Hogan) ***Heritage Heights Team*** – (R. Hubbard, H. Whitehouse, S. Gorenc, J. Shaw, B. Blackport).	• Observed fish within CRT2-4 • Flowing conditions throughout CRT2-4 and CRT2-5
	04/20	CVC/MNR was interested in viewing West Huttonville Creek from Mississauga Road upstream to CNR.	***Landowners*** - Representatives of the Osmington, Cortel, and Heathwood lands – south of CNR). ***CVC*** - (A. Labbe, L. Marray, J. Campbell, R. Haq) ***MNR*** – M. Heaton ***City*** – (S. Jorgenson) ***Heritage Heights Team*** – (R. Hubbard, H. Whitehouse, S. Gorenc, J. Shaw, B. Blackport).	• Walked HV81, HV81a and HV81b from Mississauga Road to upstream woodlot. Agreed that these reaches would be classified as "Complex Contributing" based on field observations and application of the HDFA • Walked HV3 on West Huttonville Creek between CNR downstream to Mississauga Road.
	05/10	Key areas were reaches within West Huttonville, upstream of CNR, and CRT3-6, CRT3-4, CRT3-5, south of Bovaird Drive.	***CVC –*** (A. Labbe/L. Marray) ***Heritage Heights Team –*** R. Hubbard.	
	05/175 /25	Periodic visits to selected locations to observe spot flows	G. Buckton/R. Hubbard, Savanta	Observations of decline in water throughout the subwatersheds.

Year/Date		Key Activity/Purpose of Visit	Staff/Agency/Landowner(s) Present	Comments/Observations
	06/12	Spot flow assessment and installation of temperature data loggers.	G. Buckton/R. Hubbard, Savanta	Flows had ceased in majority of watercourses – some standing pools. However, only locations that were suitable for establishing temperature loggers were in plunge pool on downstream side of Winston Churchill (D/S of CRT1-1) and in irrigation pond on CRT2-6).
	08/31	Flow observations in West Huttonville and CRT streams. Three minnow traps set.	R. Hubbard, Savanta	Viewed both West Huttonville and CRT subwatersheds to assess presence of "standing" or flowing water. Only observations were the following: • West Huttonville – only water evident in HV4 and HV3 – flowing. Stickleback (total of 14 fish) captured in the two ponded areas adjacent to driveway); • In irrigation pond on CRT2-6 – CRT2-8 sticklebacks and tadpoles.
2017	04/040 4/07	Round 1 HDFA	G. Buckton/ N. Boucher/ O. Park/ M. Green, Savanta	Assessments followed HDFA (2014) methods.
	05/180 05/19 05/24	Round 2 HDFA	G. Buckton/ N. Boucher/ O. Park/ M. Green, Savanta	Assessments followed HDFA (2014) methods.
	08/24 08/25 08/28	Round 3 HDFA	M. Letourneau/ O. Park/ M. Randolph, Savanta	Assessments followed HDFA (2014) methods.
2018	05/04	Round 1 HDFA	M. Letourneau/ R. Rossi, Savanta	Assessments followed HDFA (2014) methods.
	05/18	Round 2 HDFA	M. Letourneau/ R. Rossi, Savanta	Assessments followed HDFA (2014) methods.
	08/24	Round 3 HDFA	M. Letourneau, Savanta	Assessments followed HDFA (2014) methods.
2019	09/23	HDFA additional observations	M. Letourneau, Savanta	Assessments followed HDFA (2014) methods. Additional data recorded during wetland visits.

4.7.3.2 Benthic Invertebrates

This study relies on existing CVC IWMP data discussed section 4.7.2.3 supplemented by a scoped benthic invertebrate field program that was completed prior to 2010. Intermittent warmwater reaches were not included in the sampling plans after 2009 based on discussions with J. Nodwell (CVC) due to the inconsistent data quality and quantity.

Benthic invertebrate community survey locations are presented in Figure F2.

Benthic data has been collected in conjunction with other disciplines (water quality, fisheries, geomorphology) at CRT2 (2007-2010), CRT4 (2007-2010) and CRT3 (2009). Standard CVC benthic monitoring protocols were used. The CVC protocol is based on the OBBN (Jones et al., 2007) kick sweep method. This method involves walking from one bank to the other for three minutes while kicking the stream bed and holding a 500 µm D-net downstream to collect dislodged organisms. After three minutes, the organisms are emptied from the net, placed in a jar and preserved in the field using isopropyl alcohol. This collection is completed at three sampling locations within a sampling reach (riffle-pool-riffle). Samples were subsampled using the teaspoon method until at least 100 specimens were found. Specimens from each sample were identified to Family level.

The CVC's IWMP typically collect their samples during the early/mid-summer window and consideration was given to attempting to emulate this sampling period to provide a more comparative database. Samples were planned for collection during the summer months to minimize temporal variability.

4.7.3.3 Fish and Fish Habitat

Fish communities within the Credit River Tributaries subwatersheds were surveyed in accordance with the OSAP fish community sampling procedures (Stanfield, 2010). Surveys were conducted using a Halltech HT2000 Backpack Electrofisher and involved a standard single pass sampling technique with one netter. The electrofisher was set to a frequency of 60 or 80 Hz with an output voltage dependant on the conductivity at each site.

No permit could be obtained to electrofish in the West Huttonville Creek reaches as a result of the presence of Redside Dace, and therefore a waterproof GoPro camera mounted on a pole was used to survey fish within the selected reaches. The videos captured were viewed and images of fish were extracted as still photos and identified. Identifications were verified by a second ecologist.

Fish community survey locations are presented in Figure F2.

Previous fisheries data collection included:

- During the April 5, 2012 site walk, several dead Brook Stickleback were observed within portions of reach CRT1-3a and CRT1-3 (Figure F2). The hypothesis in the field was that these fish may have been washed out of an historic, upstream irrigation pond that is connected to the CRT1-3a reach via a small CSP since there were known downstream barriers. Savanta tested the hypothesis by placing minnow traps in this pond (April 10th, 2012) and captured a total of over 70 Brook Stickleback in four traps. This supports the hypothesis since the pond supports a robust Brook Stickleback community.
- Savanta also set a minnow trap at the downstream end of CRT2-7 on April 10, 2012, within a portion of ponded water (just to the west of Heritage Road). Six Brook Stickleback were observed, suggesting that movement upstream to Wanless Drive and perhaps a limited distance upstream may not be unrealistic. CVC has confirmed that ecology staff have observed Brook Stickleback in a culvert pool on the downstream side of Wanless Road (CVC, Fish Collection/Observation data, 2012).
- Savanta met with CVC staff at their offices on May 10, 2012 to review and discuss the results of the various spring site walks. CVC had collated the current fish community database, based upon CVC electrofishing data and field observations of fish by ecology staff at culvert crossings etc., as well as MNR's Fish Dot information. Based on these discussions, Savanta and CVC identified desirable electrofishing locations that would assist in establishing limits of "Seasonal" habitat within selected reaches. Based on the 2012 field observations and the background fish data, the reaches of greatest interest were the following:
    - CRT1-1 (upstream of Winston Churchill Boulevard);
    - CRT1-2 (downstream of the CNR);
    - CRT1 (downstream of Winston Churchill Boulevard);
    - CRT3-2, CRT3-3 and CRT3-4 (downstream of Heritage Road); and,
    - CRT4-6 and 4-5 (downstream of Bovaird Drive).

- A formal Scientific Collectors Permit application was submitted to Aurora MNR in mid-May 2012 for an expedited approval, but formal approval was unfortunately not received until late June 2012. In the absence of a permit to collect fish, Savanta undertook several roadside flow observations towards the end of May and into June to assess the gradual decline in flow conditions (i.e., "dry", "flowing" or "standing pools present"). Based on these observations, there was no active flow in any of the above tributary reaches by late May, and fully dry conditions were observed in almost all reaches by June 7, 2012. Some "standing pools" were noted. Hence, electrofishing would not have been effective within most of these reaches.
- Savanta installed temperature gauges on June 12, 2012 that were limited in their placement by the lack of water within most of the upper and middle reaches of the Credit River Tributaries. It is noted that CVC routinely monitors stream water temperatures and benthic invertebrate production at the lower reaches of the Credit River Tributaries. These are locations that generally exhibit permanent flow. Savanta's two temperature loggers (see Figure F2 for locations) revealed some extremely high summer temperatures (approaching the high 30^0C range). These findings suggest that extreme water temperatures are occurring within the residual pools.

4.7.4 Results and Analysis

4.7.4.1 Headwater Drainage Features

The detailed criteria of the 4-step HDF classification process for each of the subwatersheds by reach is in Table G1, Appendix G.

Table 4.7.7 below, summarizes the results of the HDF classification process for each reach in the Study Area, as well as the assigned Management Recommendation. The 2021 Management Recommendations are based on the classification process outlined in the 2014 HDFA Guidelines. The Proposed Site Specific 2021 Management Recommendations consider other relevant guidelines, best management practices and site-specific factors that are not accounted for in the HDFA Guidelines and that influence the proposed final management recommendation. The rationale for reaches where a lower or higher Management Recommendation is provided, relative to that based on the HDFA Guidelines alone is provided in Appendix G, Table G1. These considerations include circumstances where a wetland (non-significant) exists along an HDF but could be removed and replicated elsewhere or where the application of an upstream more restrictive management recommendation is not warranted in a downstream area based on the conditions present. In these instances, the outcome of the HDF classification would change. The HDFs where this occurs are highlighted in the detailed Table G1, Appendix G.

Figure F3, Appendix G, displays the proposed SWS HDF Management Recommendations for all HDFs in the Study Area. The "Management Recommendations" lead to headwater reaches being assigned to one of the following five categories. The following text is extracted from the 2014 HDFA Guidelines, and is presented here for information:

A. Protection – Important Functions: e.g. swamps with amphibian breeding habitat; perennial headwater drainage features; seeps and springs;

B. Conservation – Valued Functions: e.g. seasonal fish habitat with woody riparian cover; marshes with amphibian breeding habitat; or general amphibian habitat with woody riparian cover.

C. Mitigation – Contributing Functions: e.g. contributing fish habitat with meadow vegetation or limited cover

D. Recharge Protection – Recharge Functions: e.g. features with no flow with sandy or gravelly soils

E. Maintain or Replicate Terrestrial Linkage – Terrestrial Functions: e.g. features with no flow with woody riparian vegetation and connects two other natural features identified for protection

F. No Management Required – Limited Functions: e.g. features with no or minimal flow; cropped land or no riparian vegetation; no fish or fish habitat; and no amphibian habitat.

HDFs on lands not accessed (see Figure F3) during this study are recommended to be assessed as part of a future study. Specifically, access to the full extent of CRT3-7 was not obtained.

Table 4.7.7. Headwater Drainage Feature Assessment Summary for the Heritage Heights Subwatershed Study

Subcatchment	Stream Reach	2021 Site Specific Proposed HDF Management Recommendation
CREDIT RIVER TRIBUTARY CRT1	CRT1-1c	No Management Required
	CRT1-1d	No Management Required
	CRT1-1e	No Management Required
	CRT1-2a	Mitigation*
	CRT1-2b	No Management Required
	CRT1-2c	No Management Required
	CRT1-2d	No Management Required
	CRT1-2e	No Management Required
	CRT1-3	No Management Required
	CRT1-3a	Mitigation
	CRT1-3a1	No Management Required
	CRT1-3b	No Management Required
	CRT1-3c	No Management Required
	CRT1-3d	No Management Required
	CRT1-3e	No Management Required
	CRT1-3f	No Management Required
	CRT1-3g	No Management Required
	CRT1-3j	No Management Required
	CRT1-3k	No Management Required
	CRT1-3l	No Management Required
	CRT1-4	No Management Required
CREDIT RIVER TRIBUTARY CRT2	CRT2-2a	Conservation
	CRT2-3a	Conservation
	CRT2-3a1	Mitigation
	CRT2-3b	No Management Required
	CRT2-3c	No Management Required
	CRT2-3d	No Management Required
	CRT2-3e	No Management Required
	CRT2-3f	No Management Required
	CRT2-3g	No Management Required
	CRT2-3h	Mitigation
	CRT2-3h2	Conservation
	CRT2-3i	No Management Required
	CRT2-3j	Mitigation
	CRT2-3j1	Conservation

Subcatchment	Stream Reach	2021 Site Specific Proposed HDF Management Recommendation
	CRT2-3j2	Mitigation
	CRT2-3j3	No Management Required
	CRT2-3k	Protection
	CRT2-3l	Conservation
	CRT2-3l1	No Management Required
	CRT2-3m	Mitigation
	CRT2-3m1	Conservation
	CRT2-4a	No Management Required
	CRT2-4b	No Management Required
	CRT2-5a	Protection
	CRT2-6a	No Management Required
	CRT2-6b	No Management Required
	CRT2-8a	No Management Required
	CRT2-8b	No Management Required
	CRT2-8c	No Management Required
	CRT2-8d	Protection
	CRT2-9	Mitigation
	CRT2-9a	No Management Required
	CRT2-9b	No Management Required
	CRT2-10	No Management Required
	CRT2-11	No Management Required
CREDIT RIVER TRIBUTARY CRT2A	CRT2A-1	Protection
	CRT2A-2	Conservation*
	CRT2A-2a	No Management Required
	CRT2A-3	Protection
CREDIT RIVER TRIBUTARY CRT3	CRT3-3b2	No Management Required
	CRT3-3b1	No Management Required
	CRT3-4a	Conservation
	CRT3-4a1	Mitigation
	CRT3-6	Protection
	CRT3-7	Conservation
	CRT3-7a	No Management Required
	CRT3-7b	No Management Required
	CRT3-7c	No Management Required
	CRT3-7d	No Management Required
	CRT3-7e	No Management Required
	CRT3-7f	No Management Required
	CRT3-8	Conservation
	CRT3-8a	No Management Required
CREDIT RIVER TRIBUTARY CRT4	CRT4-a	Conservation
	CRT4-b	Conservation
	CRT4-c	Conservation
	CRT4-c1	Protection
	CRT4-d	Protection

Subcatchment	Stream Reach	2021 Site Specific Proposed HDF Management Recommendation
	CRT4-e	Protection
	CRT4-7	Mitigation*
	CRT4-7a	Mitigation*
	CRT4-7b	Mitigation*
	CRT4-7c	No Management Required
	CRT4-7d	No Management Required
	CRT4-8	Mitigation*
	CRT-8a	Mitigation
CREDIT RIVER TRIBUTARY CRT4A	CRT4A-1	Protection
	CRT4A-2	Mitigation
	CRT4A-3	Mitigation
CREDIT RIVER TRIBUTARY CRT5	CRT5-6	Mitigation
	CRT5-7	Mitigation
WEST HUTTONVILLE SUBCATCHMENT	HV6a	Conservation*
	HV6b	Protection
	HV6c	Mitigation*
	HV9a	No Management Required
	HV9b	No Management Required
	HV9c	No Management Required
	HV9d	No Management Required
	HV9e	No Management Required
	HV9-2	No Management Required
	HV11a	No Management Required
	HV12	No Management Required
	HV13	Mitigation*
	HV13a	No Management Required
	HV13b	No Management Required
	HV14	No Management Required
	HV14a	No Management Required
	HV14-1	No Management Required
	HV14-2	No Management Required
	HV15	No Management Required
	HV15a	No Management Required
	HV16	Conservation*
	HV17	Protection
	HV17b	Mitigation*
	HV17c	Protection
	HV31	No Management Required
	HV80	Protection
	HV80a1	Conservation*
	HV80a2	Protection
	HV80b	No Management Required
	HV80-b1	No Management Required
	HV80-b2	No Management Required

Subcatchment	Stream Reach	2021 Site Specific Proposed HDF Management Recommendation
	HV80-2	Conservation*
	HV81	Under Study**
	HV81a	Under Study**
	HV81b	Under Study**

* Denotes where site specific conditions have modified recommendation. See Table G1, Appendix G for further information.

** HDF Under Study – these areas are under study by the Mount Pleasant Heights Owners. 2021 data, once available will be integrated within the HHSWS.

4.7.4.2 Benthic Invertebrates

No benthic invertebrate sampling has occurred as part of the HHSWS since 2010. Additional sampling was planned for 2012 however sampling intermittent and ephemeral features was not possible due to lack of flow by late May/early June 2012 in the features when sampling was scheduled.

Experience suggests that benthic invertebrate communities vary significantly in the middle and upper reaches of agriculturally-influenced drainage features that are characterized by intermittent/ephemeral flow conditions. The influences of intermittent flow make the interpretation of benthic data challenging and raise the question of whether there is sufficient value in sampling these features.

Sample collection has been successful for CRT2 and CRT4 as they are perennial coldwater streams. However, CRT3 is an intermittent warmwater stream and this methodology has resulted in less frequent samples and poor quality results. CVC confirmed that these intermittent conditions have prevented benthic sampling from occurring at this station. The biotic communities will vary among intermittent watercourses relative to the duration and frequency of continuous surface water flow. The variability associated with headwater streams must be understood to avoid the confounding effects of natural drying when assessing ecological integrity or stream condition. It is noted that this was the finding during the benthic investigations during the Phase 1 portion of the HFSWS. In that study, the only meaningful benthic field data were collected at the two Huttonville Creek stations (as part of the CVC's Effectiveness Monitoring Program). These samples were collected from perennially flowing reaches of Huttonville Creek (i.e., CVC Stations EM7 and EM8). Other sampling efforts, however, that occurred within a forested pond and a vernal pool within a forest community did not provide useful data. In the case of the vernal pool, this site was dry by mid-June and only one sample was able to be collected. In the case of the forested pond, while water did remain within the pond through summer, the bottom was covered with a thick mat of decaying organic matter and oxygen levels were quite low. In both cases, the benthic indices that are normally used to derive an assessment of surface water quality (e.g., taxa richness, HBI, and EPT) all were indicative of "poor" to "severely impacted" conditions.

CVC continues to place emphasis on the downstream sampling stations EM7, EM8, CRT2 and CRT4 where there is less variability in the physical parameters of the aquatic habitat year over year. There is sufficient data from these locations to provide a baseline for evaluation of impacts from future development.

4.7.4.3 Fish and Fish Habitat

Fish community surveys were completed at nine locations by electrofishing and 5 locations by GoPro as shown in Figure F1 (Appendix G). A summary of the species captured at each reach during the electrofishing surveys is provided in Table 4.7.8.

Table 4.7.8. Fish Community Sampling Electrofishing Data

Reach	Fish Captured	Date
CRT1-1	No Fish	July 5, 2017
CRT1-2	1 Adult unidentified minnow	July 5, 2017
CRT2-5	82 Brook Stickleback	July 5, 2017
CRT2-6	11 Brook Stickleback	July 5, 2017
CRT2-7	6 Stickleback 20 Fathead Minnows	July 5, 2017
	No Fish	July 6, 2017
CRT 3-3	No Fish	July 6, 2017
CRT3-5	No Fish	July 5, 2017
CRT 3-7	No Fish	July 5, 2017
CRT4-6	No Fish	July 6, 2017
HV9	Not fished	July 6, 2017

The electrofishing effort in 2017 was successful in providing confirmation that CRT1 and CRT2 provide direct fish habitat further upstream in the watershed than initially anticipated. These upper reaches are believed to provide direct seasonal fish habitat, based on the intermittently flow nature. Additional incidental observations collected during the HDFA fieldwork determined that seasonal habitat was present in CRT1-2 and CRT2-8. The communities present are warmwater small bodied generalist fish that tolerate a wide range of habitat conditions.

Go Pro observations were collected for the West Huttonville Creek reaches on June 28, 2017. **Table 4.7.9** provides a summary of the fish community data collected.

Table 4.7.9. Go Pro Fish Species Observations in the West Huttonville Creek (June 28, 2017)

Reach	Coho Salmon (young of the year)	Brook Stickleback	Notropis sp.	Blackchin Shiner	Blacknose Shiner	Creek Chub
HV2	6	1	-	-	-	-
HV4	-	5	-	-	-	-
HV4	-	-	3	-	11	-
HV4	-	3	>30	2	1	-
HV4	-	9	5	-	-	6
HV4	-	-	>50	28	-	-
HV5	-	9	-	-	-	-
HV7	-	7	-	-	-	-
HV9	-	-	15	-	-	-
HV9	-	2	>30	-	-	4

The Go Pro was an effective method for collecting fish data in sensitive habitat. West Huttonville Creek has a diverse fish community assemblage with mostly small bodied warmwater tolerant fish. The salmonid young of the year were a notable discovery. Their presence and the occupied Redside dace habitat suggest there would be benefit to managing the Huttonville Creek as a cool/coldwater habitat.

The preliminary fish habitat classification of the watercourses within this Study Area is presented on Figure F3, Appendix G. These fish habitat classifications include direct, direct seasonal, indirect and no fish habitat based upon the criteria described in herein. Direct habitat has fish present and permanent flow. Direct seasonal habitat has fish present on a seasonal basis, due to the intermittent flow regime. Indirect habitat is not fish-bearing but provides surface flow, sediment transport, and/or allochthonous contributions to downstream fish habitat. The no fish habitat designation is used infrequently and require a disconnect between the reach and downstream fish habitat. For example, CRT5-6 does not provide fish habitat because it flows into a stormwater management pond before connecting to the natural channel again.

Fish habitat management designations depicted take into consideration the communities present and key species such as Redside Dace to determine the recommended approach to fish habitat management. Consideration was also given to field discussions with staff of CVC in 2012.

Table 4.7.10. Thermal Habitat

Subwatershed	Habitat Management Recommendation	Rationale
CRT1	Warmwater	Only tolerant warmwater fish species present.
CRT2	Warmwater above CRT2-5 Coldwater CRT2-5 and below	The lower reaches have salmonids present.
CRT2A	Warmwater	No identified groundwater input. No fish observations.
CRT3	Warmwater	Only tolerant warmwater fish species present.
CRT4	Warmwater above CRT4-3 Cool/Coldwater CRT4-3 and below	Salmonid refuge habitat was identified by CVC in the lower reaches.
CRT4A	None (CRT4A-3 and CRT4A-2)	This feature goes into a storm sewer and provides no fisheries habitat value; no identified groundwater input; no fish observations.
CRT5	None	This feature goes into a storm sewer and provides no fisheries habitat value.
HV	Cool/Coldwater	Redside Dace occupy the lower reaches.

All watercourses within the middle and upper reaches of the West Huttonville Creek subwatershed support small, warmwater tolerant fish communities. Redside Dace are associated with cool water conditions and these have been reported in the West Huttonville Creek downstream of the Mississauga Road crossing. However, flowing conditions, riparian and instream habitat, and an ability (albeit limited) for upstream access north through the CNR culvert would suggest that “direct” Redside Dace habitat would extend to the top end of Reach HV4, and this has been confirmed through discussions with the MNRF. Figure F4a illustrates the extent of existing Redside Dace habitat based on field observations, review of available background data and interpretation of Ontario Regulation 242/08, Section 29.1. Figure F4a presents two types of habitats as defined by the regulation. While depicted only conceptually on Figure F4a, habitat defined by Section 29.1 1. i-iv (direct habitat) includes areas encompassed by the meander belt width and vegetated or agricultural lands that are within 30m of the meander belt. Habitat shown defined by Section 29.1 1.v (contributing habitat) includes the immediate stream or wetland only. For the purposes of this study both the PSWs and the mapped ECL wetland polygons that are continuous with downstream RSD habitat are shown on Figure F4a as considered contributing habitat. Precise boundaries of these features will be determined through future studies and may amend HHSWS mapping.

All the upper and middle reaches of the CRT watercourses for the most part, could be regarded as providing warmwater habitat for tolerant fish species. The exceptions are those tributaries that exhibit groundwater contributions such as CRT2 upstream of Bovaird Drive (Highway 7), and portions of the downstream reaches of CRT4 where cold water habitat may be present. In these lower reaches, the habitat is suitable for a cool/cold water fish community, and the upstream extent is likely influenced by instream barriers, such as the culvert under Bovaird Drive in the case of CRT2. CVC confirms that the lower reaches of CRT4 would best be described as coldwater refuge, based on the captures of Coho Salmon and Brown Trout that have been found there regularly since 2008 (J. Nodwell, pers. comm.). CVC also indicates that CRT3 has routinely exhibited intermittent conditions such that it has not been possible to conduct electrofishing or benthic sampling.

In addition to the various stream reaches, there are historic irrigation ponds that are off or on-line. Five are indicated on Figure F4b. These features may create barriers to fish movement and opportunities to remove these ponds will be considered within the establishment of the natural heritage system.

There were eight barriers noted during fieldwork (Figure F4b). The majority are due to perched culverts that provide a seasonal barrier as the water levels drop. There is one instance where the barrier is due to a dam on CRT3-7 that is used to create a garden pond feature. This barrier is present year-round. The opportunity to remove these barriers will be considered within the establishment of the natural heritage system.

4.7.5 Interpretation

As was observed through the HFSWS, the main factor limiting the productivity of aquatic habitat in the mid and upper reaches of the West Huttonville Creek and Credit River Tributary reaches is flow. The ephemeral headwater drainage features are dry for most of the year, and thus cannot directly support fish or other aquatic organisms requiring water on a continuous or even seasonally regular basis. Even in the odd circumstance when fish may migrate into some of these upper reaches, the productive capacity is limited by the temporary nature of the habitats and the fish must either move back downstream or perish. Also, because the habitat is often restricted to standing pools for some distance further downstream, the number of fish available to move into the headwaters when flow does occur is low.

Based on flow observations, the following comments apply in terms of flow permanence and groundwater influences:

- On the West Huttonville Creek, during dry summer conditions, flow begins at the top end of Reach HV4, and although the volume of water flowing under the Mississauga Road culvert is low, it is a discernable flow. No other tributaries flow in West Huttonville Creek during these summer conditions.
- On the Credit River Tributaries, the following flow observations were made:
    - In Subwatershed CRT2, evidence of groundwater influence occurs within Reach CRT2-4 (i.e., west of Heritage Road). Flow continues through the Brampton Brick property, and downstream of Bovaird Drive to the confluence with the Credit River;
    - In Subwatershed CRT4, groundwater influence is evident downstream of the large, on-line pond (i.e., within Reaches CRT4-2 and CRT4-3).
    - Under very low water (dry year conditions) summer conditions, the only permanent water in the mid and upper portions of these tributaries exists within the few isolated farm

    - ponds that continue to hold water, but at substantially lower levels than during the spring and early summer;
    - The foregoing flow observations are consistent with the groundwater characterization completed as part of this Phase 1 work.

Overall, the West Huttonville Creek and Credit River Tributaries:

- support benthic invertebrate communities;
- support fish communities;
- provide surface flow during some times of the year;
- contribute bedload; and,
- provide allochthonous material.

These aquatic resources will be considered in the development of a functional natural heritage system.

5.0 Integration – Characterizing the Subwatershed

5.1 Integration Approach

The foregoing investigations and discussions of the existing natural systems proceeded on a discipline-specific basis, working toward an integrated characterization and assessment of the features, functions and form related to the existing systems. This integration allows for a fuller understanding of the fundamental environmental components and systems within the study area. An integrated characterization and assessment of each study discipline generally occurs on two levels, namely: i) integrated characterization to validate or confirm the findings of respective disciplines, and ii) an integrated characterization of key environmental features and systems to define the functions, attributes, and interdependencies, and to thereby provide guidance for establishing management opportunities and requirements based on future land uses.Primary environmental elements stemming from the discipline-specific characterization work described in the previous report sections include:

- Natural Heritage Wetland/Woodlot Units
- Watercourses (including headwater drainage features)
- Recharge and Discharge Areas

Each of these elements to varying degrees requires an integrated assessment in order to establish the significance and associated sensitivity of the units, particularly in the context of the urbanizing setting; the following provides some associated considerations in this regard:

1. Natural Heritage Units
    - diversity and significance of species (flora and fauna)
    - potential for corridor linkage and benefits to key biota
    - presence/absence of fluvial unit
    - local catchment area (size and land use)
    - groundwater influence to sustainability of habitats and functions
    - feature size, plant community diversity, and proximity to other features
2. Watercourses and Headwater Drainage Features
    - presence/absence of form/stability
    - baseflow – /intermittent/permanent
    - groundwater discharge (reach specific/volumetric)
    - presence/absence of riparian corridor vegetation
    - bankfull/riparian/flood flows
    - floodplain – flood storage and flood conveyance
    - sediment transport
    - fish habitat (direct/indirect)
    - benthics
    - temperature/water quality
3. Recharge and Discharge Areas
    - rate of infiltration/recharge
    - location of functional recharge area
    - functional relationship to watercourse, wetland or terrestrial feature
    - quantity of groundwater flux

The foregoing factors/considerations (and others) have been summarized as they relate to the respective environmental units. The following sections provide insight regarding these units, which will be used in subsequent study stages to inform the land use and infrastructure (road and services) planning process in an iterative manner.

5.2 Principles of Integration

The field work and accompanying assessments, associated with subwatershed characterization, has been used to establish various principles, unique to the overall Study Area. These principles reflect certain properties and characteristics of the subwatershed, which depending on their nature, lead to certain implications for (to) management associated with future land use changes.

The following sections have been organized by discipline; the principle is stated initially followed by the implications for (to) management where relevant (italics). It should be noted that by their very nature there are overlaps between the respective disciplines, which essentially lead to the integrated understanding of how the subwatershed functions.

5.2.1 Groundwater Characterization and Functions

i) The fractured nature of the upper till, along with macropores, provides the main pathway for infiltration and movement of groundwater, both laterally and to depth. This active hydraulic zone is likely limited to the upper 2 to 3 m. A reduction in infiltration can reduce the local groundwater levels and available groundwater for storage and discharge. Infiltration can be reduced through urbanization by an increase in less permeable surface area (i.e., buildings and roads) and compaction of the shallow till.

Attempt to maintain or enhance infiltration where functionally appropriate and minimize compaction of the shallow overburden.

ii) Reduced water levels may impact terrestrial communities dependent on a high water table and reduce groundwater discharge where it exists in stream reaches and effect aquatic resources.

Attempt to maintain or enhance infiltration where functionally appropriate. Also implement best management practices for underground servicing to minimize water table lowering.

iii) A reduction in water levels and storage of groundwater water may reduce available water in local water wells.

Attempt to maintain or enhance infiltration where functionally appropriate and minimize compaction of the shallow overburden.

iv) The fractured nature of the upper till, along with macropores, appears to provide an additional capacity to infiltrate and store precipitation when the shallow water levels are sufficiently low, thus buffering runoff for medium intensity rainfall events.

Compaction or removal of the shallow till may reduce this buffering capacity. This must be considered in stormwater management planning for development.

v) Smaller scale depressional topography can focus local shallow groundwater and may increase local recharge.

This should be maintained or re-created where functionally important. .

vi) The existing forested areas appear to infiltrate more water when compared to the adjacent open fields, likely due to the more permeable and porous organic mats and the closed depressional nature of these woodlots. The high permeability of the forested areas would act to mound the water table relative to the water table in the surrounding till during snowmelt or precipitation and potentially provide groundwater recharge.

Forested areas should generally be maintained with abuffer area in the shallow till to provide lateral movement of groundwater.

vii) Shallow groundwater levels adjacent to terrestrial features may act to buffer the amount of infiltration/recharge out of these features as part of the natural water balance.

Maintaining infiltration within the buffer areas surrounding these features may maintain the natural groundwater levels and local groundwater balance.

viii) The upper fractured Queenston Shale bedrock is considered the most regionally connected groundwater flow system. Installation of various infrastructure within this unit may occur where the overburden is thin and groundwater flow system impacts are possible with respect to the quantity and direction of groundwater flow.

Infrastructure trenches should be designed using best management practices to minimize water table lowering and redirection of shallow flows.

ix) The quality of the groundwater within the till units, permeable lenses and shallow bedrock has varying elevated levels of total dissolved solids but is relatively fresh in nature and provides water for a limited number of private wells.

An acceptable level of quality must be maintained where infiltrating stormwater may be promoted.

x) Groundwater discharge areas to various reaches may provide a source of potential perennial flow.

Discharge areas in drainage features should be protected from physical disruption of the permeable streambed connection; maintain where practical infiltration within the functional recharge areas for the discharge reaches.

xi) The Halton Till has a relatively high clay content and generally has a low permeability. More permeable sand lenses exist within the till and at the bedrock contact. The upper fractured shale bedrock is relatively permeable as well.

Stormwater infiltration may be more viable within these more permeable units.

5.2.2 Surface Water Characterization and Functions

i) The Regional Storm Floodplain along the lower CRTs is primarily contained within the defined ravines; the floodplains within the headwater systems and West Huttonville Creek generally encompass existing agricultural lands.

Flood protection for the CRTs and WHC subwatersheds is to be integrated with planning of the NHS and management plan for watercourses.

ii) The fractured Halton Till within the upper 2-3 m provides storage and movement of infiltrated surface water. The runoff response within drainage features depends upon the level of saturation within the Halton Till. When the Halton Till is unsaturated, as during the drought conditions of 2007 and 2012, there is little or no runoff response within the overland drainage system. When the Halton Till is saturated the runoff response is quick (as evidenced by HFSWS, 2011, Fall 2006 data).

Maintain infiltration to the fractured Halton Till, where possible, through a range of Low Impact Development (LID) stormwater management techniques.

iii) Sand and gravel lenses that are in proximity to the ground surface may provide high levels of infiltration.

The sand and gravel lenses should be considered as opportunities for infiltration stormwater management practices.

iv) Drainage systems located within or adjacent to terrestrial units such as significant woodlands and wetlands may contribute overland drainage to the terrestrial units on a frequent basis, therefore depositing sediments and nutrients, important for sustainability.

Drainage features with floodplains that include significant woodlands and wetlands should continue to contribute drainage, sediments and nutrients by maintaining the existing alignment or by being realigned in a manner that does not impact the terrestrial unit.

v) Wetlands and woodlands may provide temporary flood storage when located within drainage system floodplains.

The flood storage function of the area wetlands and woodlands should be appropriately managed either within the terrestrial units or replicated locally within the drainage system. The water balance function of the area wetlands should be appropriately managed to ensure the hydrological and ecological form and functions are maintained to pre development conditions. The use of woodlands that do not currently provide flood storage should not be considered for flood storage, unless it is demonstrated that there will be no implications to the hydrologic period, water quality and habitat quality/health.

vi) Overland micro- drainage areas to vernal pools located within woodlots to some measure sustain the vernal pool system.

Equivalent drainage areas and/or equivalent flows to vernal pools should be maintained.

vii) Drainage systems contribute runoff to riparian vegetation along the drainage system corridor, therefore contributing to the formation and sustainability of the riparian vegetation.

Existing drainage systems, whether altered through realignment, form or other alterations, should be managed to maintain and/or improve upon existing riparian vegetation communities.

viii) The stability of channel systems is dependent upon multiple factors including the flow regime within the channel. Excess shear stress within the area channels occurs when the channel bed and bank materials experience flow velocities that are capable of moving materials downstream, resulting in erosion. Channel reaches sensitive to erosion have been determined through stream morphology field work program. Critical flows have been established, above which erosion may occur within certain channel reaches.

The flow regime within the channel system post development should be managed to mitigate potential impacts to the channel system stability. Stormwater management and natural channel design techniques will be required to provide for long-term and sustainable channel stability.

ix) Some headwater drainage features contribute and convey sediment to the downstream drainage system while also removing contaminants within both the Huttonville and the CRT subwatersheds, and therefore may be an integral component of the downstream channel formation process. Currently headwater drainage features, in terms of their form and function, are heavily impacted by agricultural land management practices, which is likely to generate higher volumes of fine sediment than under “natural” conditions.

The headwater drainage system function of "natural" sediment contribution to downstream systems should be replicated by using innovative drainage systems and BMP's (i.e., replication the function of headwater drainage features where warranted).

x) Most of the existing drainage system within West Huttonville Creek and within most of the Credit River Tributaries provides "Indirect" or "Direct Seasonal" fish habitat due to lack of base flow. "Direct" Fish Habitat begins where groundwater and/or surface water contributions are sufficient to ensure that water is present year round.

Stormwater management infrastructure, including Low Impact Development measures and measures to manage wetland water balances, may potentially extend flows within both West Huttonville Creek and the Credit River Tributaries, downstream of outfalls and/or wetlands, which could extend permanent fish habitat in upstream reaches.

i. If unmitigated, the conversion of agricultural lands to urban land uses will increase the rate and volume of storm runoff locally, and potentially further downstream.

Stormwater management systems should be implemented to manage the increased rate and volume of runoff from future development and no increase water levels within identified downstream flood-prone private properties.Geomorphic Characterization and Functions

i) Increased flows and changes in sediment supply associated with land use change can exacerbate natural rates of erosion within receiving watercourses. This, in turn, can lead to channel instability, degraded aquatic habitat, create erosion hazards to property and threaten infrastructure.

By applying site-appropriate stormwater management measures, negative impacts to water quality and aquatic habitat associated with undesirable and potentially costly geomorphological change in watercourses can be mitigated. It should be noted that impacts to sediment supply should also be considered in any management strategy through the protection of natural sediment sources. Protection of such natural sources represents a fundamental component in maintaining a dynamic equilibrium state within a drainage system.

ii) Modifications to the drainage network, such as the removal of first order streams or vegetative cover can remove natural sediment sources to the downstream system and reduce the natural detention and retention of flow within the landscape, increasing not only the volume of flow in receiving reaches, but also decreasing the time in which these volumes are conveyed to the reaches.

The development of an appropriate stormwater management strategy and headwater drainage feature management should address maintaining contributions to the downstream drainage networks.

iii) Restoration and enhancement of stream corridor conditions (riparian habitat) along those sections of channel identified as being in a degraded state (typically in association with historic land use practices) represents a key opportunity to improve the overall health of the watershed. Maintenance and enhancement of a diverse riparian vegetation community within the stream corridor will mitigate erosive processes, improve morphologic diversity, enhance aquatic and terrestrial habitat conditions and contribute high quality organic matter to downstream reaches.

The protection of stream corridors through the development of a natural heritage strategy will support the preservation and enhancement of channel form and function within the subwatershed. Corridor requirements will reflect an integration of terrestrial, geomorphic, aquatic, hydrologic and groundwater considerations.

iv) The incorporation of erosion hazard limits (i.e., the meander belt width or geotechnical slope requirements) into the stream corridor will support the long-term form and function of the watercourse and valley system, while mitigating risk to property and infrastructure due to erosive forces.

For unconfined valley systems, the greater of the flood hazard limit or meander belt width allowance (along with the erosion access allowance) will be established as a constraint to development as it represents the hazard limit. For confined valley corridors, Provincial Policy dictates that the erosion hazard limit is governed by a combination of stable slope, toe erosion and access allowance (geotechnical) requirements.

v) Most of the reaches within the study area have been characterized as highly modified because of human activities and could benefit from rehabilitation.

Improving channel form and function through selective rehabilitation represents an opportunity for environmental enhancement. This should be considered in conjunction with stormwater best management practices, as well as terrestrial and aquatic habitat objectives to help establish an appropriate sediment regime.

5.2.3 Terrestrial Integration Characterization and Functions

i) The current levels of natural cover (12.9%) including wetland cover (3.2%) are below literature-based thresholds that would support optimal terrestrial, wetland and hydrological functions in watersheds located in the temperate zone.

There are opportunities to increase natural cover through focused restoration of stream corridors to help mitigate downstream impacts of development.

ii) The subwatershed landscape is sustaining low numbers but a relatively consistent composition of locally- to regionally-significant species and quality indicator species, associated with forest, open field and wetland features.

The future natural heritage system should reflect a prioritization and balancing of the best opportunities to integrate features and functions that will sustain diversity under urban conditions.

iii) Some natural heritage features within the tablelands were identified as significant. Some of these patches are isolated due to the existing agricultural landscape. Tableland habitat connectivity and corridor creation will be influenced by the proposed north-south boulevard.

Restoration of natural cover and diverse riparian habitats along watercourses is feasible within both West Huttonville Creek and Credit River Tributary subwatersheds. Stream and HDF management should consider benefits of realignments to connect isolated features to a connected NHS.

iv) Wetlands are mostly found within woodlots or along watercourses, with few present in the agricultural landscape. Several of these wetlands are provincially significant wetlands that are part of significant woodlands and/or significant wildlife habitat.

The relationships between catchment characteristics, soils, existing fluvial systems and habitats must be quantified at progressively finer levels of detail to ensure that these relationships can be appropriately managed as part of development.

v) Many of the stream reaches have been channelized and ditched as part of agricultural practices.

There is the opportunity to integrate stormwater retention with stream reaches that have been restored to a more natural channel form.

iv) Some of the forests in the subwatershed have lost important diversity, structural characteristics and functions over time (e.g., species diversity, older growth, topographic variability, runoff retention capacity) and been subjected to other disturbances, which if addressed, would enhance sustainability.

There is an opportunity to assist these habitats to evolve into a healthier and more functioning state over time through focused management activities.

5.2.4 Water Quality Characterization and Functions

i) The existing water quality for Huttonville Creek, as was determined through the HFSWS (2011) 2006 to 2007 field monitoring program, is impaired by the current and historical agricultural land uses and practices. PWQO guidelines for E.Coli, Zinc, Total Phosphorous and other parameters have been exceeded during both dry and wet weather monitoring. Similar results would be expected for the Credit River Tributaries, based on existing land use and soil conditions to Huttonville Creek.

Based on future land use conditions, stormwater management infrastructure should be designed provide stormwater quality control for future developments in accordance with the MECP Enhanced standard of treatment and potentially improve the current water quality conditions. The headwater areas provide a hydrologic function, nutrients, sediment, particulate matter and organics to the downstream aquatic habitat.

The headwater area aquatic habitat support function should be maintained through implementing a drainage system that includes the use of Low Impact Development, open swales and/or traditional SWM measures..

ii) The existing sand and gravel lenses provide a water quality function as filtration mediums.

Infiltration stormwater quality management measures that filter contaminants from runoff should be considered for implementation within the sand and gravel lense locations.

5.2.5 Aquatic Characterization and Functions

i) Permanent flow, sustained by groundwater, occurs in portions of the Credit River Tributaries and in thelower reaches of West Huttonville Creek (begins to the north of the CNR). Redside Dace are identified within the lower reaches of West Huttonville Creek, but not in the Credit River Tributaries. Groundwater discharge is a feature of typical Redside Dace habitat.

Within the Credit River Tributaries there is evidence of groundwater contribution starting in CRT2-4 and in downstream reaches through to CRT2's confluence with the Credit River, as well as in the lower reaches of CRT4 to it's confluence with the Credit River. Both tributaries have salmonid records in the lower reaches.

Groundwater discharge should be maintained to sustain permanent flow and support water quality in Redside Dace occupied habitat reaches and salmonid rearing and spawning habitat.

ii) Flow in the headwaters of both West Huttonville Creek the Credit River Tributaries is ephemeral or intermittent providing indirect and direct seasonal habitat. Therefore, the aquatic communities that are present in the headwater drainage features are composed of tolerant warmwater species (e.g., fathead minnow and brook stickleback) that are able to exploit these habitats when water is present, and are generalists in terms of habitat requirements. Based on field observations, there are no critical direct fish habitats (i.e., essential spawning habitat) in the headwaters upon which populations that exists downstream depend.

The fish species that utilize drainage features under the existing conditions will be able to take advantage of extended flow or additional refugia that may be created because of extended flow from stormwater management facilities.

5.3 Integration – Watercourses and HDFs

The integration principles outlined in the preceding section have been applied through this initial Phase 1 assessment to develop a constraint ranking for the watercourses and headwater drainage features (HDF) within the Study Area. Each watercourse and HDF has been assessed on a reach-by-reach basis, based upon various environmental factors and considerations, and a "consensus" rating has been developed accordingly. The findings of the assessment will ultimately be reviewed further through the Phase 2 Impact Assessment and then refined to provide guidance regarding the management opportunities and requirements for each of the surface drainage features within the Study Area. The following summarizes the approaches and criteria applied, by discipline, in developing the individual rankings / classifications for the area watercourses and HDF.

In the draft Phase 1 Characterization (2012), drainage features were identified and preliminary management classifications were determined. Each feature was assessed by contributing disciplines (i.e. hydrology, geomorphology, hydrogeology, fisheries, and terrestrial ecology), with a constraint ranking of "high", "medium" or "low" provided by each. The final ranking of high, medium, or low was established using an integrated and consultative process, which then provided preliminary direction regarding the management opportunities for each feature. Under this previous approach, low rated features were typically first order streams or headwater drainage features, whereas medium and high constraint features corresponded to regulated watercourses.

In the current study, the approach has been modified to incorporate elements of the previous watercourse constraint evaluations, as well as the application of the *Evaluation, Classification and Management of Headwater Drainage Features Guideline* (TRCA and CVC, 2014), which has become an accepted practise since the initial Phase 1 Characterization work in 2012. This approach differentiates between watercourses, generally with drainage areas greater than 50 ha, and HDFs, generally with drainage areas less than 50 ha. In doing so, this approach has resulted in the following outcomes:

- Watercourses are either a high constraint (red) stream or a medium constraint (blue) stream. This approach has no low constraint stream ranking as drainage features that were typically considered low constraints are now addressed through the HDF Guidelines;
- Headwater Drainage Features are classified as either Protection (red dashed), Conservation (yellow), Mitigation (green), or No Management (green dashed).

This approach provides an integrated multi-discipline assessment of drainage features in the Study Area. It builds upon the recommendations from TRCA/CVC protocols, and includes management recommendations for watercourses consistent with historic practices, with corresponding colour coding/symbolism to represent each feature type, constraint ranking/classification. This modified approach has been established to provide clarity and consistency in the feature designation (i.e. "Watercourse" or "HDF"), as noted in the following, as well as in establishing the constraint ranking/classification of the features.

- **Watercourses** are permanently to intermittent flowing drainage features with defined bed and banks. They exhibit clear evidence of active channel process including planform, profile, and material sorting, with evidence of a balance between erosion and deposition throughout the reach. They are often second-order or greater, but may be first order when verified by the practitioner(s). Watercourses are currently identified as regulated features by the CA, and fish are typically found within these features. The contributing drainage area is 50 ha or greater.

- **Headwater Drainage Features (HDFs)** are non-permanently flowing drainage features that may not have defined bed or banks. The presence of bed and bank definition within these features may be attributed to anthropogenic intervention (e.g. cutting a drainage feature into the surface), or seasonally as spring freshet concentrates flows in depressions, causing channel development into surfaces lacking vegetated cover. HDFs are first order intermittent and ephemeral channels, swales and connected headwater wetlands, but do not include rills or furrows. They are currently not identified as regulated features, and fish may or may not be found within the feature. The contributing drainage area is generally less than 50 ha.

Table 5.3.1 and Table 5.3.2 summarize watercourse rankings; Table 4.7.7 summarizes HDF classifications. Figure F3 presents all drainage feature rankings.

For HDFs, the evaluation has been completed initially by applying the 2014 HDF Guidelines to determine the management recommendation and then, through an understanding of existing and proposed site conditions, proposed Site Specific (2021) management recommendations have been made that may differ from the outcome of the HDF Guidelines. The proposed Site Specific 2021 Management Recommendations consider other relevant guidelines, best management practices and site-specific factors that are not accounted for in the HDFA Guidelines and that influence the proposed final management recommendation. Where a different management recommendation is provided, relative to that based on the HDFA Guidelines alone, rationale is provided in Appendix G, Table G1. Rationales include circumstances where a wetland (non-significant) exists along an HDF but could be removed and replicated elsewhere or where the application of an upstream more restrictive management recommendation is not warranted in a downstream area based on the conditions present. In these instances, the outcome of the HDF classification change.

This SWS Phase 1 Report is intended to characterize existing watercourses and HDFs. The SWS Phase 2 Report will address management strategies. Typical management strategies for watercourses and HDFs outlined below will be further assessed and detailed during the Phase 2 Impact Assessment.

- High Constraint - Watercourse and corridor to be protected in current form and location with applicable regulatory hazard setbacks and ecological buffers. Some exceptions to this apply for infrastructure, management of ill-defined floodplains or restoration/rehabilitation works;
- Medium Constraint – Watercourse and corridor to remain open and may stay in current location or be realigned for servicing or NHS/community design reasons where restoration and enhancement is included in natural channel designs. Applicable regulatory hazard setbacks apply; ecological buffers may apply; and

HDF management varies depending upon the management recommendations of Protection. Conservation, Mitigation and No Management as outlined in the *Evaluation, Classification and Management of Headwater Drainage Features Guidelines*, (TRCA/CVC, 2014).

Table 5.3.1. Watercourse Rankning Considerations

<table>
<tr><th rowspan="2">Stream Characteristics</th><th colspan="3">Ranking Considerations</th></tr>
<tr><th>High Ranking</th><th>Medium Ranking</th><th>Low Ranking</th></tr>
<tr><td rowspan="3">Flow Assessment</td><td>▪ Drainage area is >125ha
▪ Stream power, see below</td><td>▪ Drainage area is 50 ha to 125 ha
▪ Stream power, see below</td><td>▪ Drainage Area is <50 ha
▪ Stream power, see below</td></tr>
<tr><td colspan="3"><table>
<tr><th rowspan="2">Stream Power Ranking</th><th colspan="3">CRTs</th><th colspan="3">West Huttonville</th></tr>
<tr><th>2 year</th><th>25 year</th><th>Regional</th><th>2 year</th><th>25 year</th><th>Regional</th></tr>
<tr><td>Low</td><td><25</td><td><80</td><td><400</td><td><20</td><td><80</td><td><200</td></tr>
<tr><td>Medium</td><td>25 to 100</td><td>80 to 450</td><td>400 to 2000</td><td>20 to 50</td><td>80 to 205</td><td>200 to 250</td></tr>
<tr><td>High</td><td>>100</td><td>>450</td><td>>2000</td><td>>50</td><td>>205</td><td>>250</td></tr>
</table></td></tr>
<tr><td colspan="3">Overall flow assessment ranking:
a) HIGH: If both criteria are rated “High”, the Flow Assessment Ranking is “High”.
b) MEDIUM. If one criteria is “High” and the other is “Low” or “Medium”, the Flow Assessment Ranking is Medium”.
c) LOW: If one of the criteria is rated “Low” and the other is rated “Medium”, the Flow Assessment Ranking is “Low”</td></tr>
<tr><td>Aquatic Habitat</td><td>▪ Typically exhibit a defined channel (with an obvious bed and bank), as well as defined channel morphology (e.g., pools and riffles).
▪ Often exhibit some degree of groundwater connectivity (at least seasonally), and will often flow strongly through the mid-late spring and into summer.
▪ May be associated with a defined top-of-bank or valley corridor,
▪ Typically include a well-established riparian vegetation zone.
▪ Presence of water in these reaches through long stretches of the year create the opportunity for</td><td>▪ Have a defined channel but may or may not have well-defined valleyland morphology.
▪ Typically exhibit intermittent flow that occurs most strongly during spring and may extend into early summer. These reaches typically become dry by a point in June and may re-establish flow later in the year during/following intense summer or fall rain events.
▪ Typically be identified as “seasonal” or “complex contributing” habitat and may often have been altered by historic agricultural practices.</td><td>▪ Ephemeral field swales whose primary function is for flow conveyance typically only during limited periods associated with the spring freshet. These reaches are designated as “simple contributing” habitat or “Not Fish Habitat” due to their lack of channel definition and limited flow. These reaches provide no direct fish habitat for fish or benthic invertebrate production.</td></tr>
</table>

<table>
<tr><th rowspan="2">Stream Characteristics</th><th colspan="3">Ranking Considerations</th></tr>
<tr><th>High Ranking</th><th>Medium Ranking</th><th>Low Ranking</th></tr>
<tr><td></td><td>“permanent” fish habitat and likely offer benthic invertebrate production.</td><td></td><td></td></tr>
<tr><td>Terrestrial Habitat</td><td>▪ Are located entirely within the Greenbelt; or
▪ Contain significant natural heritage features (valleyland, woodland, wetland, wildlife habitat); and/or,
▪ By themselves are not significant, but provide an existing or potentially important ecological connecting corridor between two significant natural features (e.g., HV5 connects significant woodlands present in NSIU’s M & N).</td><td>▪ Contain local wetlands or small linear PSWs; or,
▪ Are narrow, less ecologically important features along the stream reaches.</td><td>▪ non-vegetated swales that do not provide a corridor connection between important natural features.</td></tr>
<tr><td rowspan="2">Geomorphology</td><td colspan="3">Considerations include:
▪ Channel Form –the degree to which the active channel displayed a discernible cross-sectional form (i.e., defined bed and banks);
▪ Bed Morphology - the degree to which the active channel displayed a discernible form in profile (i.e., well developed riffle-pool morphology);
▪ Bed Substrate –the range of materials that composed the stream bottom. The composition of bed materials provides an indication of the channel’s sensitivity to augmented flows.
▪ Sediment Transport/Supply –evidence of active geomorphic processes (erosion, deposition, migration) observed within the reach.</td></tr>
<tr><td>▪ The reaches typically display conditions that are unique and lend to a high value from a geomorphic perspective or display characteristics (such as a defined valley system) that could not be replicated in a post-development scenario.</td><td>▪ These reaches displayed both form (defined bed and banks) and function, however, they also exhibit evidence of degradation through historical modification or existing land use practices.</td><td>▪ These reaches provide a function to downstream receiving watercourses but lack a defined form; they have also generally been highly modified to support land use activities.</td></tr>
</table>

Table 5.3.2. Integrated Watercourse and Corridor Constraint Rating

Reach	Flow Description	Flow Assessment	Aquatic Habitat Assessment	Terrestrial Vegetation Significance and Linkage Functions	Stream Morphology	Net Constraint Ranking
CREDIT RIVER TRIBUTARY CRT1						
CRT1-1	Permanent	High	High	High	High	High
CRT1-2	Intermittent	Medium	Medium	High	Medium	Medium
CREDIT RIVER TRIBUTARY CRT2						
CRT2-1	Permanent	High	High	High	High	High
CRT2-2	Permanent	High	High	High	High	High
CRT2-3	Permanent	High	High	High	High	High
CRT2-4	Permanent	High	High	High	High	High
CRT2-5	Intermittent	Medium	Medium	Medium	Medium	Medium
CRT2-6	Intermittent	Medium	Medium	Medium	Medium	Medium
CRT2-7	Intermittent	Medium	Medium	Medium	Medium	Medium
CRT2-8	Intermittent	Medium	Medium	Low	Low	Medium
CREDIT RIVER TRIBUTARY CRT3						
CRT3-1	Permanent	Low	High	High	High	High
CRT3-2	Seasonal	Medium	Medium	High	High	High
CRT3-3	Seasonal	Medium	Medium	High	High	High
CRT3-4	Seasonal	Medium	Medium	Medium	Low	Medium
CRT3-5	Intermittent	Low	Medium	Medium	Low	Medium
CREDIT RIVER TRIBUTARY CRT4						
CRT4-1	Permanent	Medium	High	High	High	High
CRT4-2	Permanent	High	High	High	High	High
CRT4-3	Permanent	High	High	High	High	High
CRT4-5	Intermittent	Medium	Medium	Medium	Medium	Medium
CRT4-6	Intermittent	Medium	Medium	Medium	Medium	Medium
WEST HUTTONVILLE CREEK						
HV3	Permanent	High	High	High	Medium	High
HV4	Permanent	High	High	High	Medium	High
HV5	Permanent	High	Medium	High	Medium	High
HV7	Intermittent	Medium	Medium	Medium	Low	Medium
HV9	Intermittent	Medium	Medium	Medium	Low	Medium
HV10	Intermittent	Medium	Medium	Medium	Low	Medium
HV11	Intermittent	Medium	Medium	Medium	Low	Medium

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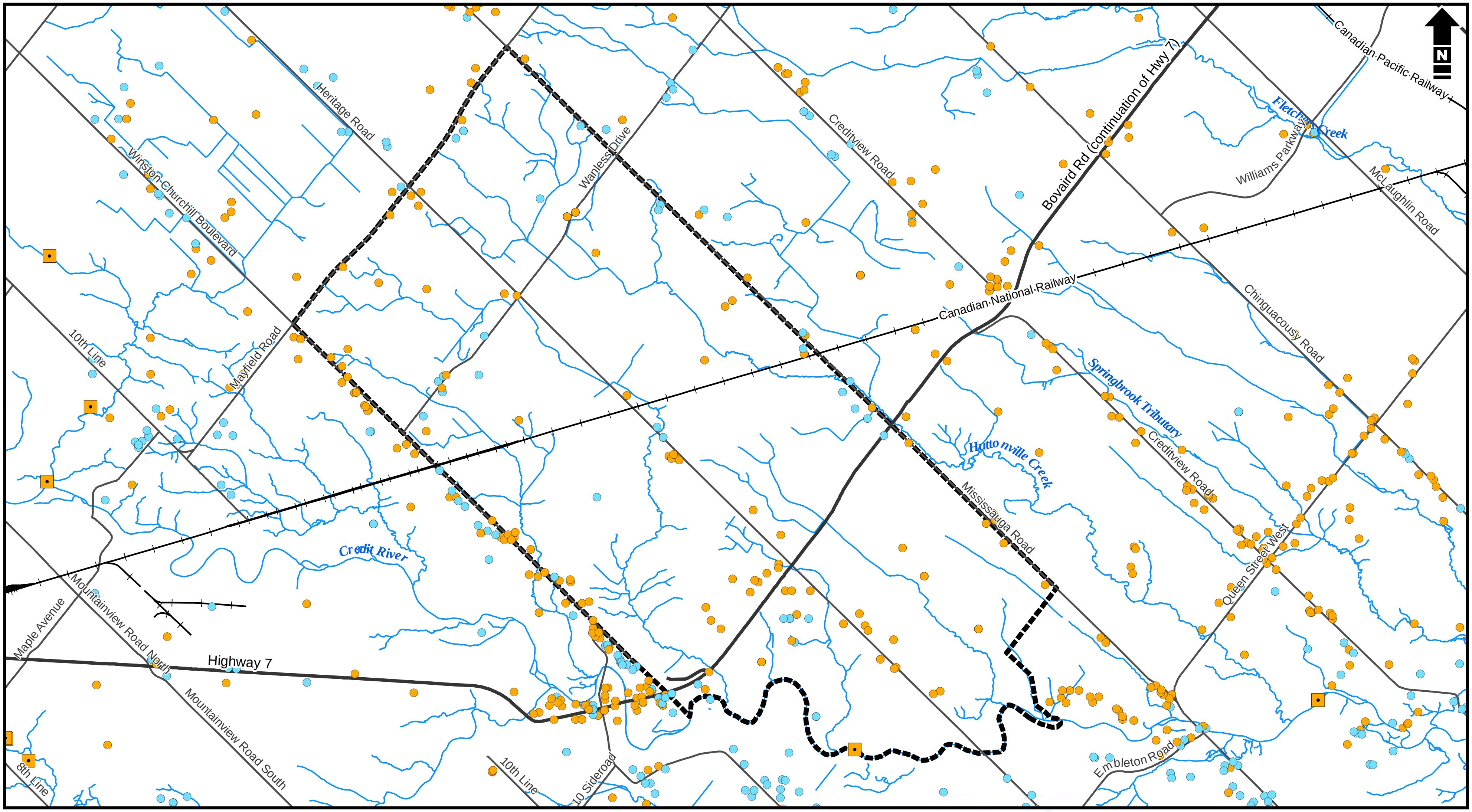
Appendix A
Climate

Appendix B

Hydrogeology

APPENDIX ‘B’

HYDROGEOLOGY



Legend

- ● Overburden Wells
- ● Bedrock Wells
- ▣ Water Well Locations and Permits to Take Water
- Drainage
- Railroad
- Highway / Expressway
- Road
- Heritage Heights Study Area

1:45,000

500 0 500
Metres

NAD 1983 UTM ZONE 17N

Reference: Ontario Ministry of Natural Resources (2010), Credit Valley Conservation Authority (2010)

T:\2011013 HeritageHeightsSWS\GIS\ArcGIS\MXDs\2011022 FIGURE-GW-1 Well Locations and Permit To Take Water Locations.mxd

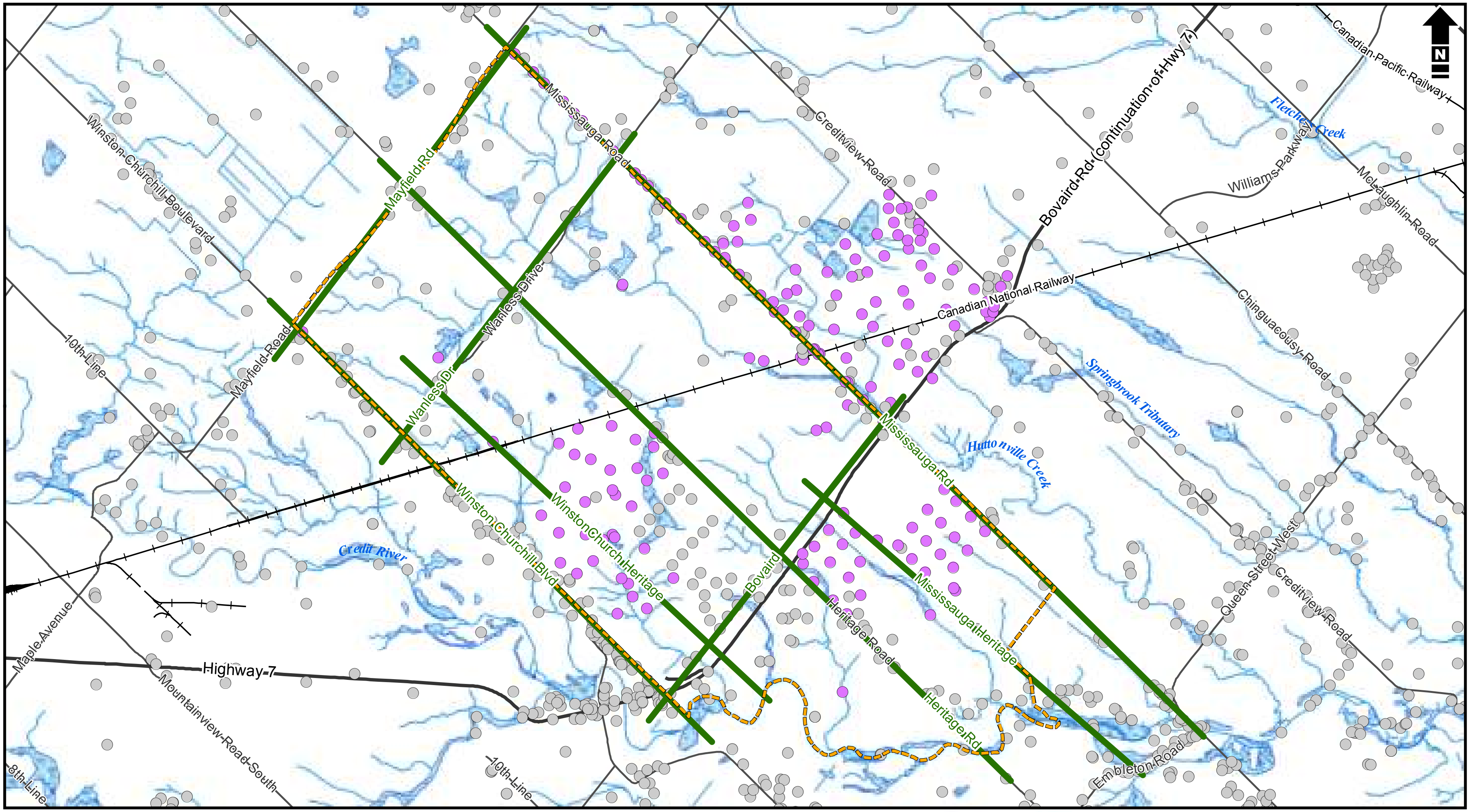
North West Brampton Heritage Heights Subwatershed Study

Water Well Locations and Permit To Take Water Locations

Date: 19 Nov 2012
Project: 15519-528
Technical: P. Chin
Reviewer: D. Van Vliet
Drawn: C. Curry

Disclaimer: Prepared solely for the use of the City of Brampton as specified in the accompanying report. No representation of any kind is made to other parties with which the City of Brampton has not entered into contract.

Figure
GW-1



Legend

- ● Water Well Record
- ● High Quality Borehole, New Data
- ▬ Profile Line
- ▬ Highway / Expressway
- — Road
- ┼ Railroad
- — Drainage
- ▨ Wetland
- ╍ Heritage Heights Study Area

1:45,000

500 0 500

Metres

NAD 1983 UTM ZONE 17N

Reference: Ontario Ministry of Natural Resources (2010), Credit Valley Conservation Authority (2010)

amec

SAVANTA

Matrix Solutions Inc.

BURNSIDE

Blackport & Associates

STONYBROOK

North West Brampton Heritage Heights Subwatershed Study

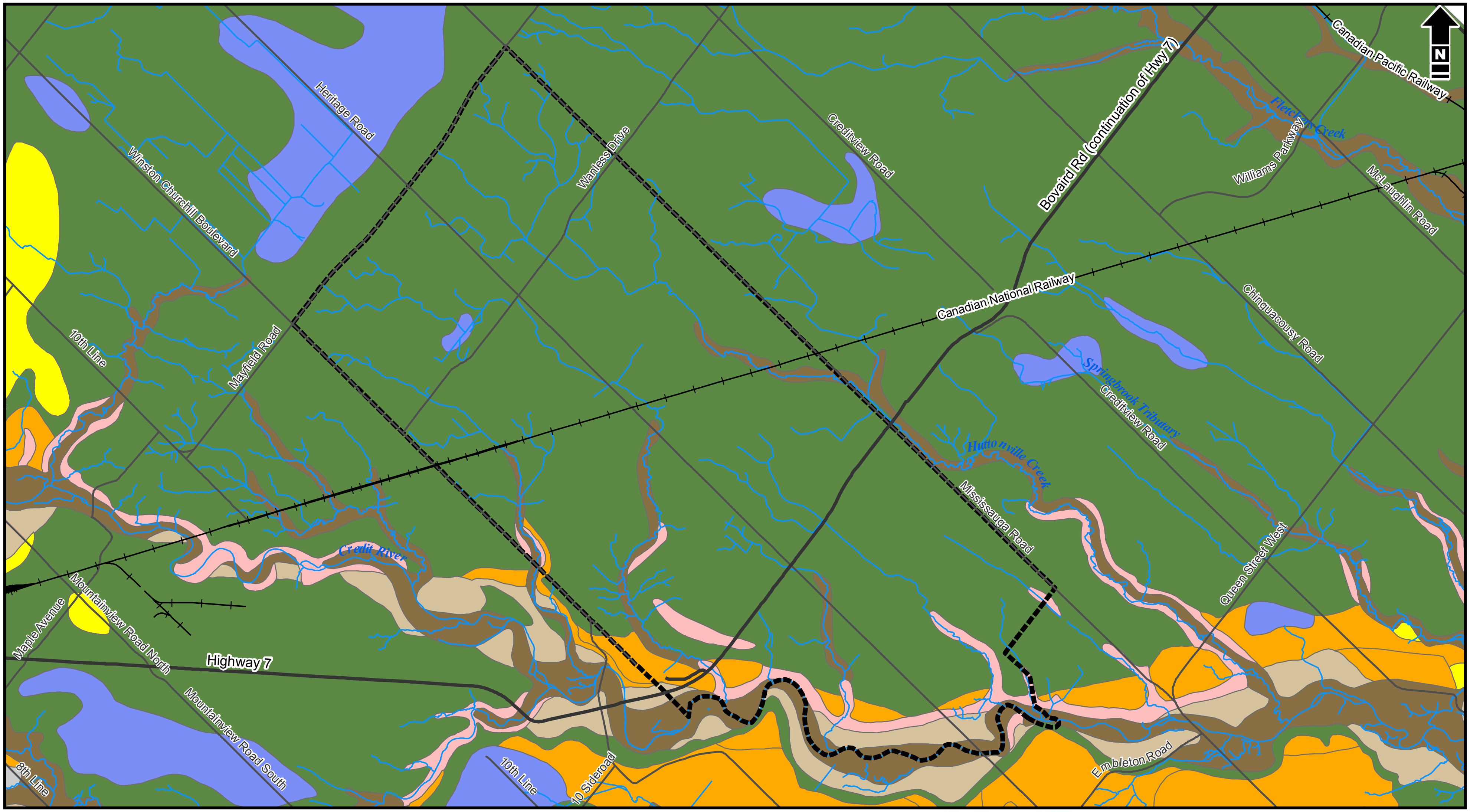
Cross-Section Locations

Date: 15 Nov 2012	Project: 15519-528	Technical: P. Chin	Reviewer: D. Van Vliet	Drawn: L. Weaver

Disclaimer: Prepared solely for the use of the City of Brampton as specified in the accompanying report. No representation of any kind is made to other parties with which the City of Brampton has not entered into contract.

Figure GW-2

T:\2011013_HeritageHeights\SWS\GIS\ArcGIS\MXDs\20111022_FIGURE-GW-2-Cross_Section_Locations.mxd



Legend

- ┼ Railroad
- ━ Highway / Expressway
- ─ Road
- ▬ ▬ Heritage Heights Study Area
- ─ Drainage

Surficial Geology

- 🟧 Deltaic and Lacustrine Depositis
- ▨ Bedrock
- 🟩 Halton Till
- 🟨 Sand
- 🟦 Glaclolacustrine Deposits
- 🟫 Modern Alluvium
- ▨ Other Terrace Alluvium
- ⬜ Organic Deposits

1:45,000

500 0 500

Metres

NAD 1983 UTM ZONE 17N

Reference: Ontario Ministry of Natural Resources (2010), Credit Valley Conservation Authority (2010)

T:\2011013_HeritageHeightsSWS\GIS\ArcGIS\MXDs\2011022_FIGURE-GW-3_Study_Area_and_Surficial_Geology.mxd

Blackport & Associates

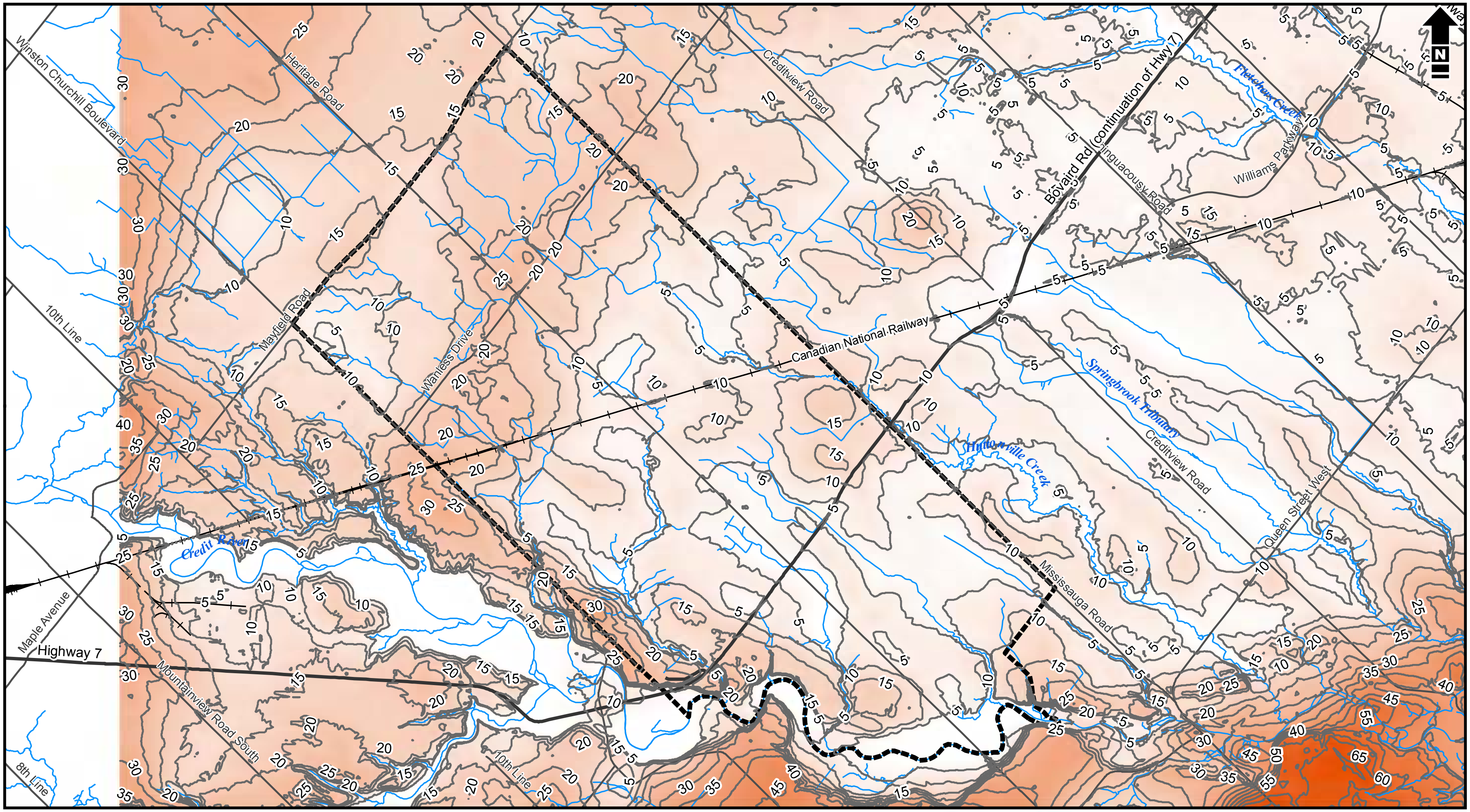
North West Brampton Heritage Heights Subwatershed Study

Study Area and Surficial Geology

Date: 15 Nov 2012	Project: 15519-528	Technical: P. Chin	Reviewer: D. Van Vliet	Drawn: C. Curry

Disclaimer: Prepared solely for the use of the City of Brampton as specified in the accompanying report. No representation of any kind is made to other parties with which the City of Brampton has not entered into contract.

Figure GW-3



Legend

- Contours - Interval 5m
- ┼ Railroad
- Highway / Expressway
- Road
- Heritage Heights Study Area
- Drainage

Overburden Thickness (m)

High : 70

Low : 0

1:45,000

500 0 500

Metres

NAD 1983 UTM ZONE 17N

Reference: Ontario Ministry of Natural Resources (2010), Credit Valley Conservation Authority (2010)

T:\2011013 HeritageHeightsSWS\GIS\ArcGIS\MXDs\2011022 FIGURE-GW-4 Overburden Thickness.mxd

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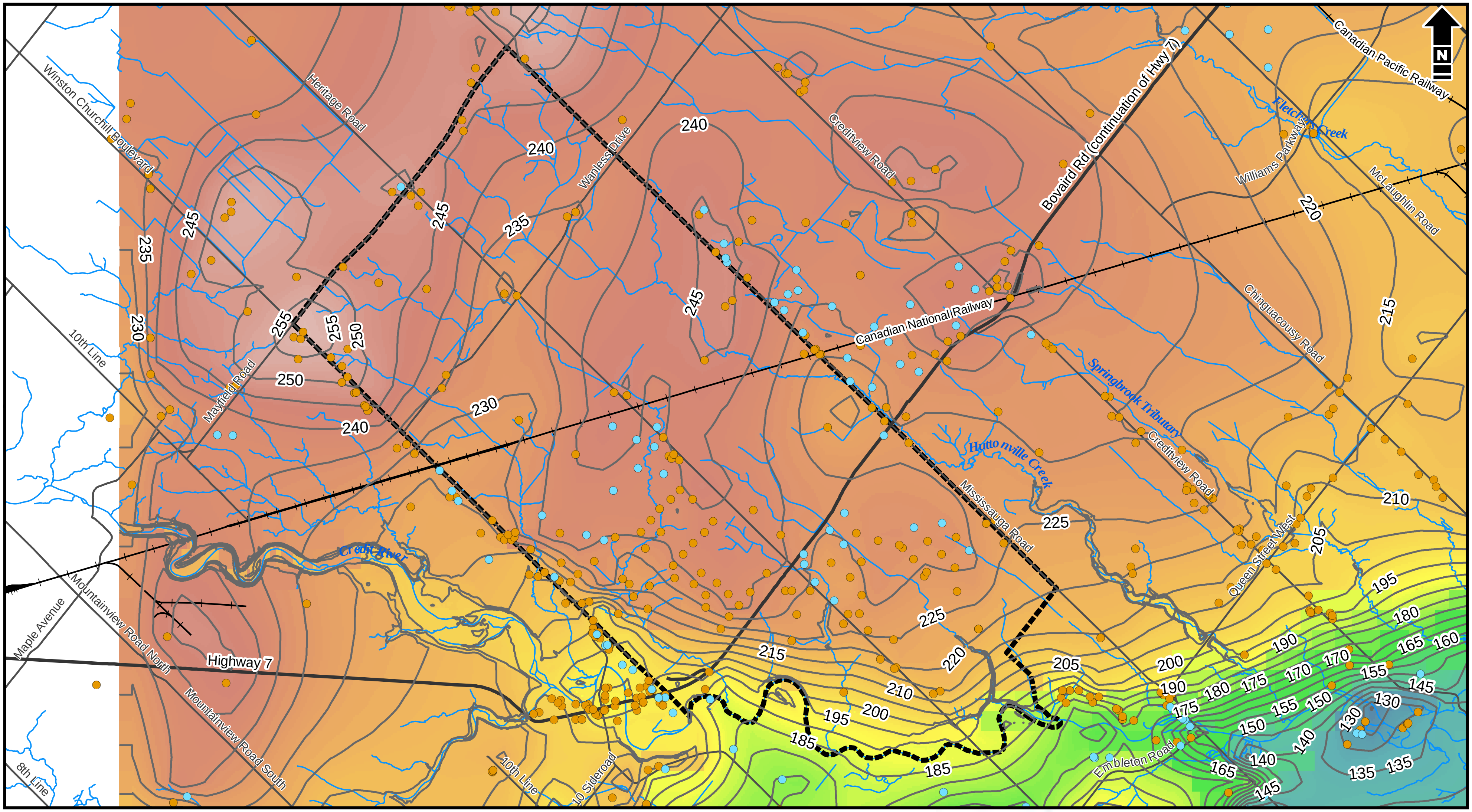
North West Brampton Heritage Heights Subwatershed Study

Overburden Thickness

Date: 15 Nov 2012	Project: 15519-528	Technical: P. Chin	Reviewer: D. Van Vliet	Drawn: C. Curry

Figure GW-4



Legend

- ● Overburden Pushdown Wells
- ● Bedrock Wells
- Contours - Interval 5m
- Railroad
- Highway / Expressway
- Road
- Heritage Heights Study Area
- Drainage

Bedrock Surface Elevation (m)

High : 270

Low : 110

1:45,000

500 0 500

Metres

NAD 1983 UTM ZONE 17N

Reference: Ontario Ministry of Natural Resources (2010), Credit Valley Conservation Authority (2010)

T:\2011013 HeritageHeights\SWS\GIS\ArcGIS\MXDs\2011022 FIGURE-GW-6 Bedrock Topography.mxd

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North West Brampton Heritage Heights Subwatershed Study

Bedrock Topography

Date: 19 Nov 2012	Project: 15519-528	Technical: P. Chin	Reviewer: D. Van Vliet	Drawn: C. Curry

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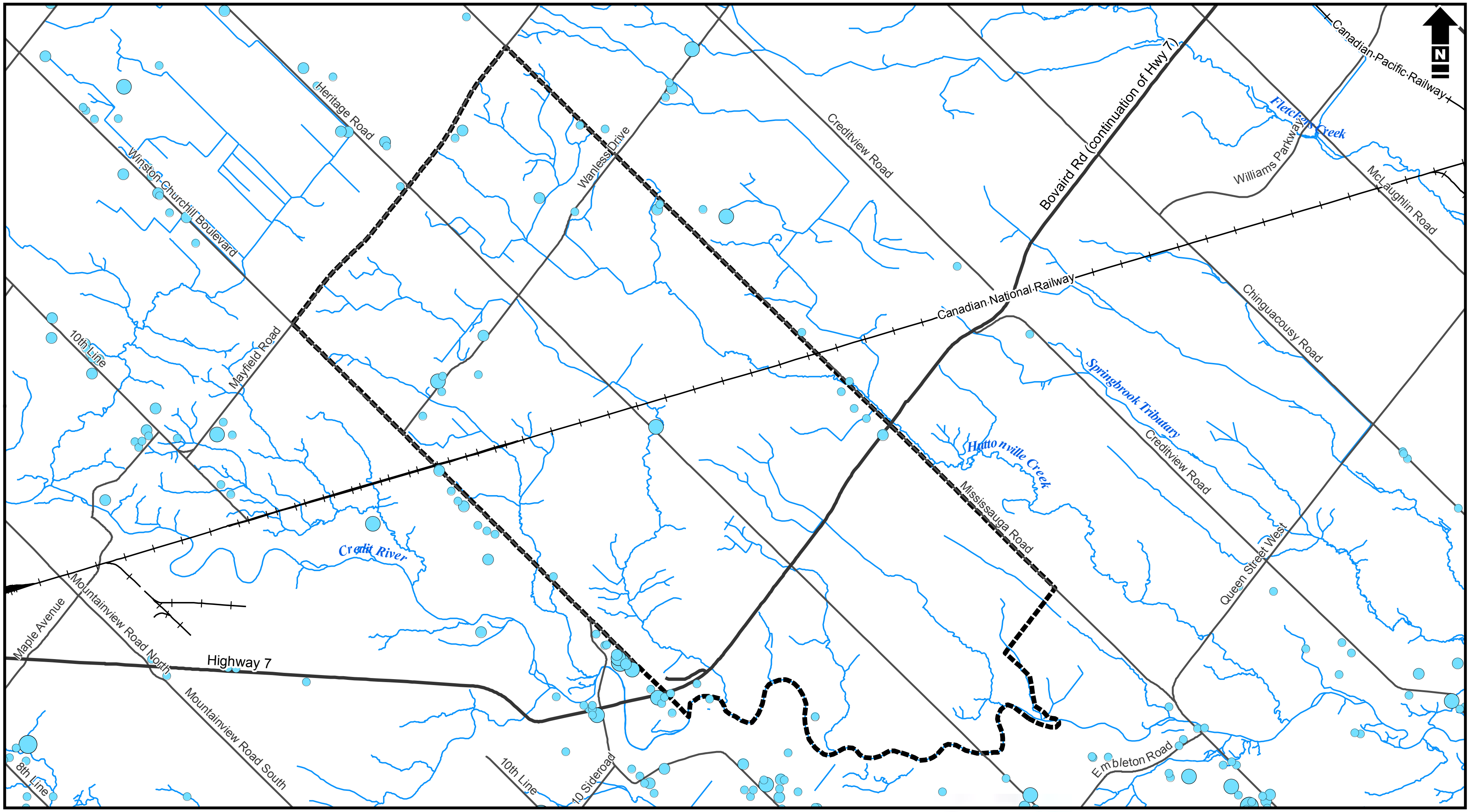
Figure GW-5



Legend

Specific Capacity - Overburden (igpm - ft)

- ● < 0.1
- ● 0.1 - 1.0
- ● 1.0 - 5.0
- ● 5.0 - 10.0
- ● >10.0
- Drainage
- Railroad
- Highway / Expressway
- Road
- Heritage Heights Study Area

Reference: Ontario Ministry of Natural Resources (2010), Credit Valley Conservation Authority (2010)

1:45,000

500 0 500

Metres

NAD 1983 UTM ZONE 17N

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Burnside

Matrix Solutions Inc.

Savanta

Stonybrook

North West Brampton Heritage Heights Subwatershed Study

Specific Capacity - Overburden

Date: 15 Nov 2012 | Project: 15519-528 | Technical: P. Chin | Reviewer: D. Van Vliet | Drawn: C. Curry

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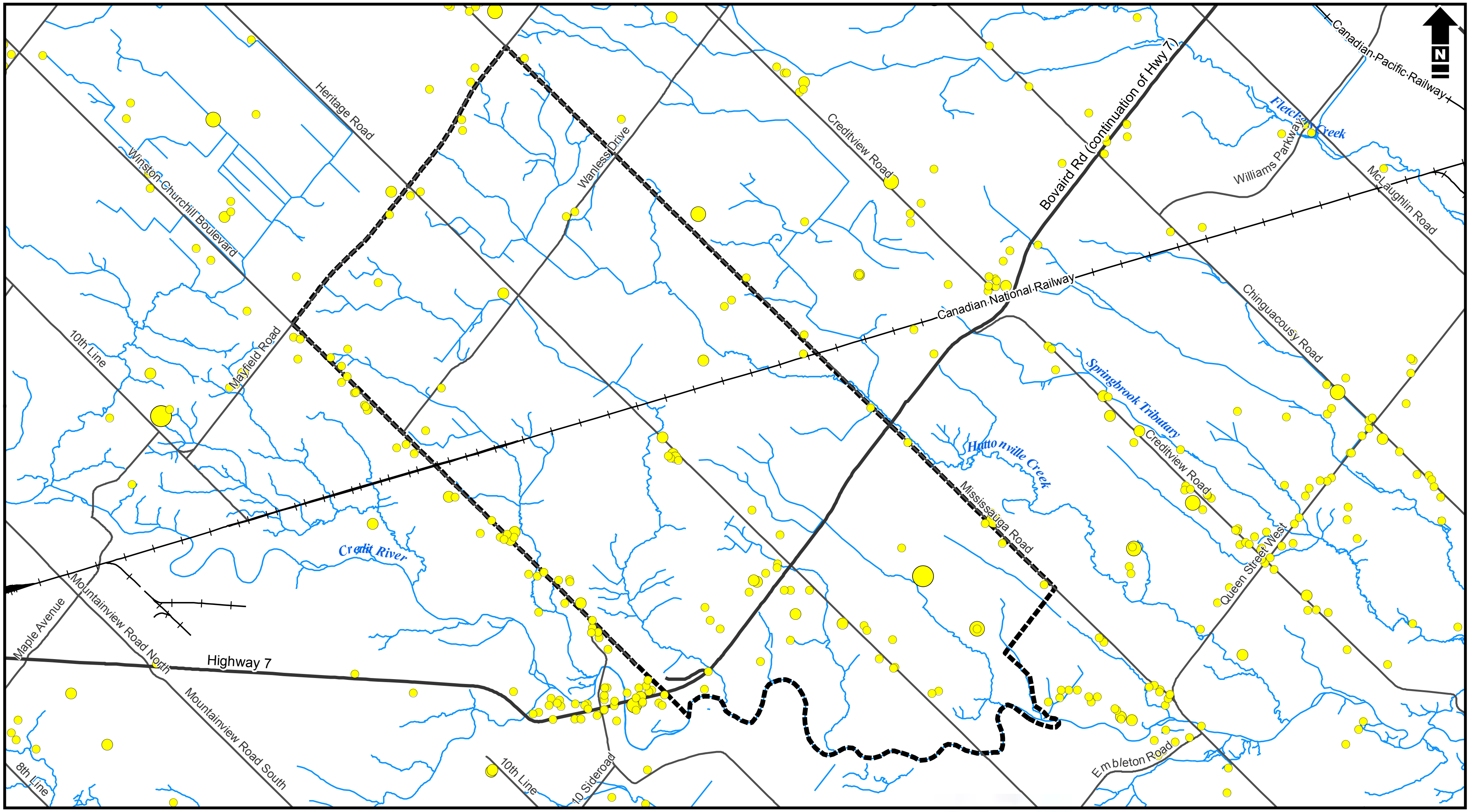
Figure

GW-6

T:\2011013_HeritageHeightsSWS\GIS\ArcGIS\MXDs\2011022_FIGURE-GW-7_Specific_Capacity-Overburden.mxd



Legend

Specific Capacity - Bedrock (igpm - ft)

- ● < 0.1
- ● 0.1 - 1.0
- ● 1.0 - 5.0
- ● 5.0 - 10.0
- ● > 10.0
- Drainage
- Railroad
- Highway / Expressway
- Road
- Heritage Heights Study Area

1:45,000

500 0 500

Metres

NAD 1983 UTM ZONE 17N

Reference: Ontario Ministry of Natural Resources (2010), Credit Valley Conservation Authority (2010)

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Burnside

Blackport & Associates

Stonybrook

North West Brampton Heritage Heights Subwatershed Study

Specific Capacity - Bedrock

Date: 15 Nov 2012
Project: 15519-528
Technical: P. Chin
Reviewer: D. Van Vliet
Drawn: C. Curry

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Figure
GW-7

T:\2011013_HeritageHeightsSWS\GIS\ArcGIS\MXDs\20111022_FIGURE-GW-8_Specific_Capacity-Bedrock.mxd

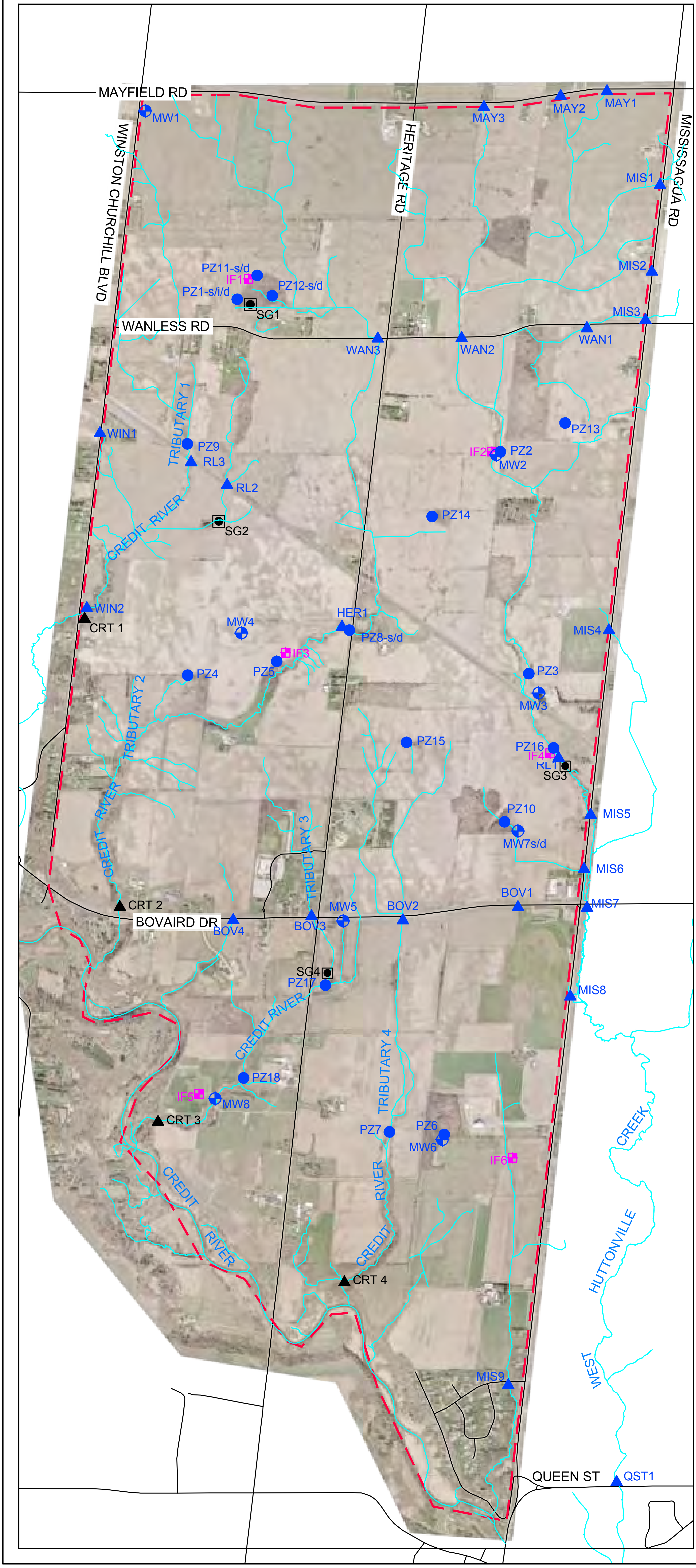

FIGURE GW-8

CITY OF BRAMPTON

REGION OF PEEL

HYDROGEOLOGICAL STUDY

MONITORING LOCATIONS

LEGEND

- APPROXIMATE SITE OUTLINE
- WATERCOURSE
- ⊕ MONITORING WELL
- ● PIEZOMETER
- ▲ SURFACE WATER MONITORING LOCATION
- ▲ CVC SURFACE WATER MONITORING LOCATION
- ▣ STAFF GAUGE
- ▦ INFILTRATION TEST LOCATION

	Min l/s	Max l/s	Median l/s
MAY1	0	0.5	0
MAY2	0	0.1	0
MAY3	0	0.1	0
MIS1	0	4	0
MIS2	0	0	0
MIS3	0	3	0
MIS4	0	0	0
MIS5	0	125	2
MIS6	0	18	0
MIS7	0	254	14
MIS8	0	30	0
MIS9	0	9	0.5
WAN1	0	4	0
WAN2	0	57	0
WAN3	0	46	0
BOV1	0	0.1	0
BOV2	0	20	0
BOV3	0	4	0
BOV4	0	2	0
HER1	0	110	0
QST1	0	378	54
RL1	0	90	1
RL2	0	7	0
RL3		24	0
WIN1	0	2	0
WIN2 (CRT1)	0	12	0
CRT2	0.8	31.5	5
CRT3	0	4.3	0
CRT4	0	16	4

Spot Flow
June 2010 - November 2014
July 2017 - November 2017

N

0 200 400 600 800 1000 1200
Metres

Scale 1:20,000
August 2012
Project Number: 300030932

Projection: UTM Zone 17
Datum: NAD83

Prepared by: S. Ker

Verified by: J. Shaw

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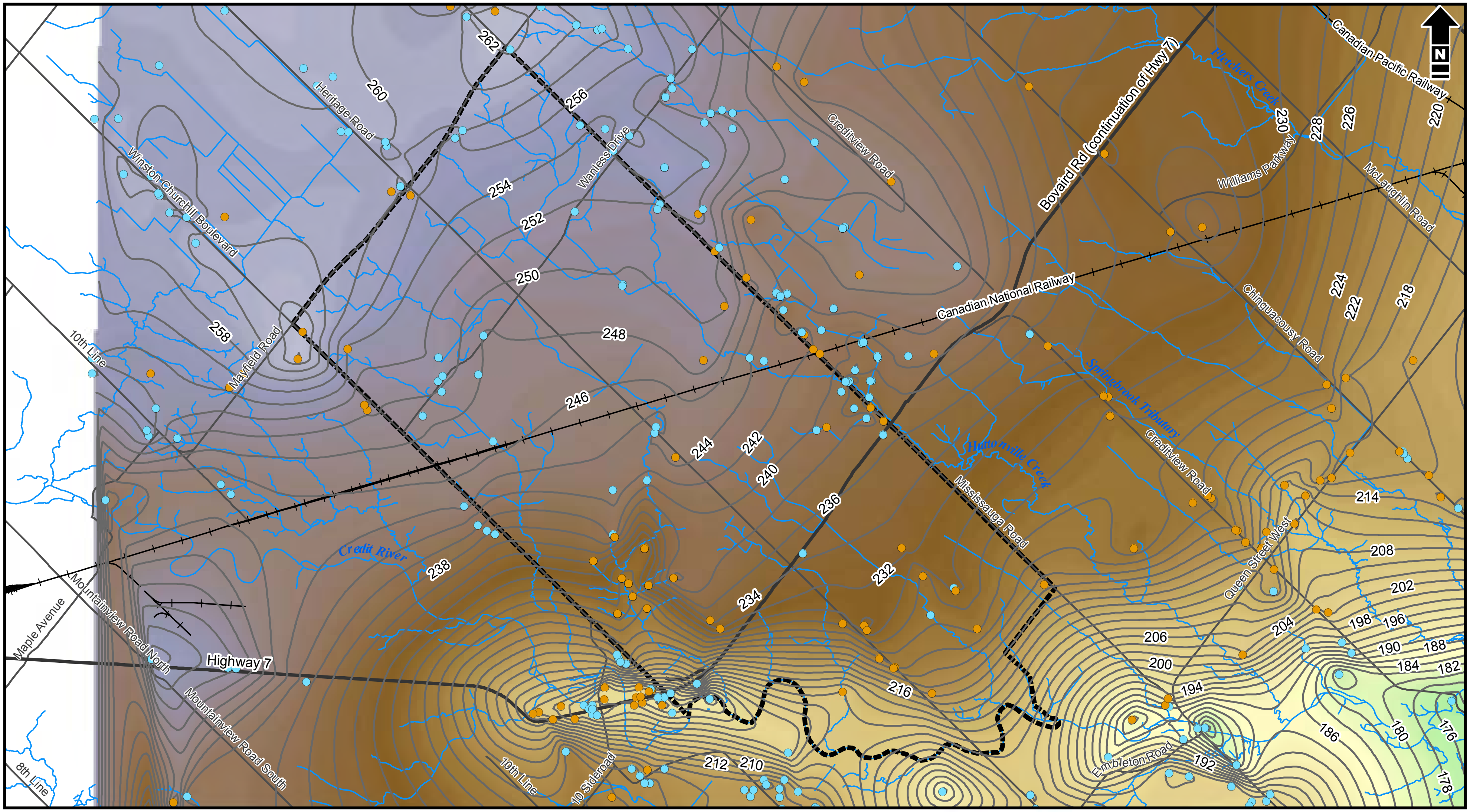
Matrix Solutions Inc.
Blackport & Associates
BURNSIDE
STONYBROOK

030932 HG STUDY 2012 BASE.dwg



Legend

- ● Overburden Wells
- ● Bedrock Wells
- Contours - Interval 2m
- Railroad
- Highway / Expressway
- Road
- Heritage Heights Study Area
- Drainage

Shallow Water Level - Well Depth < 15m (m)

High : 278

Low : 155

1:45,000

500 0 500
Metres

NAD 1983 UTM ZONE 17N

Reference: Ontario Ministry of Natural Resources (2010), Credit Valley Conservation Authority (2010)

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Blackport & Associates
STONYBROOK

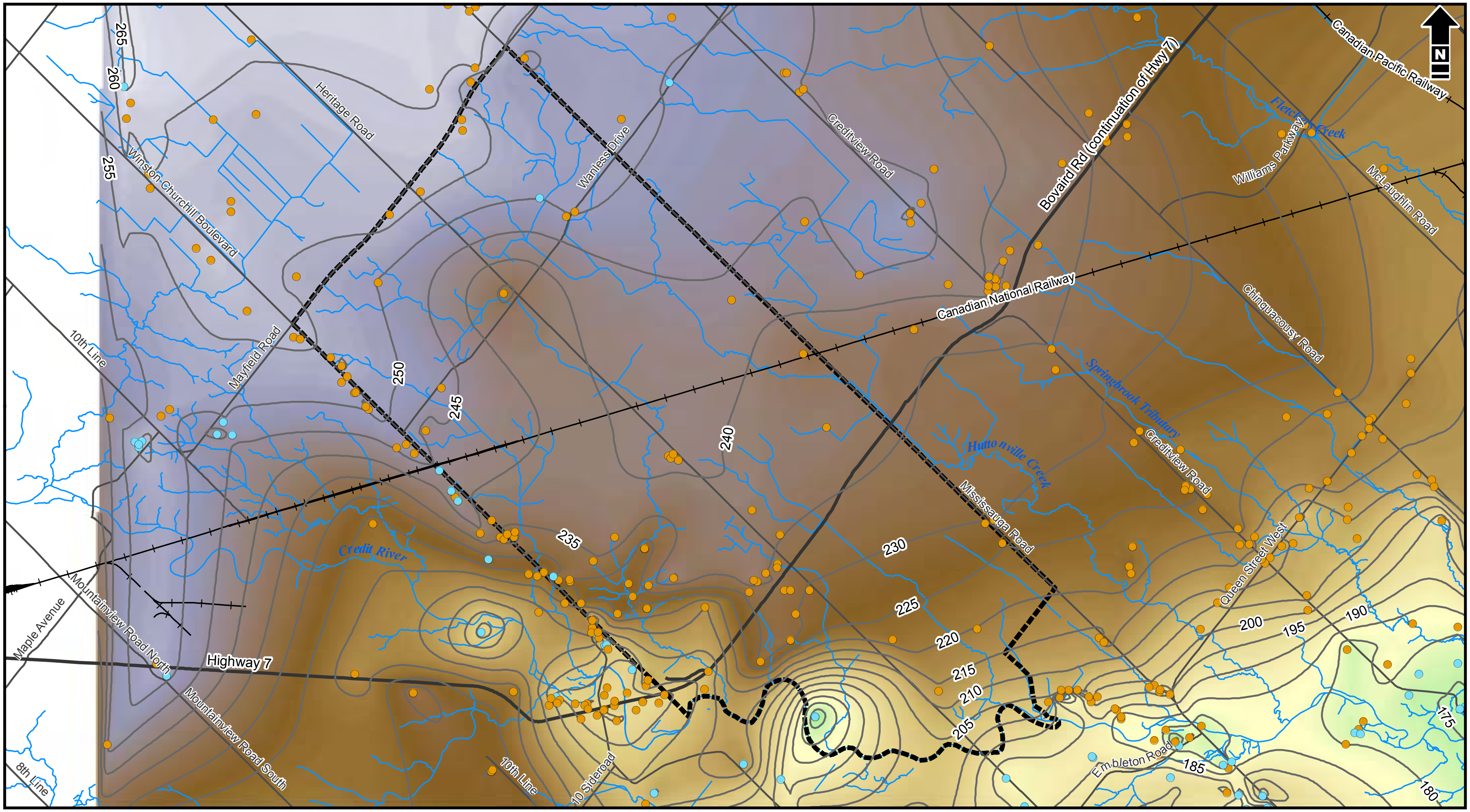
North West Brampton Heritage Heights Subwatershed Study

Shallow Water Levels

Date: 15 Nov 2012	Project: 15519-528	Technical: P. Chin	Reviewer: D. Van Vliet	Drawn: C. Curry

Figure
GW-9

T:\2011013 HeritageHeightsSWS\GIS\ArcGIS\MXDs\2011022 FIGURE-GW-10 Shallow Water Levels.mxd



Legend

- ● Overburden Wells
- ● Bedrock Wells
- — Contours - Interval 5m
- ┼ Railroad
- ▬ Highway / Expressway
- — Road
- ■■ Heritage Heights Study Area
- — Drainage

Deep Water Level (m) - Well Depth > 15m

High : 270

Low : 160

1:45,000

500 0 500

Metres

NAD 1983 UTM ZONE 17N

Reference: Ontario Ministry of Natural Resources (2010), Credit Valley Conservation Authority (2010)

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North West Brampton Heritage Heights Subwatershed Study

Deep Water Levels

Date: 15 Nov 2012	Project: 15519-528	Technical: P. Chin	Reviewer: D. Van Vliet	Drawn: C. Curry

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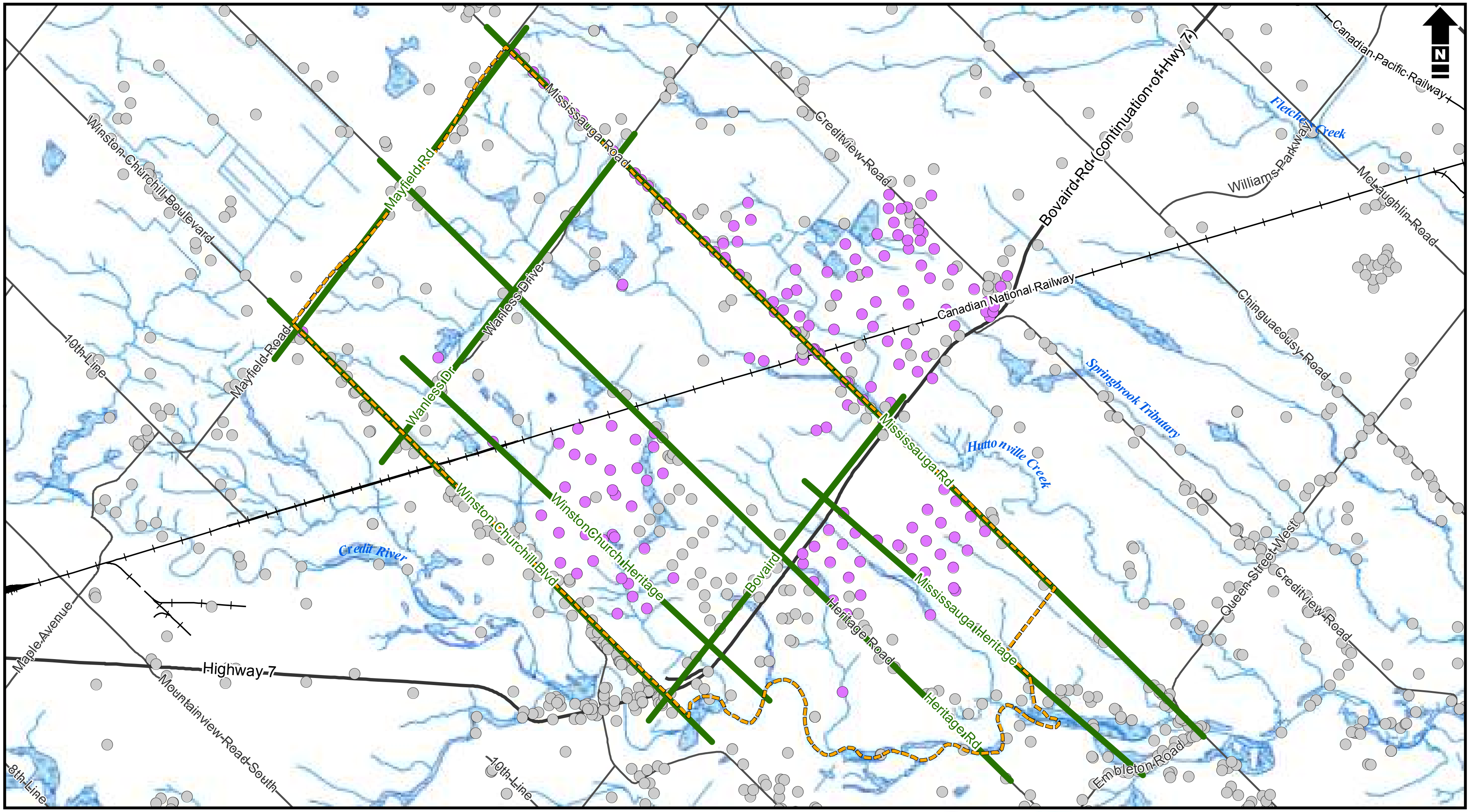
Figure
GW-10

T:\2011013 HeritageHeightsSWS\GIS\ArcGIS\MXDs\2011022 FIGURE-GW-11 Deep Water Levels.mxd

APPENDIX B HYDROGEOLOGY

B-1 Geologic Cross-Sections



Legend

- ● Water Well Record
- ● High Quality Borehole, New Data
- Profile Line
- Highway / Expressway
- Road
- Railroad
- Drainage
- Wetland
- Heritage Heights Study Area

1:45,000

500 0 500

Metres

NAD 1983 UTM ZONE 17N

Reference: Ontario Ministry of Natural Resources (2010), Credit Valley Conservation Authority (2010)

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North West Brampton Heritage Heights Subwatershed Study

Cross-Section Locations

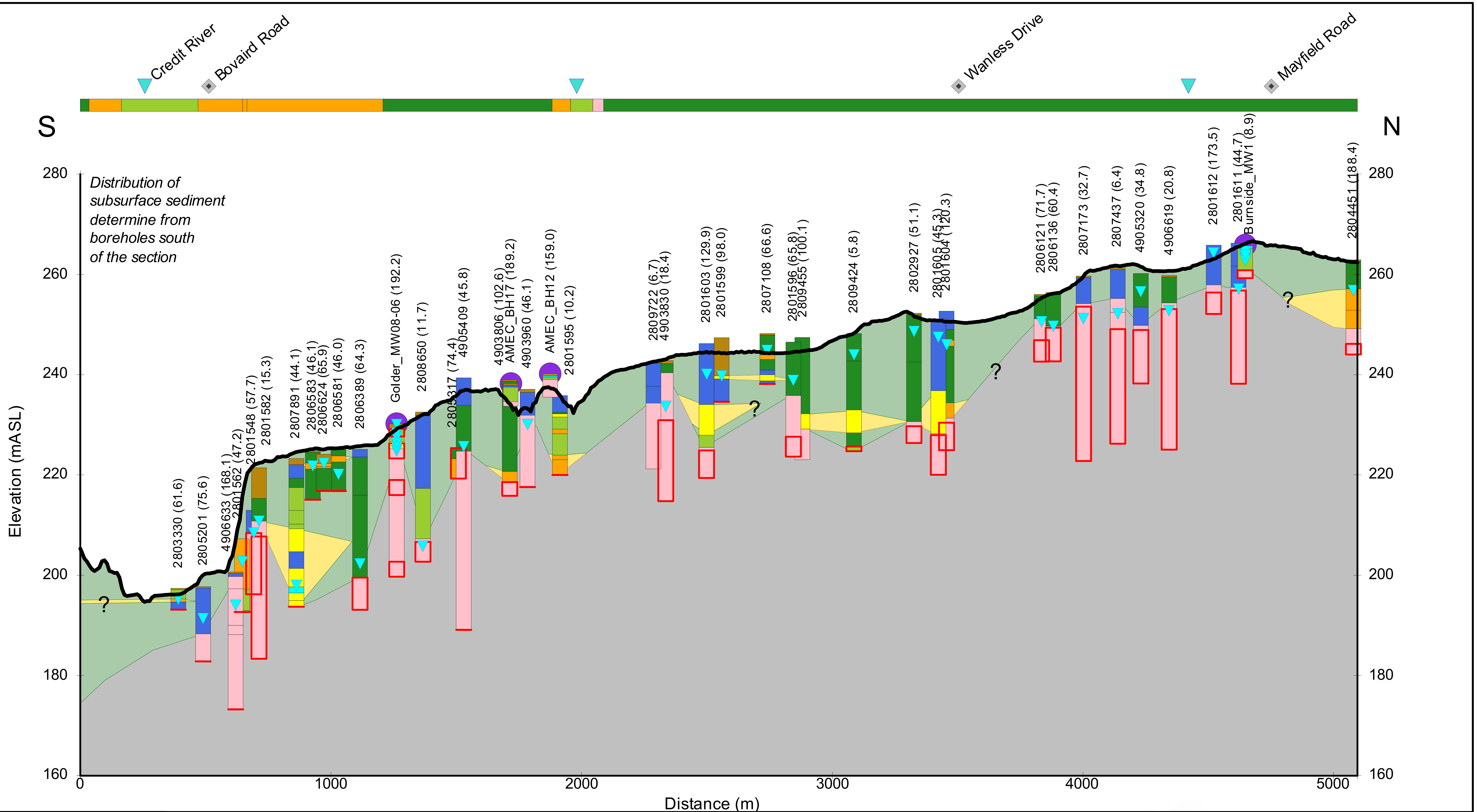
Date: 15 Nov 2012	Project: 15519-528	Technical: P. Chin	Reviewer: D. Van Vliet	Drawn: L. Weaver

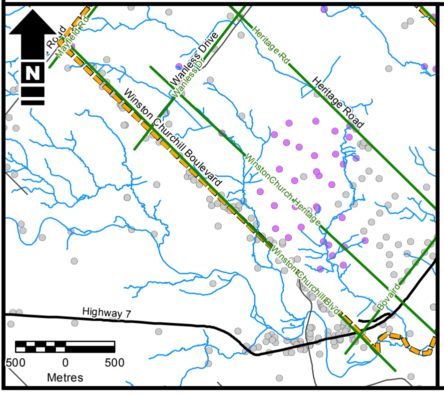
Disclaimer: Prepared solely for the use of the City of Brampton as specified in the accompanying report. No representation of any kind is made to other parties with which the City of Brampton has not entered into contract.

Figure

B1

T:\2011013 HeritageHeightsSWS\GIS\ArcGIS\MXDs\2011022 FIGURE-GW-2-Cross Section Locations.mxd





T:\2011013_HeritageHeightsSWS\GIS\ArcGIS\MXDs\2011022_FIGURE-XX-XSWinstonChurchill.mxd

Legend
- ● Water Well Record
- ● High Quality Borehole, New Data
- — Profile
- — Drainage
- — Road
- — Highway / Expressway
- ▬ ▬ Heritage Heights Study Area

Water Well Record / Borehole Lithology
- 🟦 Clay
- 🟦 Silt
- 🟩 Diamict
- 🟨 Sand, silty sand
- 🟧 Gravel, gravelly sand
- 🟫 Fill, topsoil
- ⬜ Organic material
- 🟪 Bedrock
- ⬛ Unknown

- ☐ Well Screen
- ▽ Water Level
- ◆ Cross-Section Intersection
- ▼ River Crossing
- ● High Quality Borehole, New Data

Surficial Geology
- 🟧 Coarse-grained Granular Sediment, Outwash
- 🟩 Till, Diamict
- 🟪 Bedrock

Hydrostratigraphic Units
- 🟩 Fine-grained, unconsolidated material
- 🟨 Coarse-grained, unconsolidated material
- ⬜ Paleozoic Bedrock

Reference: Ontario Ministry of Natural Resources (2010), Credit Valley Conservation Authority (2010)

Vertical Exaggeration: 20x

Blackport & Associates

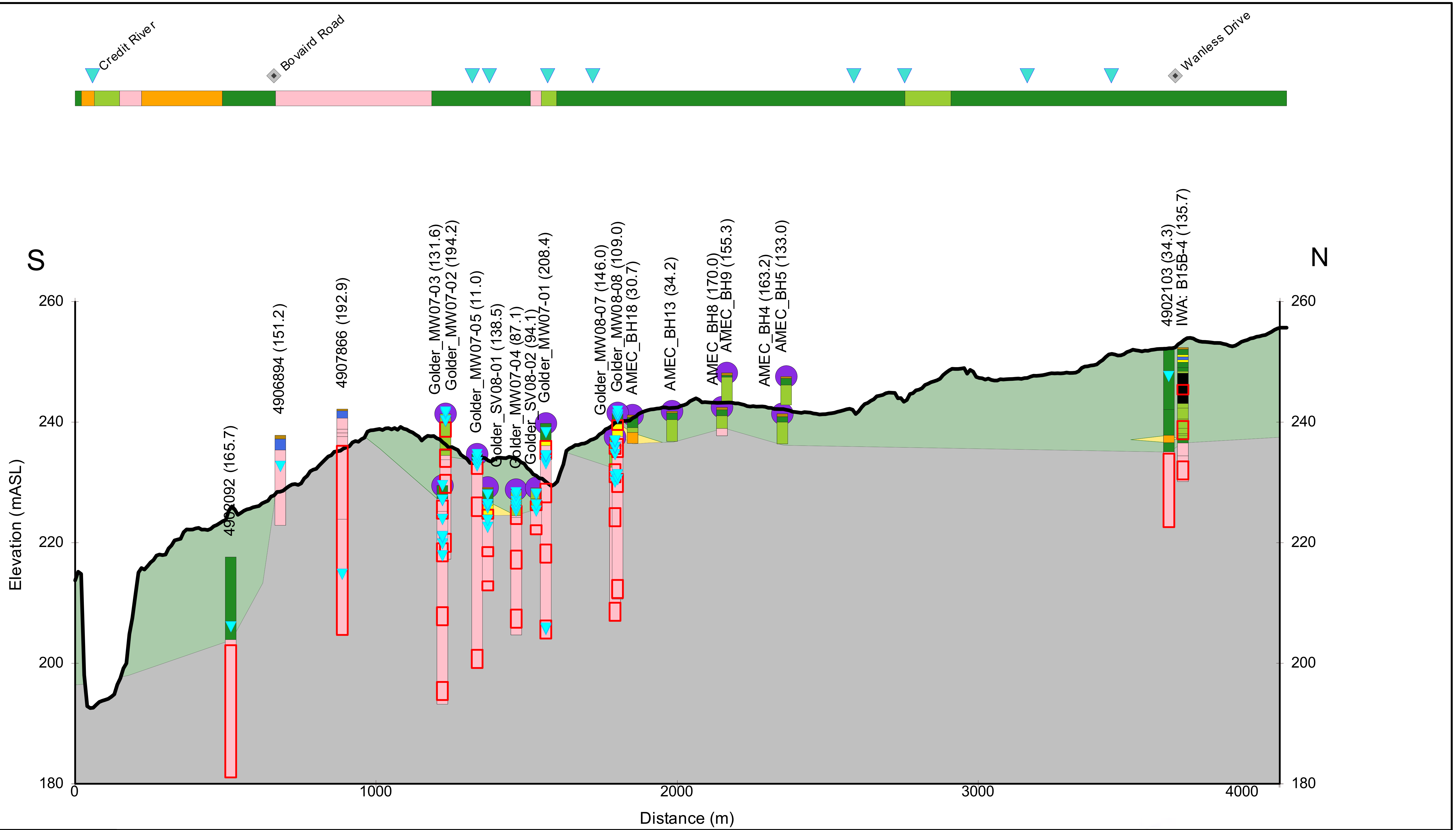
North West Brampton Heritage Heights Subwatershed Study

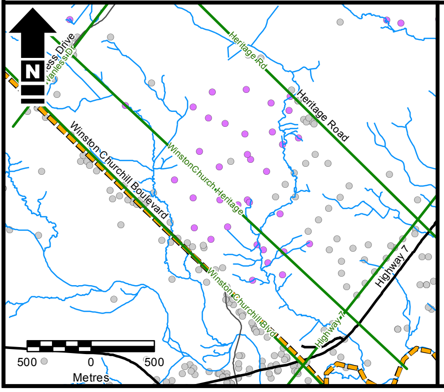
Winston Churchill Blvd. Cross-Section

Date: 29 Aug 2012	Project: 15519-528	Technical: L. Weaver	Reviewer: P. Chin	Drawn: L. Weaver

Disclaimer: Prepared solely for the use of the City of Brampton as specified in the accompanying report. No representation of any kind is made to other parties with which the City of Brampton has not entered into contract.

Figure B2





Legend

- ● Water Well Record
- ● High Quality Borehole, New Data
- Profile
- Drainage
- Road
- Highway / Expressway
- Heritage Heights Study Area

Water Well Record / Borehole Lithology

- 🟦 Clay
- 🟩 Silt
- 🟩 Diamict
- 🟨 Sand, silty sand
- 🟧 Gravel, gravelly sand
- 🟫 Fill, topsoil
- ⬜ Organic material
- 🟪 Bedrock
- ⬛ Unknown

- 🟥 Well Screen
- ▽ Water Level
- ◆ Cross-Section Intersection
- ▼ River Crossing
- ● High Quality Borehole, New Data

Surficial Geology

- 🟧 Coarse-grained Granular Sediment, Outwash
- 🟩 Till, Diamict
- 🟪 Bedrock

Hydrostratigraphic Units

- 🟩 Fine-grained, unconsolidated material
- 🟨 Coarse-grained, unconsolidated material
- ⬜ Paleozoic Bedrock

Reference: Ontario Ministry of Natural Resources (2010), Credit Valley Conservation Authority (2010)

Vertical Exaggeration: 20x

Blackport & Associates

North West Brampton Heritage Heights Subwatershed Study

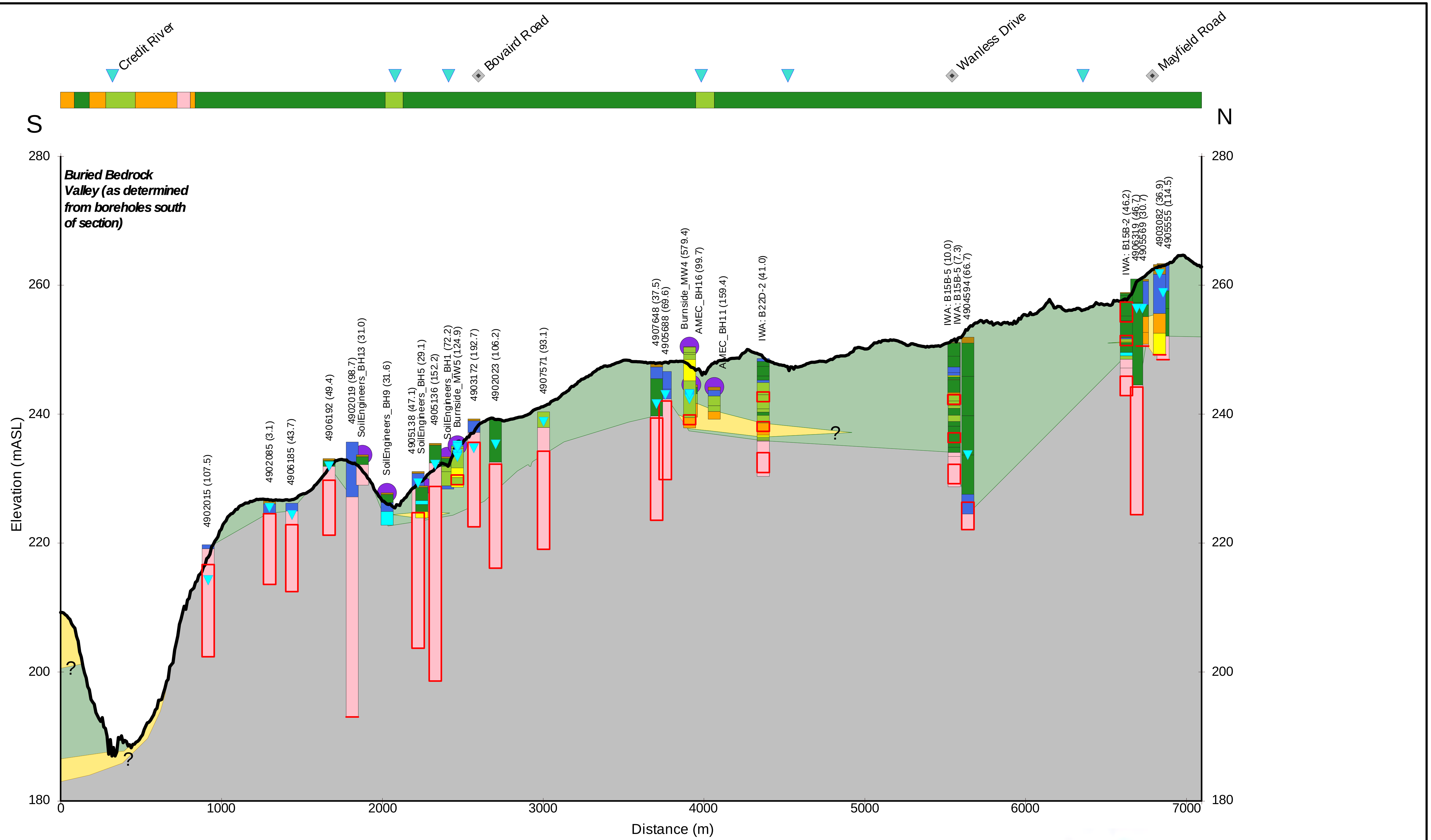
Winston Churchill Blvd. - Heritage Rd. Cross-Section

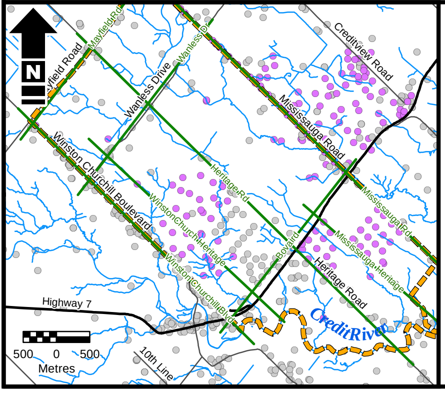
Date: 29 Aug 2012	Project: 15519-528	Technical: L. Weaver	Reviewer: P. Chin	Drawn: L. Weaver

Disclaimer: Prepared solely for the use of the City of Brampton as specified in the accompanying report. No representation of any kind is made to other parties with which the City of Brampton has not entered into contract.

Figure B3

T:\2011013_HeritageHeightsSWS\GIS\ArcGIS\MXDs\2011022_FIGURE-XX-XSWinstonHeritage.mxd





T:\2011013_HeritageHeightsSWS\GIS\ArcGIS\MXDs\2011022_FIGURE-XX-XSHeritage.mxd

Legend

- ▬ Profile
- ▬ ▬ Heritage Heights Study Area
- ▬ Highway / Expressway
- ▬ Road
- ▬ Drainage
- ● Water Well Record
- ● High Quality Borehole, New Data

Water Well Record / Borehole Lithology

- ■ Clay
- ■ Silt
- ■ Diamict
- ■ Sand, silty sand
- ■ Gravel, gravelly sand
- ■ Fill, topsoil
- ■ Organic material
- ■ Bedrock
- ■ Unknown

- ☐ Well Screen
- ▽ Water Level
- ◆ Cross-Section Intersection
- ▼ River Crossing
- ● High Quality Borehole, New Data

Surficial Geology

- ■ Coarse-grained Granular Sediment, Outwash
- ■ Till, Diamict
- ■ Bedrock

Hydrostratigraphic Units

- ■ Fine-grained, unconsolidated material
- ■ Coarse-grained, unconsolidated material
- ■ Paleozoic Bedrock

Reference: Ontario Ministry of Natural Resources (2010), Credit Valley Conservation Authority (2010)

Vertical Exaggeration: 40x

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North West Brampton Heritage Heights Subwatershed Study

Heritage Rd. Cross-Section

DRAFT

Date: 19 Nov 2012	Project: 15519-528	Technical: L. Weaver	Reviewer: P. Chin	Drawn: L. Weaver

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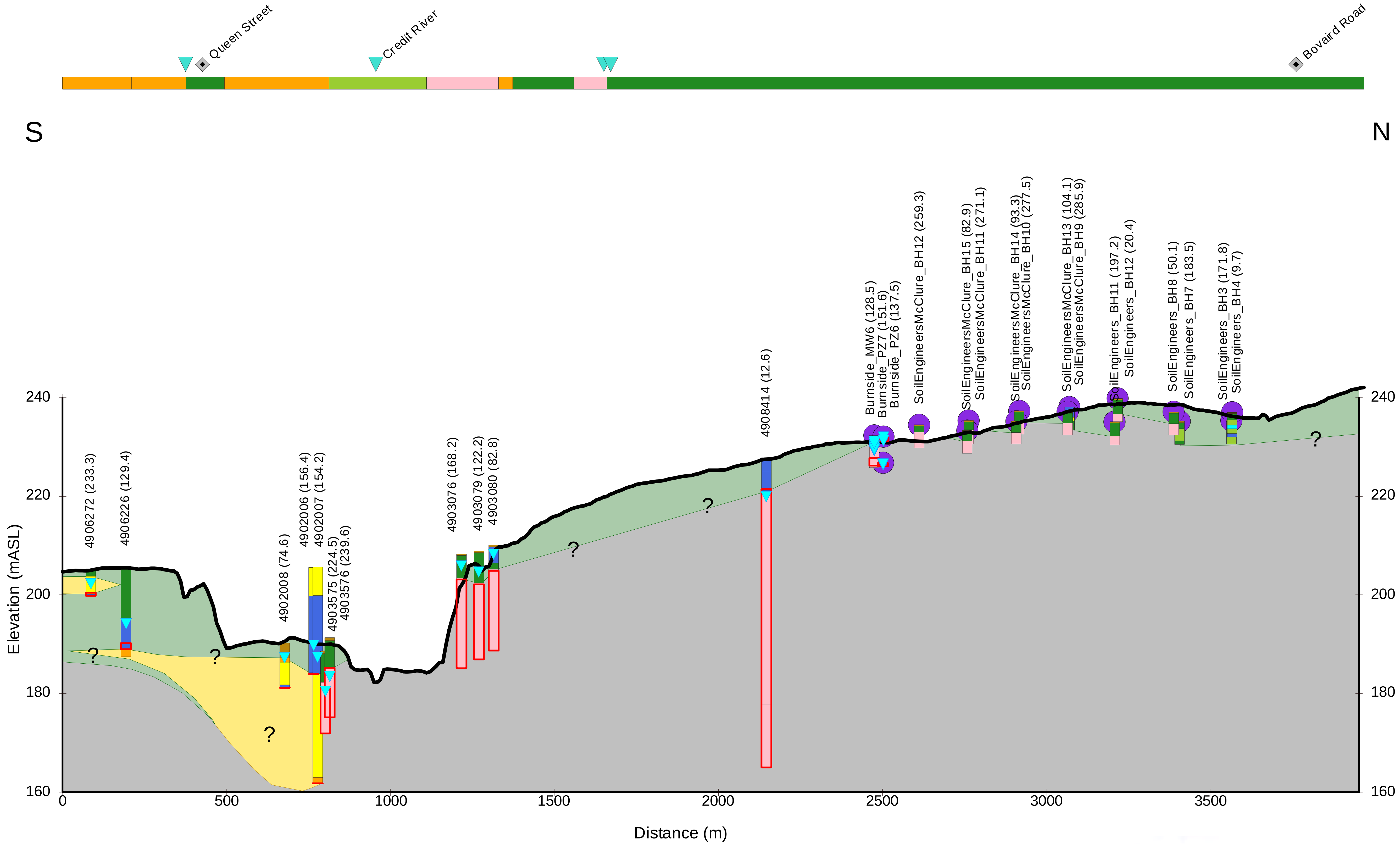
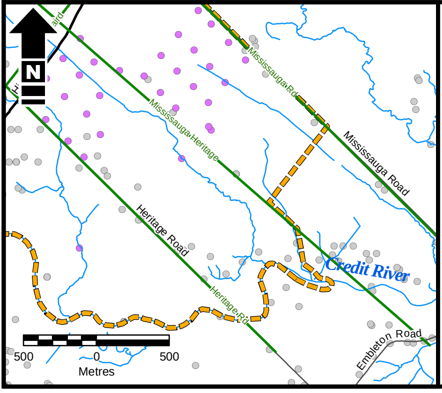
Figure B4





Legend
- Profile
- Heritage Heights Study Area
- Highway / Expressway
- Road
- Drainage
- Water Well Record
- High Quality Borehole, New Data

Water Well Record / Borehole Lithology
- Clay
- Silt
- Diamict
- Sand, silty sand
- Gravel, gravelly sand
- Fill, topsoil
- Organic material
- Bedrock
- Unknown

- Well Screen
- Water Level
- Cross-Section Intersection
- River Crossing
- High Quality Borehole, New Data

Surficial Geology
- Coarse-grained Granular Sediment, Outwash
- Till, Diamict
- Bedrock

Hydrostratigraphic Units
- Fine-grained, unconsolidated material
- Coarse-grained, unconsolidated material
- Paleozoic Bedrock

Reference: Ontario Ministry of Natural Resources (2010), Credit Valley Conservation Authority (2010)

Vertical Exaggeration: 15x

Blackport & Associates

North West Brampton Heritage Heights Subwatershed Study

Mississauga Rd. - Heritage Rd.
Cross-Section

Date: 19 Nov 2012	Project: 15519-528	Technical: L. Weaver	Reviewer: P. Chin	Drawn: L. Weaver

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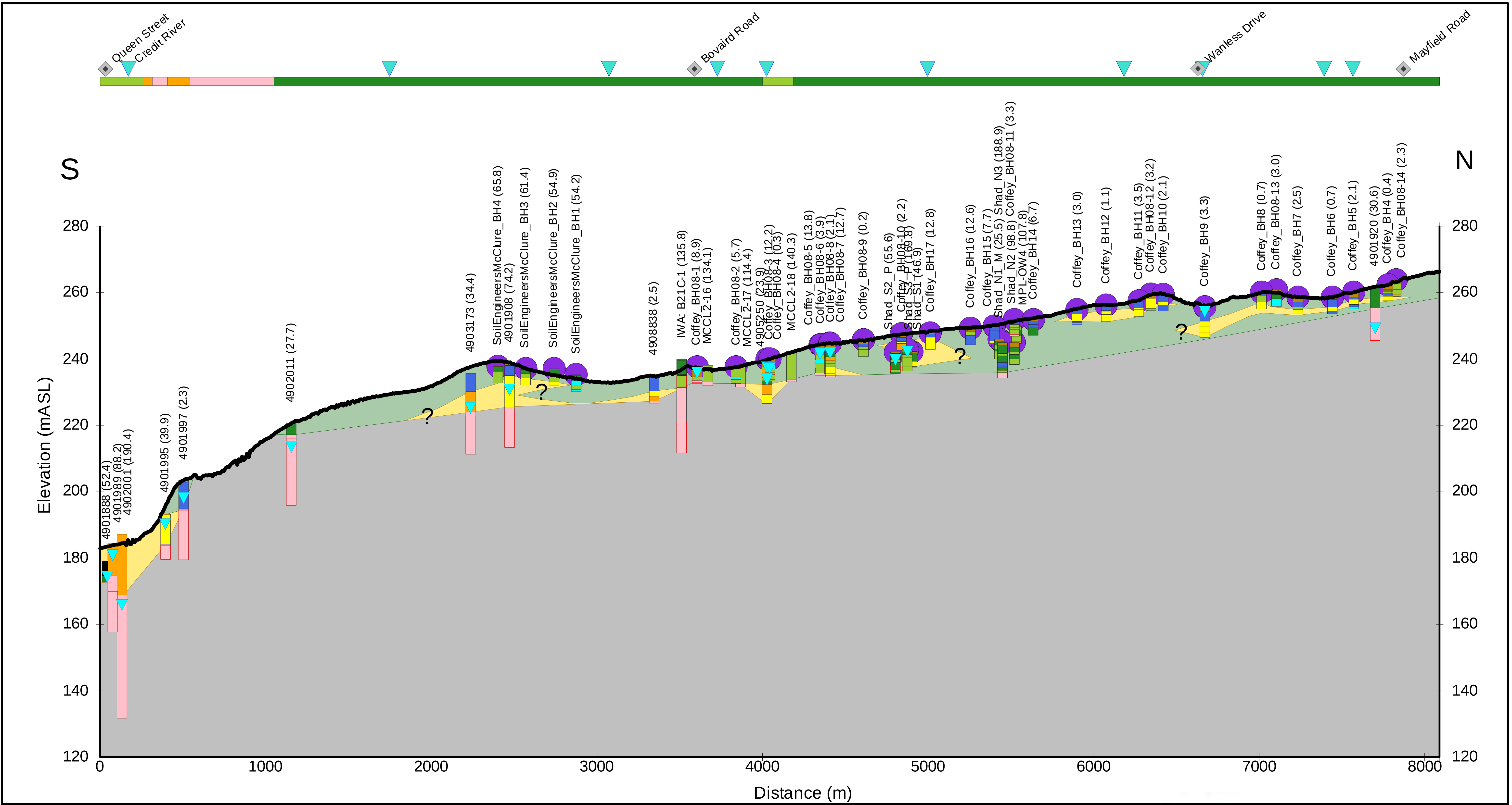
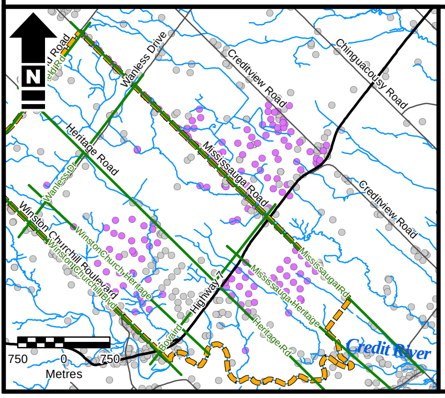
Figure
B5

T:\2011013_HeritageHeightsSWS\GIS\ArcGIS\MXDs\2011022_FIGURE-XX-XSMississaugaHeritage.mxd





:\2011013_HeritageHeightsSWS\GIS\ArcGIS\MXDs\2011022_FIGURE-XX-XSMississauga.mxd

Legend
- Profile
- Heritage Heights Study Area
- Highway / Expressway
- Road
- Drainage
- Water Well Record
- High Quality Borehole, New Data

Water Well Record / Borehole Lithology

🟦	Clay
🟦	Silt
🟩	Diamict
🟨	Sand, silty sand
🟧	Gravel, gravelly sand
🟫	Fill, topsoil
⬜	Organic material
🟪	Bedrock
⬛	Unknown

☐	Well Screen
▽	Water Level
◆	Cross-Section Intersection
▼	River Crossing
●	High Quality Borehole, New Data

Surficial Geology

🟧	Coarse-grained Granular Sediment, Outwash
🟩	Till, Diamict
🟪	Bedrock

Hydrostratigraphic Units

🟩	Fine-grained, unconsolidated material
🟨	Coarse-grained, unconsolidated material
⬜	Paleozoic Bedrock

Reference: Ontario Ministry of Natural Resources (2010), Credit Valley Conservation Authority (2010)

Vertical Exaggeration: 20x

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North West Brampton Heritage Heights Subwatershed Study

Mississauga Rd. Cross-Section

Date: 19 Nov 2012	Project: 15519-528	Technical: L. Weaver	Reviewer: P. Chin	Drawn: L. Weaver

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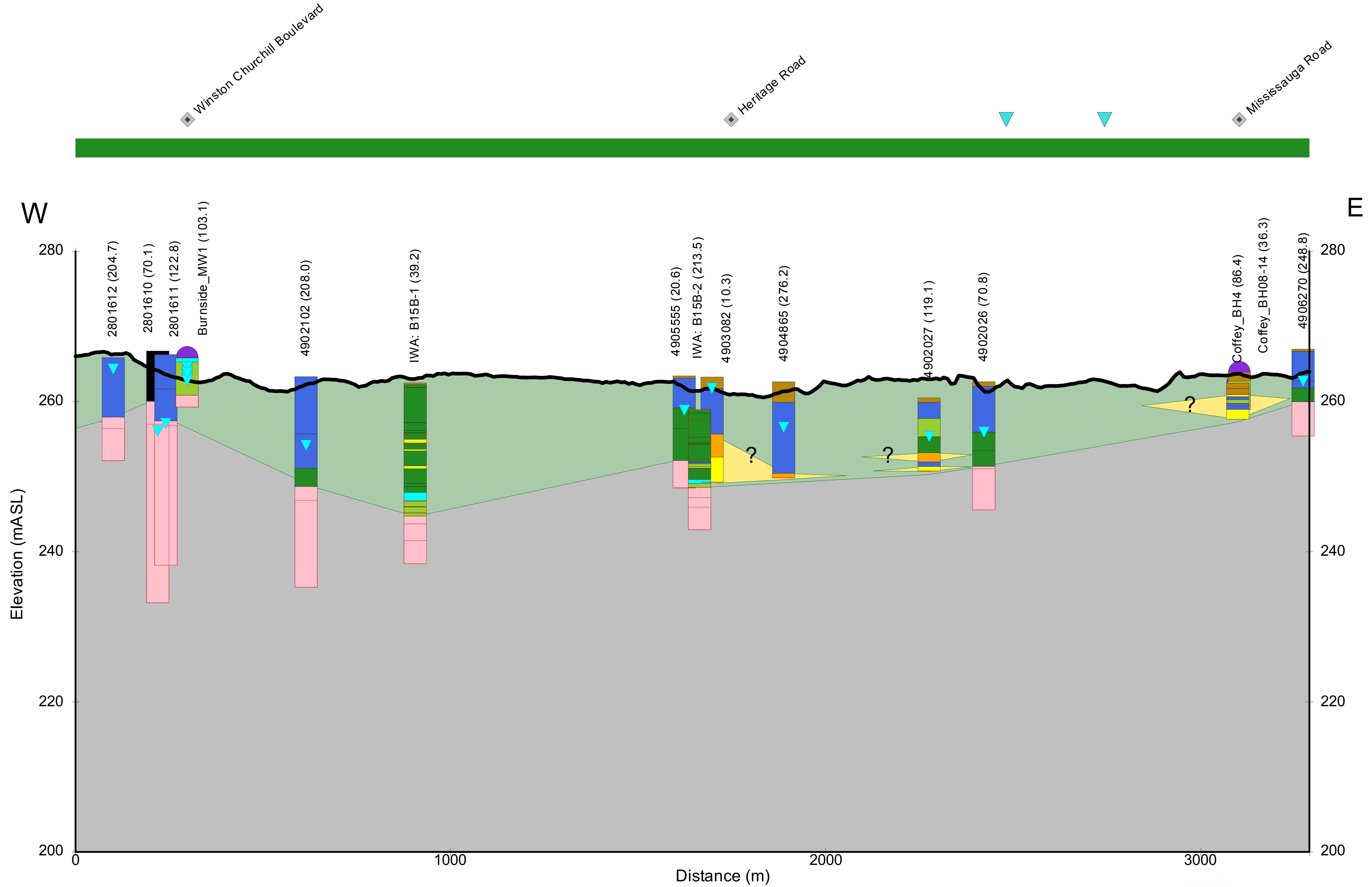
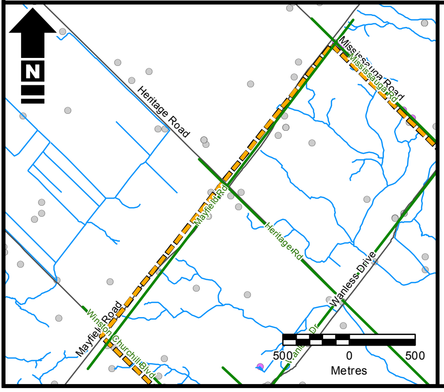
Figure
B6



T:\2011013_HeritageHeightsSWS\GIS\ArcGIS\MXDs\2011022_FIGURE-XX-XSMayfield.mxd



Legend
- ● Water Well Record
- ● High Quality Borehole, New Data
- — Profile
- — Drainage
- — Road
- — Highway / Expressway
- ▬ ▬ Heritage Heights Study Area

Water Well Record / Borehole Lithology
- 🟦 Clay
- ▨ Silt
- 🟩 Diamict
- 🟨 Sand, silty sand
- 🟧 Gravel, gravelly sand
- 🟫 Fill, topsoil
- ▨ Organic material
- ▨ Bedrock
- ⬛ Unknown

- ☐ Well Screen
- ▽ Water Level
- ◈ Cross-Section Intersection
- ▼ River Crossing
- ● High Quality Borehole, New Data

Surficial Geology
- 🟧 Coarse-grained Granular Sediment, Outwash
- 🟩 Till, Diamict
- ▨ Bedrock

Hydrostratigraphic Units
- ▨ Fine-grained, unconsolidated material
- 🟨 Coarse-grained, unconsolidated material
- ▨ Paleozoic Bedrock

Reference: Ontario Ministry of Natural Resources (2010), Credit Valley Conservation Authority (2010)

Vertical Exaggeration: 20x

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Matrix Solutions Inc.
Blackport & Associates
STONYBROOK

North West Brampton Heritage Heights Subwatershed Study

Mayfield Rd. Cross-Section

Date: 29 Aug 2012	Project: 15519-528	Technical: L. Weaver	Reviewer: P. Chin	Drawn: L. Weaver

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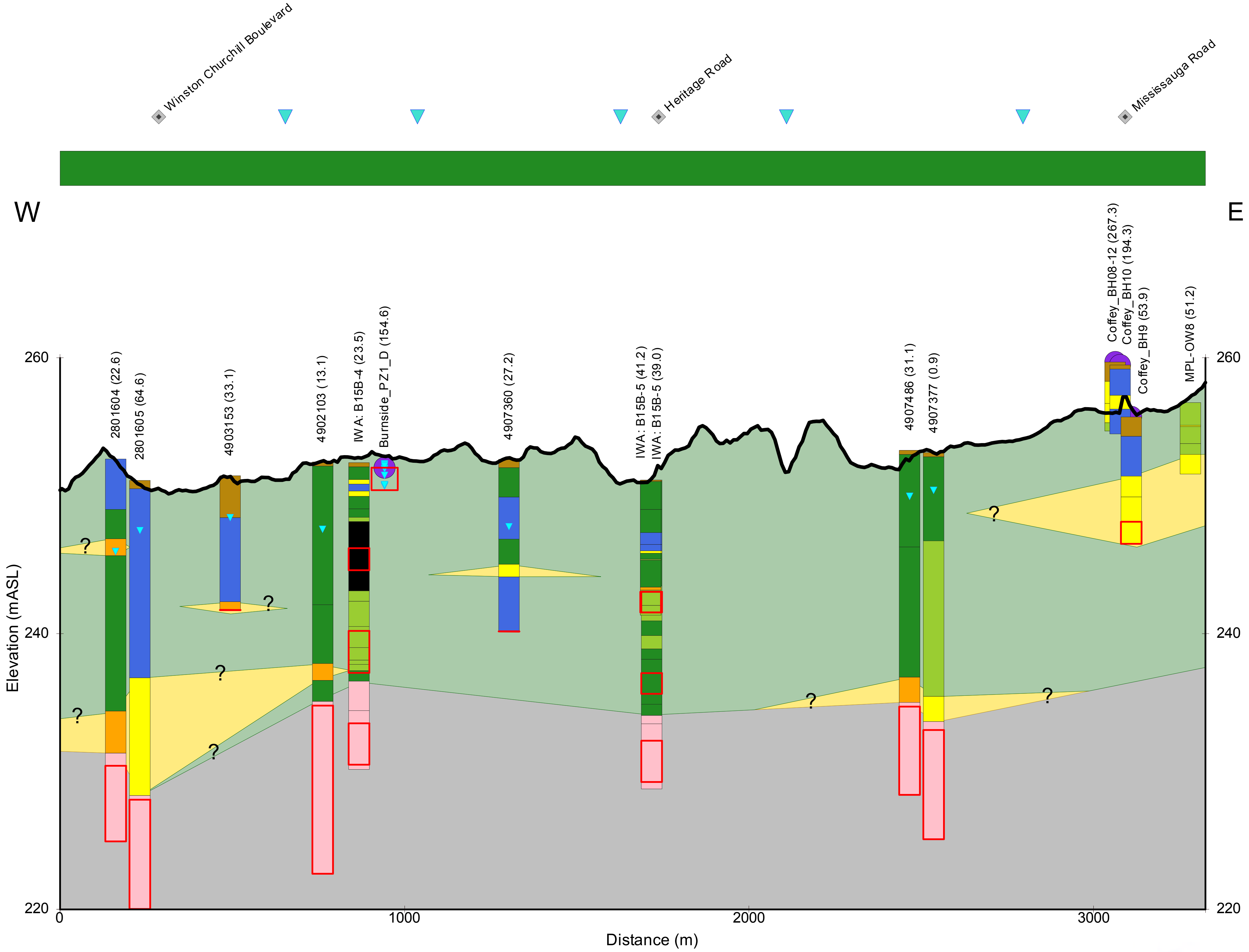
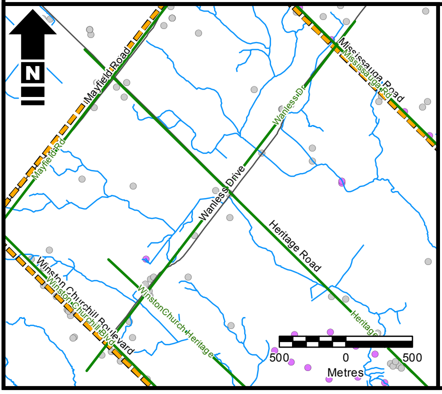
Figure
B7

T:\2011013_HeritageHeightsSWS\GIS\ArcGIS\MXDs\2011022_FIGURE-XX-XSWanless.mxd





Legend

- ● Water Well Record
- ● High Quality Borehole, New Data
- — Profile
- — Drainage
- — Road
- — Highway / Expressway
- ▬ Heritage Heights Study Area

Water Well Record / Borehole Lithology

- 🟦 Clay
- ▨ Silt
- ▨ Diamict
- 🟨 Sand, silty sand
- 🟧 Gravel, gravelly sand
- 🟫 Fill, topsoil
- ▨ Organic material
- ▨ Bedrock
- ⬛ Unknown

- 🟥 Well Screen
- ▽ Water Level
- ◆ Cross-Section Intersection
- ▼ River Crossing
- ● High Quality Borehole, New Data

Surficial Geology

- 🟧 Coarse-grained Granular Sediment, Outwash
- 🟩 Till, Diamict
- ▨ Bedrock

Hydrostratigraphic Units

- ▨ Fine-grained, unconsolidated material
- 🟨 Coarse-grained, unconsolidated material
- ▨ Paleozoic Bedrock

Reference: Ontario Ministry of Natural Resources (2010), Credit Valley Conservation Authority (2010)

Vertical Exaggeration: 40x

Blackport & Associates

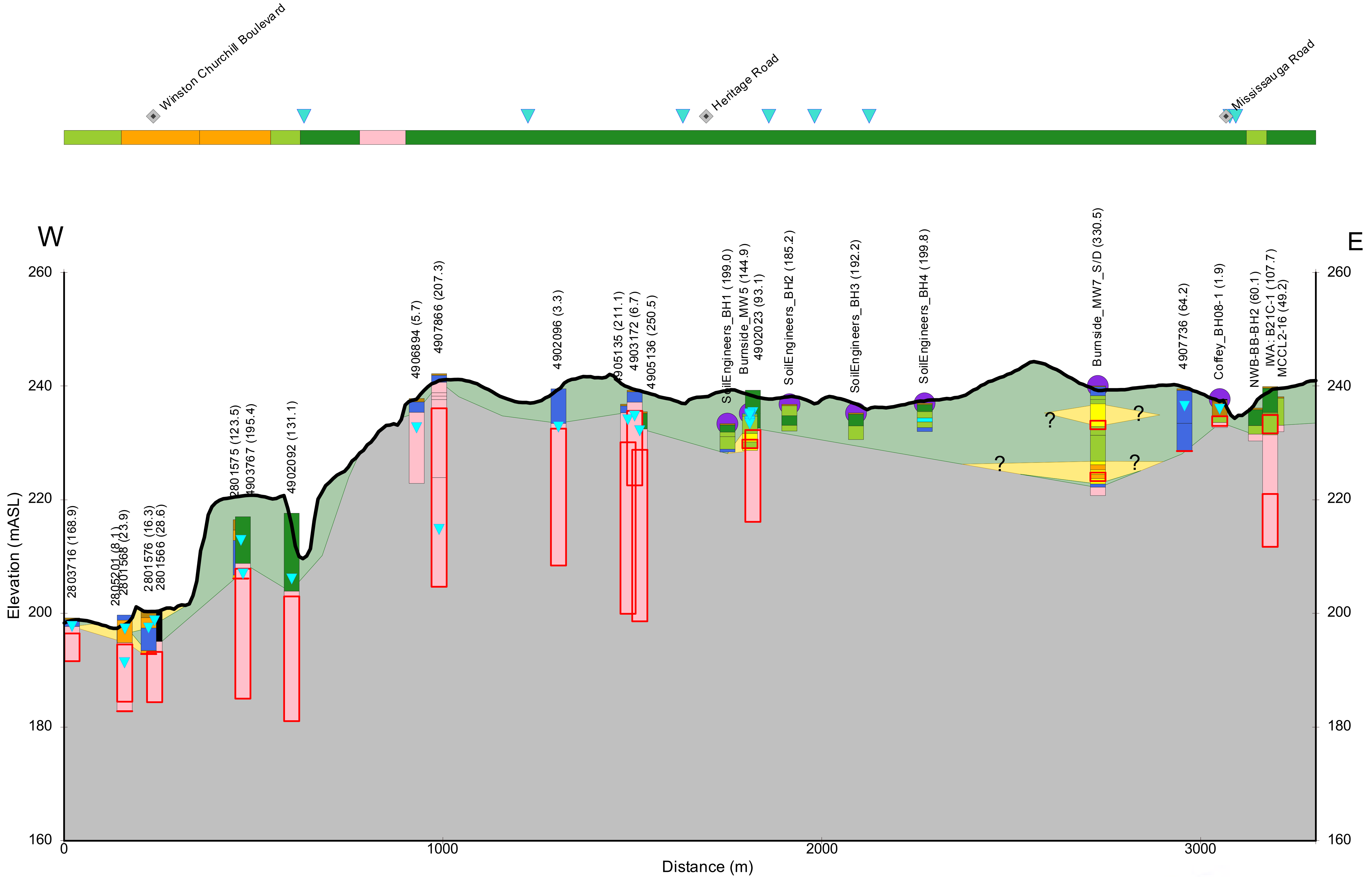
North West Brampton Heritage Heights Subwatershed Study

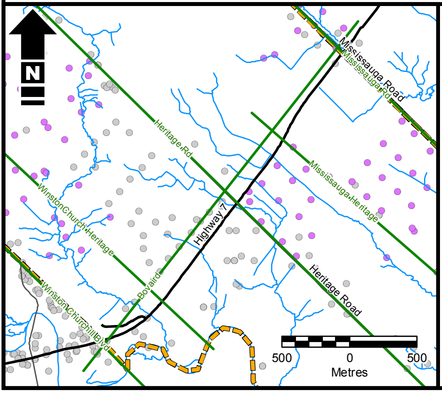
Wanless Dr. Cross-Section

Date: 29 Aug 2012	Project: 15519-528	Technical: L. Weaver	Reviewer: P. Chin	Drawn: L. Weaver

Disclaimer: Prepared solely for the use of the City of Brampton as specified in the accompanying report. No representation of any kind is made to other parties with which the City of Brampton has not entered into contract.

Figure B8





Legend

- ● Water Well Record
- ● High Quality Borehole, New Data
- Profile
- Drainage
- Road
- Highway / Expressway
- Heritage Heights Study Area

Water Well Record / Borehole Lithology

- 🟦 Clay
- ▨ Silt
- 🟩 Diamict
- 🟨 Sand, silty sand
- 🟧 Gravel, gravelly sand
- 🟫 Fill, topsoil
- ▨ Organic material
- ▨ Bedrock
- ⬛ Unknown

- ☐ Well Screen
- ▽ Water Level
- ◆ Cross-Section Intersection
- ▼ River Crossing
- ● High Quality Borehole, New Data

Surficial Geology

- 🟧 Coarse-grained Granular Sediment, Outwash
- 🟩 Till, Diamict
- ▨ Bedrock

Hydrostratigraphic Units

- ▨ Fine-grained, unconsolidated material
- 🟨 Coarse-grained, unconsolidated material
- ▨ Paleozoic Bedrock

Reference: Ontario Ministry of Natural Resources (2010), Credit Valley Conservation Authority (2010)

Vertical Exaggeration: 15x

Blackport & Associates

North West Brampton Heritage Heights Subwatershed Study

Bovaird Rd. Cross-Section

Date: 29 Aug 2012	Project: 15519-528	Technical: L. Weaver	Reviewer: P. Chin	Drawn: L. Weaver

Figure B9

B-2 Borehole Logs

LOG OF DRILLING OPERATIONS

MW1

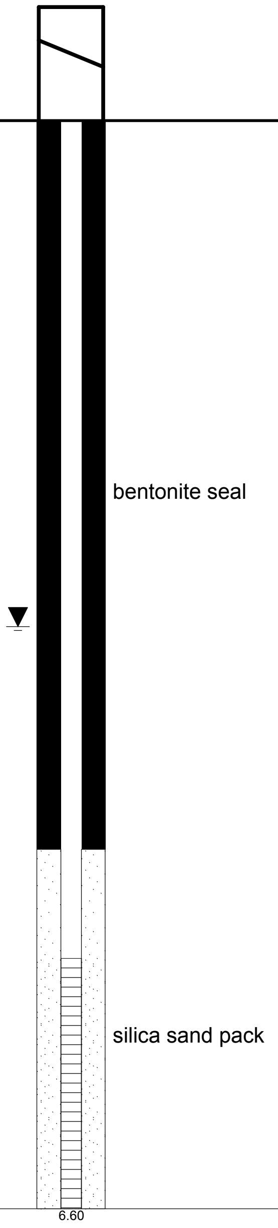
Page 1 of 1

BURNSIDE
R.J. Burnside & Associates Limited
292 Speedvale Avenue West, Guelph, Ontario N1H 1C4
telephone (519) 823-4995 fax (519) 836-5477

Client: **Heritage Heights Landowners**	Project Name: **Hydrogeological Study**	Logged by: **J. Shaw**
Project No.: **PTN018233**	Location: **Brampton, Ontario**	Ground (m amsl): **265.85**
Drilling Co.: **Lantech Drilling Services Inc.**	Date Started: **6/8/2010**	Static Water Level (m amsl):
Drilling Method: **Hollow Stem Auger**	Date Completed: **6/8/2010**	Sand Pack (m amsl): **4.4 m to 6.6 m**

Surface Elevation (m): **265.85**

Stratigraphic Description	Depth (m)
TOPSOIL	0.08
CLAYEY SILT, some sand, trace gravel, brown, moist, stiff	0.61
CLAYEY SILT TILL, some sand, trace gravel, brown, moist, hard - red at 4.6 m - grey, dry at 4.8 m	5.03
WEATHERED SHALE	6.60



SAMPLE Num.	Type	Int.	N.Val.
SS1	SS	☒	9
SS2	SS	☒	43
SS3	SS	☒	35
SS4	SS	☒	43
SS5	SS	☒	47
SS6	SS	☒	161
SS7	SS	☒	68/13cm

Prepared By: **J. Shaw** Checked By: **J. Thompson** Date Prepared: **12/2/2010**

This borehole log was prepared for hydrogeological and/or environmental purposes and does not necessarily contain information suitable for a geotechnical assessment of the subsurface conditions. Borehole data requires interpretation by R. J. Burnside & Associates Limited personnel before use by others.

LEGEND	MONITORING WELL DATA	SAMPLE TYPE			
▼ Water found @ time of drilling	Pipe: **51 mm dia. PVC**	AC	Auger Cutting	SS	Split Spoon
▽ Static Water Level -	Screen: **51 mm dia. PVC #10 slot**	CS	Continuous	AR	Air Rotary
		RC	Rock Core	WC	Wash Cuttings

LOG OF DRILLING OPERATIONS

MW2

BURNSIDE

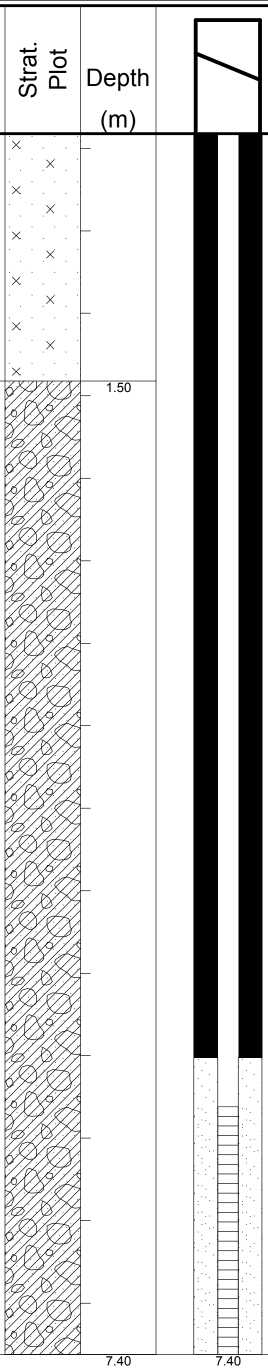
R.J. Burnside & Associates Limited
292 Speedvale Avenue West, Guelph, Ontario N1H 1C4
telephone (519) 823-4995 fax (519) 836-5477

Page 1 of 1

Client: **Heritage Heights Landowners**	Project Name: **Hydrogeological Study**	Logged by: **J. Shaw**
Project No.: **PTN018233**	Location: **Brampton, Ontario**	Ground (m amsl): **250.09**
Drilling Co.: **Lantech Drilling Services Inc.**	Date Started: **6/9/2010**	Static Water Level (m amsl):
Drilling Method: **Hollow Stem Auger**	Date Completed: **6/9/2010**	Sand Pack (m amsl): **5.6m to 7.4m**

Surface Elevation (m): **250.09**

Depth (m)	Stratigraphic Description
	SILTY SAND, trace clay, trace organics, brown grey, wet, compact
1.50	SILTY SAND TILL, trace gravel, reddish brown, moist, compact
	- reddish grey at 3.8 m
	- wet at 5.3 m
7.40	



bentonite seal

silica sand pack

SAMPLE Num.	Type	Int.	N.Val.
1	SS		11
2	SS		6
3	SS		26
4	SS		50/5cm
5	SS		50/15cm
6	SS		51/15cm
7	SS		31

Prepared By: **J. Shaw** Checked By: **J. Thompson** Date Prepared: **12/2/2010**

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LEGEND
▼ Water found @ time of drilling
▽ Static Water Level -

MONITORING WELL DATA
Pipe: **51 mm dia. PVC**
Screen: **51 mm dia. PVC #10 slot**

SAMPLE TYPE
AC Auger Cutting
CS Continuous
RC Rock Core
SS ☒ Split Spoon
AR ▨ Air Rotary
WC Wash Cuttings

LOG OF DRILLING OPERATIONS

MW3

BURNSIDE

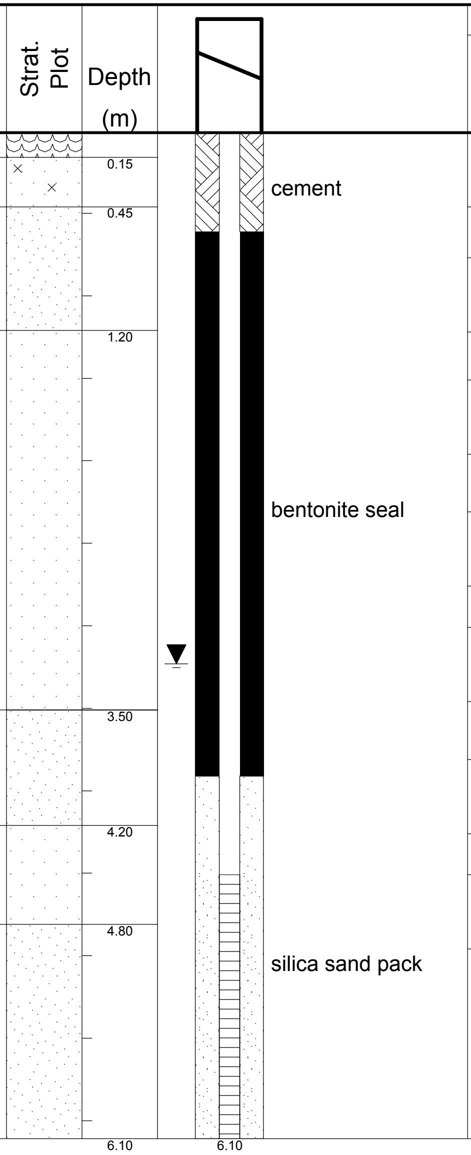
R.J. Burnside & Associates Limited
292 Speedvale Avenue West, Guelph, Ontario N1H 1C4
telephone (519) 823-4995 fax (519) 836-5477

Page 1 of 1

Client: **Heritage Heights Landowners**	Project Name: **Hydrogeological Study**	Logged by: **J. Shaw**
Project No.: **PTN018233**	Location: **Brampton, Ontario**	Ground (m amsl): **245.49**
Drilling Co.: **Lantech Drilling Services Inc.**	Date Started: **6/9/2010**	Static Water Level (m amsl):
Drilling Method: **Hollow Stem Auger**	Date Completed: **6/9/2010**	Sand Pack (m amsl): **3.9m to 6.1m**

Surface Elevation (m): **245.49**

Stratigraphic Description	Depth (m)
TOPSOIL	
SANDY SILT, trace gravel, dark brown, moist, firm	0.15
SILTY SAND TILL, trace gravel, brown, moist, compact	0.45
SAND, medium grained, brown, saturated, compact - fine grained, trace silt, very dense at 2.3 m - trace gravel, grey at 3 m	1.20
SANDY SILT TILL, trace gravel, grey, moist, dense	3.50
SAND, medium to fine grained, trace gravel, some silt, grey, saturated, dense	4.20
SANDY SILTY TILL, trace gravel, trace clay, grey, moist, dense	4.80
	6.10



SAMPLE Num.	Type	Int.	N.Val.
1	SS	☒	7
2	SS	☒	19
3	SS	☒	18
4	SS	☒	59
5	SS	☒	59
6	SS	☒	40
7	SS	☒	31

Depth Scale (ft) (m): 5.0 ft, 10.0 ft, 15.0 ft, 20.0 ft; 1.0 m, 2.0 m, 3.0 m, 4.0 m, 5.0 m, 6.0 m

Prepared By: **J. Shaw** Checked By: **J. Thompson** Date Prepared: **12/2/2010**

This borehole log was prepared for hydrogeological and/or environmental purposes and does not necessarily contain information suitable for a geotechnical assessment of the subsurface conditions. Borehole data requires interpretation by R. J. Burnside & Associates Limited personnel before use by others.

LEGEND	MONITORING WELL DATA	SAMPLE TYPE			
▼ Water found @ time of drilling	Pipe: **51 mm dia. PVC**	AC	Auger Cutting	SS ☒	Split Spoon
▽ Static Water Level -	Screen: **51 mm dia. PVC #10 slot**	CS	Continuous	AR ▨	Air Rotary
		RC	Rock Core	WC	Wash Cuttings

LOG OF DRILLING OPERATIONS

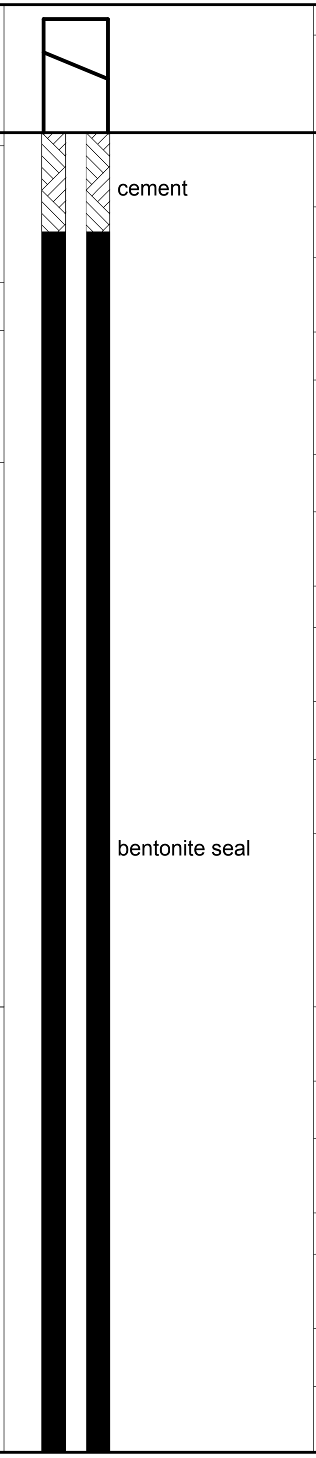
BURNSIDE
R.J. Burnside & Associates Limited
292 Speedvale Avenue West, Guelph, Ontario N1H 1C4
telephone (519) 823-4995 fax (519) 836-5477

MW4

Client: **Heritage Heights Landowners**	Project Name: **Hydrogeological Study**	Logged by: **J. Shaw**
Project No.: **PTN018233**	Location: **Brampton, Ontario**	Ground (m amsl): **250.49**
Drilling Co.: **Lantech Drilling Services Inc.**	Date Started: **6/10/2010**	Static Water Level (m amsl):
Drilling Method: **Hollow Stem Auger**	Date Completed: **6/10/2010**	Sand Pack (m amsl): **10m to 12.1m**

Surface Elevation (m): **250.49**

Stratigraphic Description	Depth (m)
FILL - sand and gravel, some silt, grey, moist, compact	
CLAYEY SILT TILL, some sand, trace gravel, brown, moist, stiff	0.08
SANDY SILT, brown, moist, compact	0.91
SILTY SAND TILL, trace gravel, brown, moist, very dense	1.20
SILTY SAND, brown, moist, very dense - 1 cm medium grained sand layer at 2.4 m - 7.5 cm medium grained sand and gravel layer at 3.2 m - no recovery at 4.5m	2.00
SANDY SILT TILL, trace gravel, trace clay, brown, moist, very dense	5.30



SAMPLE

Num.	Type	Int.	N.Val.
1	SS	☒	13
2	SS	☒	11
3	SS	☒	55
4	SS	☒	54/0.15m
5	SS	☒	50/0.10m
6	SS	☒	50/0.05m
8	SS	☒	100/0.15m
9	SS	☒	100/0.13m
10	SS	☒	100/0.1m
11	SS	☒	100/0.08m

Prepared By: **J. Shaw** Checked By: **J. Thompson** Date Prepared: **12/2/2010**

This borehole log was prepared for hydrogeological and/or environmental purposes and does not necessarily contain information suitable for a geotechnical assessment of the subsurface conditions. Borehole data requires interpretation by R. J. Burnside & Associates Limited personnel before use by others.

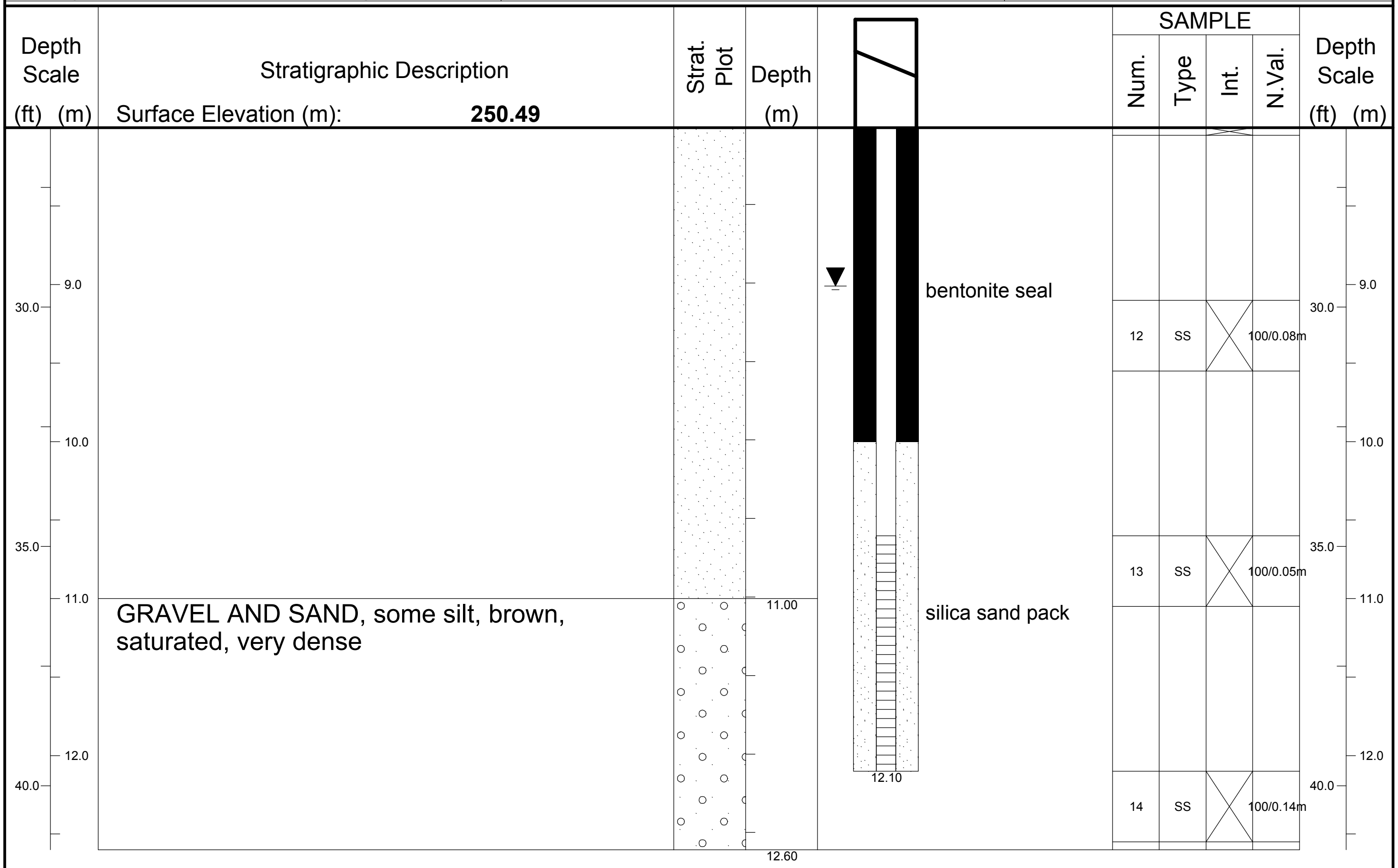
LEGEND	MONITORING WELL DATA	SAMPLE TYPE			
▼ Water found @ time of drilling	Pipe: **51 mm dia. PVC**	AC ◧	Auger Cutting	SS ☒	Split Spoon
▽ Static Water Level -	Screen: **51 mm dia. PVC #10 slot**	CS ▯	Continuous	AR ▨	Air Rotary
		RC ▯	Rock Core	WC ▭	Wash Cuttings

LOG OF DRILLING OPERATIONS

MW4

Client: **Heritage Heights Landowners**	Project Name: **Hydrogeological Study**	Logged by: **J. Shaw**
Project No.: **PTN018233**	Location: **Brampton, Ontario**	Ground (m amsl): **250.49**
Drilling Co.: **Lantech Drilling Services Inc.**	Date Started: **6/10/2010**	Static Water Level (m amsl):
Drilling Method: **Hollow Stem Auger**	Date Completed: **6/10/2010**	Sand Pack (m amsl): **10m to 12.1m**

Depth Scale (ft) (m)
Stratigraphic Description
Surface Elevation (m): **250.49**



Depth (m)	Stratigraphic Description
11.00	GRAVEL AND SAND, some silt, brown, saturated, very dense
12.60	

Num.	Type	Int.	N.Val.
12	SS	☒	100/0.08m
13	SS	☒	100/0.05m
14	SS	☒	100/0.14m

Prepared By: **J. Shaw** Checked By: **J. Thompson** Date Prepared: **12/2/2010**

This borehole log was prepared for hydrogeological and/or environmental purposes and does not necessarily contain information suitable for a geotechnical assessment of the subsurface conditions. Borehole data requires interpretation by R. J. Burnside & Associates Limited personnel before use by others.

LEGEND	MONITORING WELL DATA	SAMPLE TYPE			
▼ Water found @ time of drilling	Pipe: **51 mm dia. PVC**	AC	Auger Cutting	SS ☒	Split Spoon
▽ Static Water Level -	Screen: **51 mm dia. PVC #10 slot**	CS	Continuous	AR ▨	Air Rotary
		RC	Rock Core	WC	Wash Cuttings

LOG OF DRILLING OPERATIONS

MW5

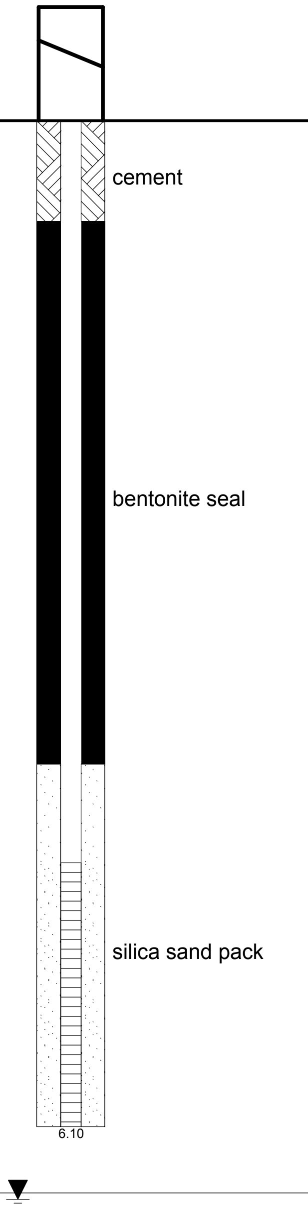
BURNSIDE

R.J. Burnside & Associates Limited
292 Speedvale Avenue West, Guelph, Ontario N1H 1C4
telephone (519) 823-4995 fax (519) 836-5477

Client: **Heritage Heights Landowners**	Project Name: **Hydrogeological Study**	Logged by: **J. Shaw**
Project No.: **PTN018233**	Location: **Brampton, Ontario**	Ground (m amsl): **235.18**
Drilling Co.: **Lantech Drilling Services Inc.**	Date Started: **6/10/2010**	Static Water Level (m amsl):
Drilling Method: **Hollow Stem Auger**	Date Completed: **6/10/210**	Sand Pack (m amsl): **3.9m to 6.1m**

Surface Elevation (m): **235.18**

Stratigraphic Description	Depth (m)
CLAYEY SILT, some sand, trace organics, dark brown, moist, firm	0.15
SANDY SILT, trace gravel, trace clay, brown, moist, stiff	0.45
SANDY SILT TILL, trace clay, trace gravel, reddish brown, moist to wet, compact - very dense at 1.5 m	3.50
SAND, fine to medium grained, trace silt bedding (1 mm thick), grey, moist, very dense	5.00
SILT AND SAND, fine grained, grey/red banding, moist, very dense	6.10
SAND, medium grained, trace to some silt, grey, moist, very dense - becoming fine grained at 6.4 m	6.50



SAMPLE			
Num.	Type	Int.	N.Val.
1	SS	☒	11
2	SS	☒	12
3	SS	☒	123
4	SS	☒	50/0.08m
5	SS	☒	50/0.08m
6	SS	☒	50/0.12m
7	SS	☒	50/0.1m
8	SS	☒	105

Prepared By: **J. Shaw** Checked By: **J. Thompson** Date Prepared: **12/2/2010**

This borehole log was prepared for hydrogeological and/or environmental purposes and does not necessarily contain information suitable for a geotechnical assessment of the subsurface conditions. Borehole data requires interpretation by R. J. Burnside & Associates Limited personnel before use by others.

LEGEND
▼ Water found @ time of drilling
▽ Static Water Level -

MONITORING WELL DATA
Pipe: **51 mm dia. PVC**
Screen: **51 mm dia. PVC #10 slot**

SAMPLE TYPE					
AC	◧	Auger Cutting	SS	☒	Split Spoon
CS	▯	Continuous	AR	▩	Air Rotary
RC	▯	Rock Core	WC	▭	Wash Cuttings

LOG OF DRILLING OPERATIONS

MW6

BURNSIDE
R.J. Burnside & Associates Limited
292 Speedvale Avenue West, Guelph, Ontario N1H 1C4
telephone (519) 823-4995 fax (519) 836-5477

Page 1 of 1

Client: **Heritage Heights Landowners**	Project Name: **Hydrogeological Study**	Logged by: **J. Shaw**
Project No.: **PTN018233**	Location: **Brampton, Ontario**	Ground (m amsl): **232.30**
Drilling Co.: **Lantech Drilling Services Inc.**	Date Started: **6/14/2010**	Static Water Level (m amsl):
Drilling Method: **Hollow Stem Auger**	Date Completed: **6/14/2010**	Sand Pack (m amsl): **3.9m to 6.1m**

Depth Scale (ft) (m) | Stratigraphic Description | Surface Elevation (m): **232.30** | Strat. Plot | Depth (m)

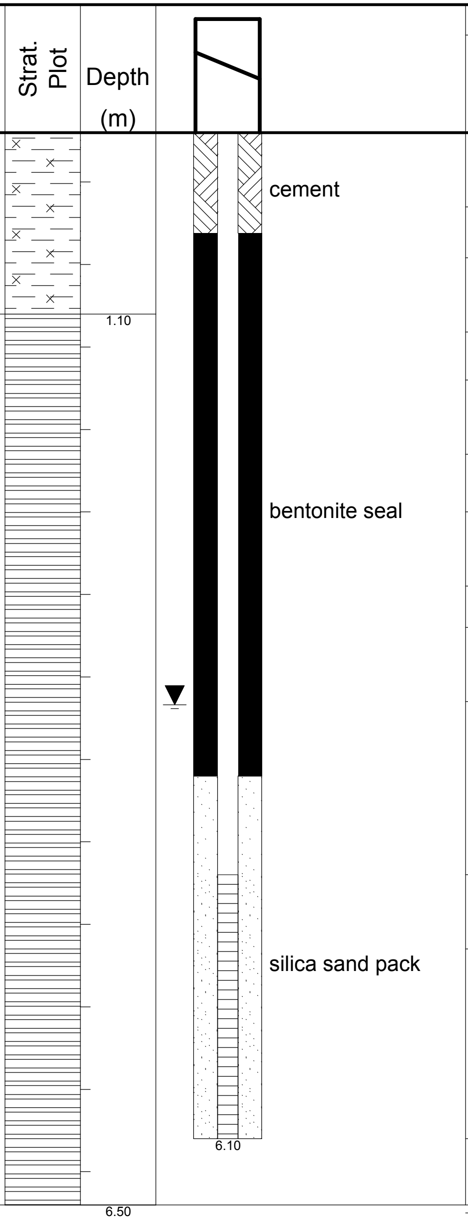
CLAYEY SILT, some sand, trace gravel, brown, moist, stiff

1.10 — WEATHERED SHALE, red, dry, hard

- occasional grey bands at 3 m

- wet at 6.1 m

6.50



SAMPLE Num.	Type	Int.	N.Val.
1	SS		12
2	SS		50/0.03m
3	SS		50/0.08m
4	SS		73/0.13m
5	SS		50/0.05m
6	SS		79/0.03m
7	SS		90/0.15m

Depth Scale (ft): 5.0, 10.0, 15.0, 20.0
Depth Scale (m): 1.0, 2.0, 3.0, 4.0, 5.0, 6.0

Prepared By: **J. Shaw** Checked By: **J. Thompson** Date Prepared: **12/2/2010**

This borehole log was prepared for hydrogeological and/or environmental purposes and does not necessarily contain information suitable for a geotechnical assessment of the subsurface conditions. Borehole data requires interpretation by R. J. Burnside & Associates Limited personnel before use by others.

LEGEND	MONITORING WELL DATA	SAMPLE TYPE			
▼ Water found @ time of drilling	Pipe: **51 mm dia. PVC**	AC	Auger Cutting	SS ☒	Split Spoon
▽ Static Water Level -	Screen: **51 mm dia. PVC #10 slot**	CS	Continuous	AR ▨	Air Rotary
		RC	Rock Core	WC	Wash Cuttings

LOG OF DRILLING OPERATIONS

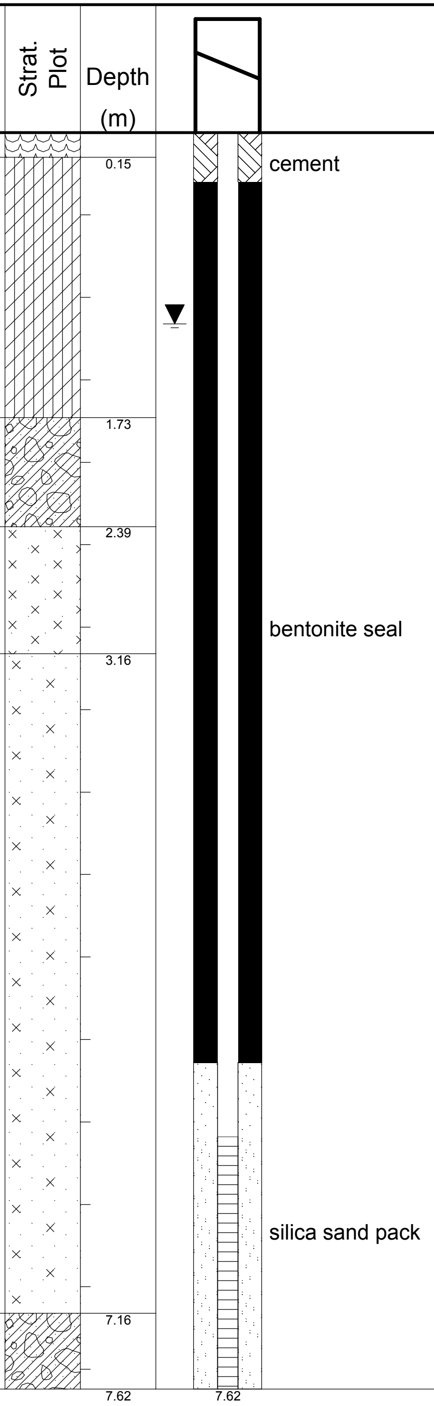
MW7s

BURNSIDE

R.J. Burnside & Associates Limited
292 Speedvale Avenue West, Guelph, Ontario N1H 1C4
telephone (519) 823-4995 fax (519) 836-5477

Page 1 of 1

Client: **City of Brampton**	Project Name: **Hydrogeological Study**	Logged by: **K. Churcher**
Project No.: **300030932.0000**	Location: **Brampton, Ontario**	Ground (m amsl): **241**
Drilling Co.: **Lantech Drilling Services Inc.**	Date Started: **4/19/2012**	Static Water Level (m amsl):
Drilling Method: **Hollow Stem Auger**	Date Completed: **4/19/2012**	Sand Pack (m amsl): **5.6m to 7.6m**



Depth Scale (ft)	Depth Scale (m)	Stratigraphic Description Surface Elevation (m): **241.00**	Depth (m)	SAMPLE Num.	SAMPLE Type	SAMPLE Int.	SAMPLE N.Val.	Depth Scale (ft)	Depth Scale (m)
		TOPSOIL							
		SILTY CLAY, trace gravel, trace sand, brown, damp, stiff, weakly plastic	0.15						
	1.0								1.0
5.0								5.0	
	2.0	SANDY SILT TILL, trace clay, trace to some gravel, brown, moist, dense to very dense, weak to medium plasticity - 10 cm thick sand layer at 1.9 m - gray at 2.4 m	1.73						2.0
		SANDY SILT, trace clay, trace gravel, gray, damp, very dense, medium plasticity	2.39						
10.0	3.0							10.0	3.0
		SILTY SAND, fine grained, trace clay, trace gravel, brown, damp, uniform, very dense	3.16						
	4.0								4.0
15.0		- becoming saturated at 4.6 m						15.0	
	5.0								5.0
20.0	6.0			SS1	SS	☒	100/12.7cm	20.0	6.0
	7.0								7.0
		SILTY SAND TILL, some gravel, trace clay, brown, saturated, very dense, weakly plastic	7.16						
25.0			7.62					25.0	

Prepared By: **K. Churcher** Checked By: **J. Thompson** Date Prepared: **5/4/2012**

This borehole log was prepared for hydrogeological and/or environmental purposes and does not necessarily contain information suitable for a geotechnical assessment of the subsurface conditions. Borehole data requires interpretation by R. J. Burnside & Associates Limited personnel before use by others.

LEGEND
▼ Water found @ time of drilling
▽ Static Water Level -

MONITORING WELL DATA
Pipe: **51 mm dia. PVC**
Screen: **51 mm dia. PVC #10 slot**

SAMPLE TYPE					
AC	◧	Auger Cutting	SS	☒	Split Spoon
CS	☐	Continuous	AR	▨	Air Rotary
RC	☐	Rock Core	WC	☐	Wash Cuttings

LOG OF DRILLING OPERATIONS

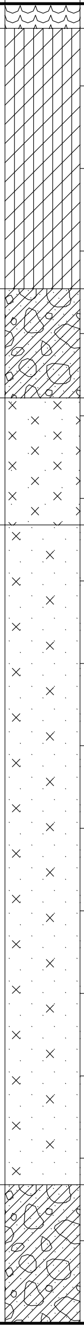
MW7d

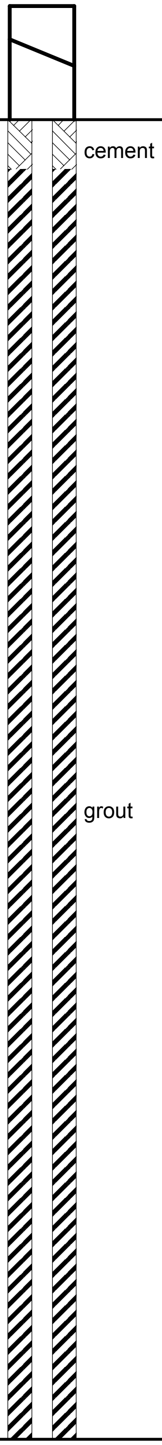
BURNSIDE
R.J. Burnside & Associates Limited
292 Speedvale Avenue West, Guelph, Ontario N1H 1C4
telephone (519) 823-4995 fax (519) 836-5477

Client: **City of Brampton**	Project Name: **Hydrogeological Study**	Logged by: **K. Churcher**
Project No.: **300030932.0000**	Location: **Brampton, Ontario**	Ground (m amsl): **241**
Drilling Co.: **Lantech Drilling Services Inc.**	Date Started: **4/18/2012**	Static Water Level (m amsl):
Drilling Method: **Hollow Stem Auger**	Date Completed: **4/19/2012**	Sand Pack (m amsl): **14.8m to 19.3m**

Surface Elevation (m): **241.00**

Depth (m)	Stratigraphic Description
	TOPSOIL
0.15	SILTY CLAY, trace gravel, trace sand, brown, damp, stiff, weakly plastic
1.73	SAND AND SILT TILL, trace clay, trace to some gravel, brown, moist, dense to very dense, weak to medium plasticity - 10 cm thick sand layer at 1.9 m - gray at 2.4 m
2.39	SANDY SILT, trace clay, trace gravel, gray, damp, very dense, medium plasticity
3.16	SILTY SAND, fine grained, trace clay, trace gravel, brown, damp, uniform, very dense - becoming saturated at 4.6 m
7.16	SILTY SAND TILL, some gravel, trace clay, brown, saturated, very dense, weakly plastic





Num.	Type	Int.	N.Val.
SS1	SS		8
SS2	SS		10
SS3	SS		32
SS4	SS		63
SS5	SS		78/27.9cm
SS6	SS		50/12.7cm
SS7	SS		60/10.16cm
SS8	SS		50/7.62cm

Prepared By: **K. Churcher** Checked By: **J. Thompson** Date Prepared: **5/4/2012**

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LEGEND
▼ Water found @ time of drilling
▽ Static Water Level -

MONITORING WELL DATA
Pipe: **51 mm dia. PVC**
Screen: **51 mm dia. PVC #10 slot**

SAMPLE TYPE
AC Auger Cutting
CS Continuous
RC Rock Core
SS ☒ Split Spoon
AR Air Rotary
WC Wash Cuttings

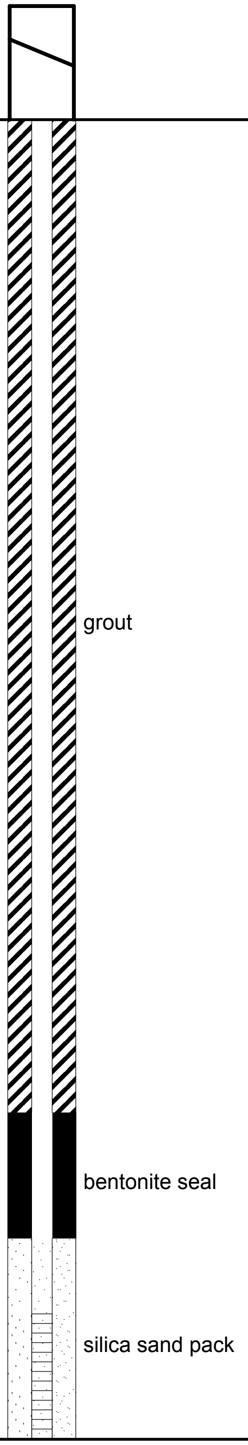
LOG OF DRILLING OPERATIONS

MW7d

Client: **City of Brampton**	Project Name: **Hydrogeological Study**	Logged by: **K. Churcher**
Project No.: **300030932.0000**	Location: **Brampton, Ontario**	Ground (m amsl): **241**
Drilling Co.: **Lantech Drilling Services Inc.**	Date Started: **4/18/2012**	Static Water Level (m amsl):
Drilling Method: **Hollow Stem Auger**	Date Completed: **4/19/2012**	Sand Pack (m amsl): **14.8m to 19.3m**

Surface Elevation (m): **241.00**

Depth (m)	Stratigraphic Description
8.69	SANDY SILT, trace to some clay, gray, moist, very dense - some gravel at 11.7 m
13.26	SAND, fine to medium grained, gray, saturated, well graded, very dense
13.88	GRAVEL, some sand, trace silt, saturated, well graded, very dense
14.78	SAND, fine to coarse grained, trace silt, trace gravel, gray, saturated, well graded, very dense
15.59	GRAVEL, trace silt, trace clay, trace sand, brown, saturated, well graded, very dense



Num.	Type	Int.	N.Val.	Depth Scale (ft)
SS9	SS		50/10.16cm	30.0
SS10	SS		100/15.2cm	35.0
SS11	SS		100/15.2cm	40.0
SS12	SS		80	45.0
SS13	SS		100/10.2cm	50.0

Depth Scale (ft): 30.0, 35.0, 40.0, 45.0, 50.0
Depth Scale (m): 9.0, 10.0, 11.0, 12.0, 13.0, 14.0, 15.0

Prepared By: **K. Churcher** Checked By: **J. Thompson** Date Prepared: **5/4/2012**

This borehole log was prepared for hydrogeological and/or environmental purposes and does not necessarily contain information suitable for a geotechnical assessment of the subsurface conditions. Borehole data requires interpretation by R. J. Burnside & Associates Limited personnel before use by others.

LEGEND	MONITORING WELL DATA	SAMPLE TYPE	
▼ Water found @ time of drilling	Pipe: **51 mm dia. PVC**	AC ◪ Auger Cutting	SS ☒ Split Spoon
▽ Static Water Level -	Screen: **51 mm dia. PVC #10 slot**	CS ▯ Continuous	AR ▨ Air Rotary
		RC ▭ Rock Core	WC ▭ Wash Cuttings

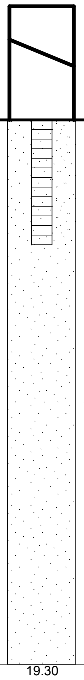
LOG OF DRILLING OPERATIONS

MW7d

BURNSIDE
R.J. Burnside & Associates Limited
292 Speedvale Avenue West, Guelph, Ontario N1H 1C4
telephone (519) 823-4995 fax (519) 836-5477

Client: **City of Brampton**	Project Name: **Hydrogeological Study**	Logged by: **K. Churcher**
Project No.: **300030932.0000**	Location: **Brampton, Ontario**	Ground (m amsl): **241**
Drilling Co.: **Lantech Drilling Services Inc.**	Date Started: **4/18/2012**	Static Water Level (m amsl):
Drilling Method: **Hollow Stem Auger**	Date Completed: **4/19/2012**	Sand Pack (m amsl): **14.8m to 19.3m**

Depth Scale (ft)	Depth Scale (m)	Stratigraphic Description Surface Elevation (m): **241.00**	Depth (m)	SAMPLE Num.	Type	Int.	N.Val.
		SAND, fine to medium grained, gray, saturated, well graded, very dense	16.31				
55.0				SS14	SS	☒	100/7.62cm
	17.0						
		SILTY CLAY, trace sand, brown mottled with gray, moist, hard, weak to medium plasticity, fragments of shale	17.26	SS15	SS	☒	100/5.08cm
	18.0	SHALE, weathered, reddish brown, moist - greenish gray banding at 18.2 m	17.83				
60.0				SS16	SS	☒	100/5.08cm
	19.0						
			19.30	SS17	SS	☒	100/10.2cm



Prepared By: **K. Churcher** Checked By: **J. Thompson** Date Prepared: **5/4/2012**

This borehole log was prepared for hydrogeological and/or environmental purposes and does not necessarily contain information suitable for a geotechnical assessment of the subsurface conditions. Borehole data requires interpretation by R. J. Burnside & Associates Limited personnel before use by others.

LEGEND	MONITORING WELL DATA	SAMPLE TYPE			
▼ Water found @ time of drilling	Pipe: **51 mm dia. PVC**	AC ▨	Auger Cutting	SS ☒	Split Spoon
▽ Static Water Level -	Screen: **51 mm dia. PVC #10 slot**	CS	Continuous	AR ▨	Air Rotary
		RC	Rock Core	WC	Wash Cuttings

LOG OF DRILLING OPERATIONS

MW8

BURNSIDE
R.J. Burnside & Associates Limited
292 Speedvale Avenue West, Guelph, Ontario N1H 1C4
telephone (519) 823-4995 fax (519) 836-5477

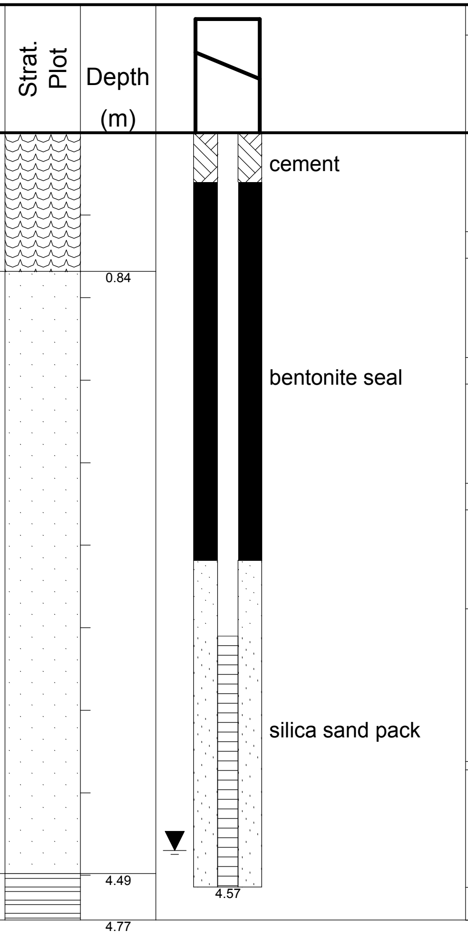
Page 1 of 1

Client: **City of Brampton**	Project Name: **Hydrogeological Study**	Logged by: **K. Churcher**
Project No.: **300030932.0000**	Location: **Brampton, Ontario**	Ground (m amsl): **221**
Drilling Co.: **Lantech Drilling Services Inc.**	Date Started: **4/20/2012**	Static Water Level (m amsl):
Drilling Method: **Hollow Stem Auger**	Date Completed: **4/20/2012**	Sand Pack (m amsl): **2.6m to 4.6m**

Surface Elevation (m): **221.00**

Depth Scale (ft)	Depth Scale (m)
	1.0
5.0	
	2.0
	3.0
10.0	
	4.0
15.0	

Stratigraphic Description	Depth (m)
TOPSOIL	
SAND, fine to medium grained, trace silt, trace gravel, brown, damp, loose - becoming coarser with more gravel at 1.7 m - fragments of red shale at 2.5 m - becoming saturated, some silt at 3.8 m	0.84
SHALE, weathered, red with greenish gray banding, saturated	4.49
	4.77



SAMPLE Num.	Type	Int.	N.Val.
SS1	SS	☒	9
SS2	SS	☒	8
SS3	SS	☒	29
SS4	SS	☒	59
SS5	SS	☒	50/5.08cm
SS6	SS	☒	50/5.08cm

Prepared By: **K. Churcher** Checked By: **J. Thompson** Date Prepared: **5/4/2012**

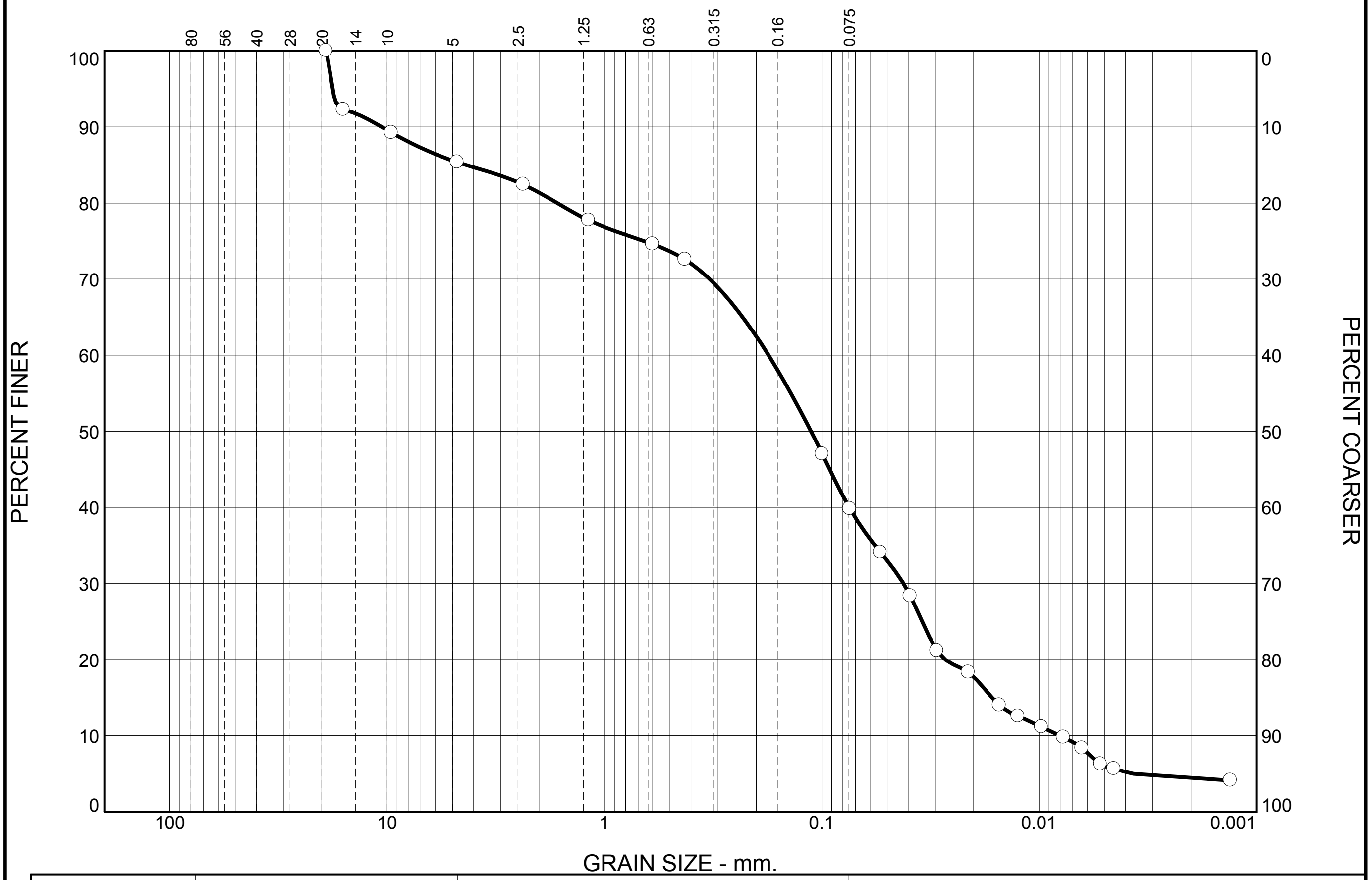
This borehole log was prepared for hydrogeological and/or environmental purposes and does not necessarily contain information suitable for a geotechnical assessment of the subsurface conditions. Borehole data requires interpretation by R. J. Burnside & Associates Limited personnel before use by others.

LEGEND	MONITORING WELL DATA	SAMPLE TYPE				
▼ Water found @ time of drilling	Pipe: **51 mm dia. PVC**	AC	◧	Auger Cutting	SS ☒	Split Spoon
▽ Static Water Level -	Screen: **51 mm dia. PVC #10 slot**	CS	☐	Continuous	AR ▨	Air Rotary
		RC	☐	Rock Core	WC ☐	Wash Cuttings

BHLOG GUELPH P:\GINT\PROJECTS\300 JOBS\300030932 HERITAGE HEIGHTS 2012.GPJ TEMPLATE.GDT 8/16/12

B-3 Grain-size Analysis

Grain Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0	0	15	4	8	33	36	4

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			4.3418	0.1758	0.1121	0.0421	0.0165	0.0080	1.26	21.91

Material Description	USCS	AASHTO
○ SILT and SAND, some gravel, trace clay		

Project No. 12-055 **Client:** R.J. Burnside & Associates Limited

Project: Burnside File 300030932.0000

Heritage Heights Site

○ **Sample Number:** MW7d Sa5

K = 6.4 x 10^-5 cm/sec

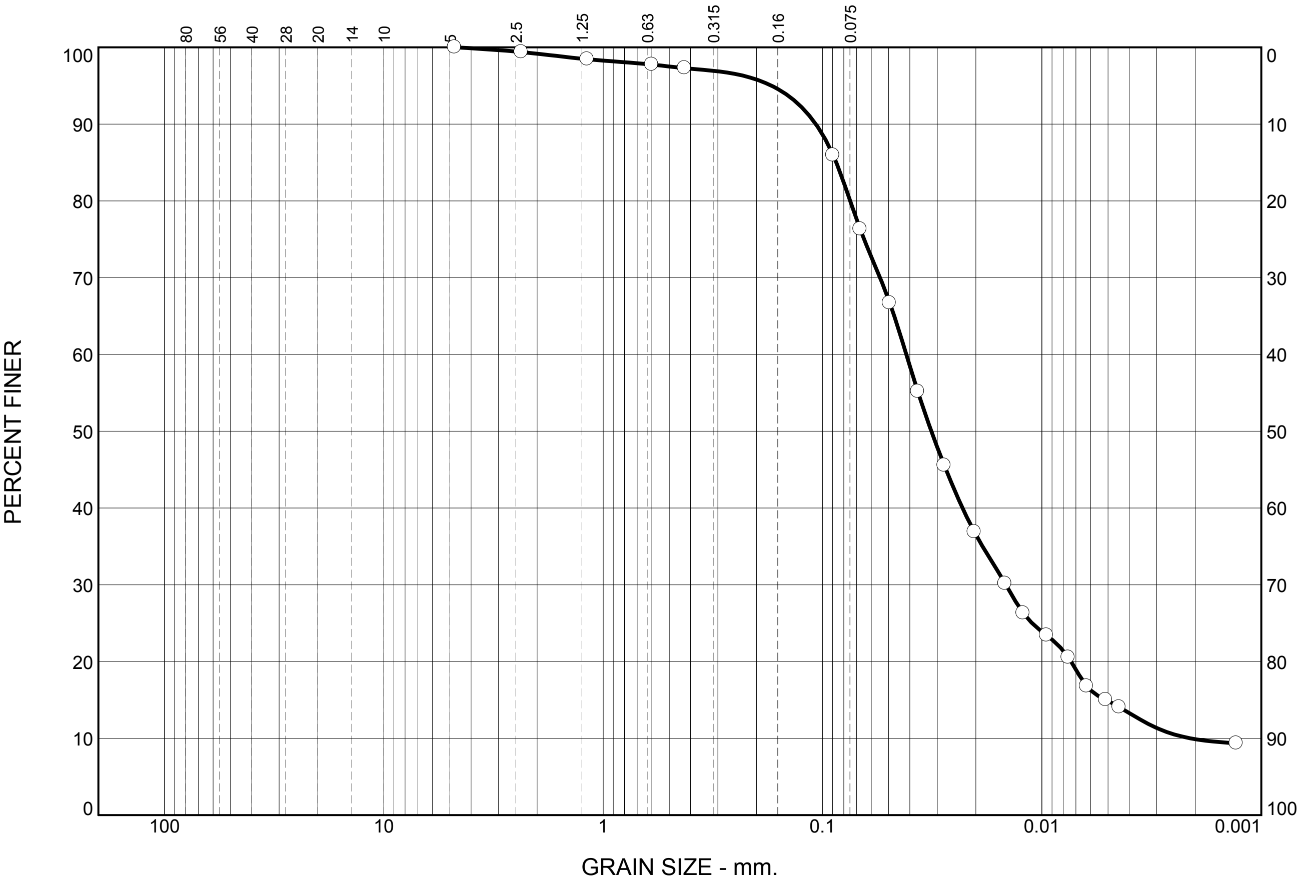
Remarks:

alston associates inc.
consulting engineers

Figure 1

Tested By: RP **Checked By:** JB

Grain Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0	0	0	1	2	17	70	10

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.0866	0.0415	0.0319	0.0146	0.0051	0.0021	2.44	19.72

Material Description	USCS	AASHTO
○ SANDY SILT, trace to some clay		

Project No. 12-055 **Client:** R.J. Burnside & Associates Limited

Project: Burnside File 300030932.0000

Heritage Heights Site

○ **Sample Number:** MW7d Sa10

K = 5.8 x 10^-6 cm/sec

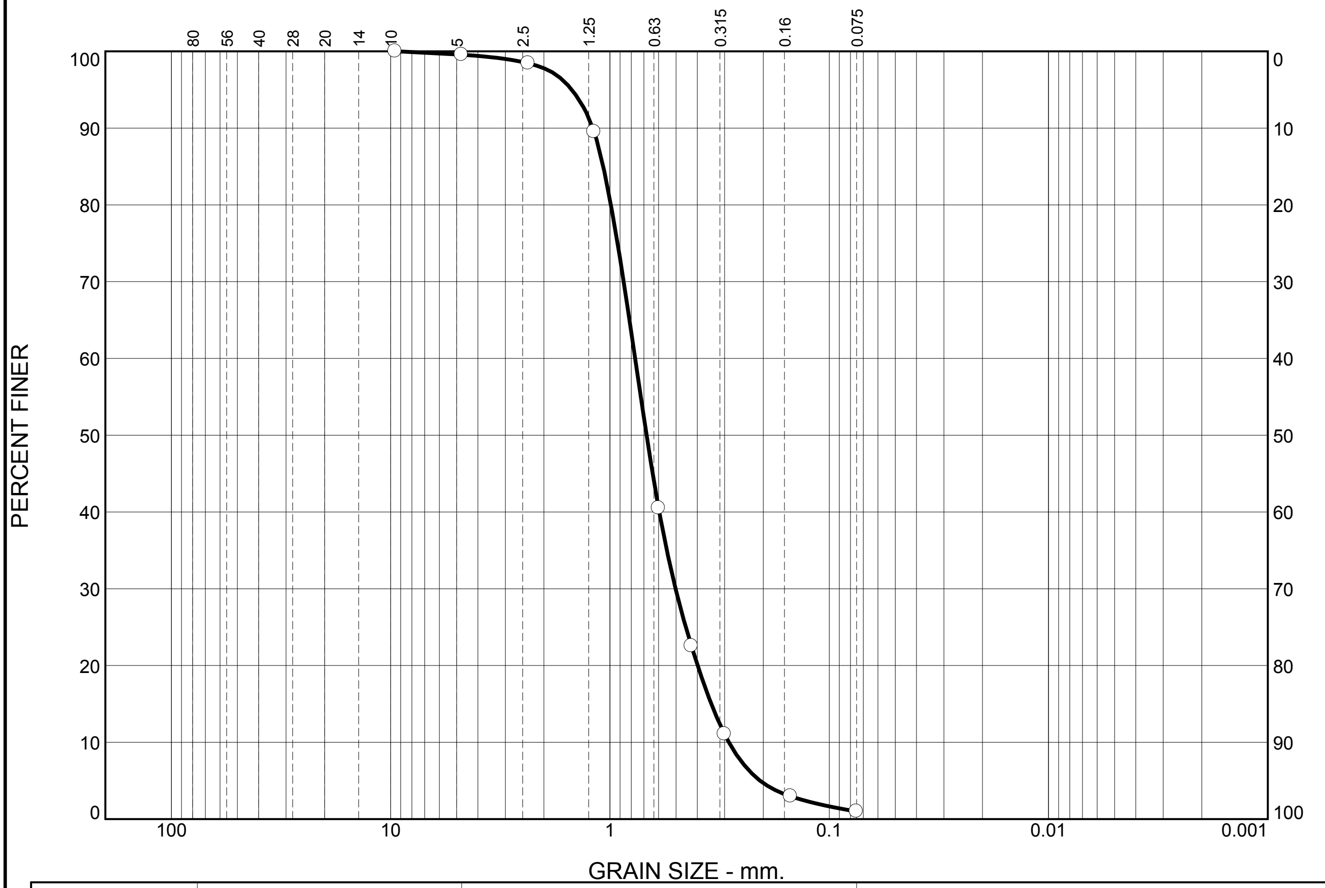
Remarks:

alston associates inc.
consulting engineers

Figure 2

Tested By: RP **Checked By:** JB

Grain Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0	0	0	2	75	22	1	

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			1.0726	0.7680	0.6807	0.5019	0.3450	0.2866	1.14	2.68

Material Description	USCS	AASHTO
○ SAND, trace silt	SP	

Project No. 12-055 **Client:** R.J. Burnside & Associates Limited

Project: Burnside File 300030932.0000

Heritage Heights Site

○ **Sample Number:** MW7d Sa14

K = 9.0 x 10^-2 cm/sec

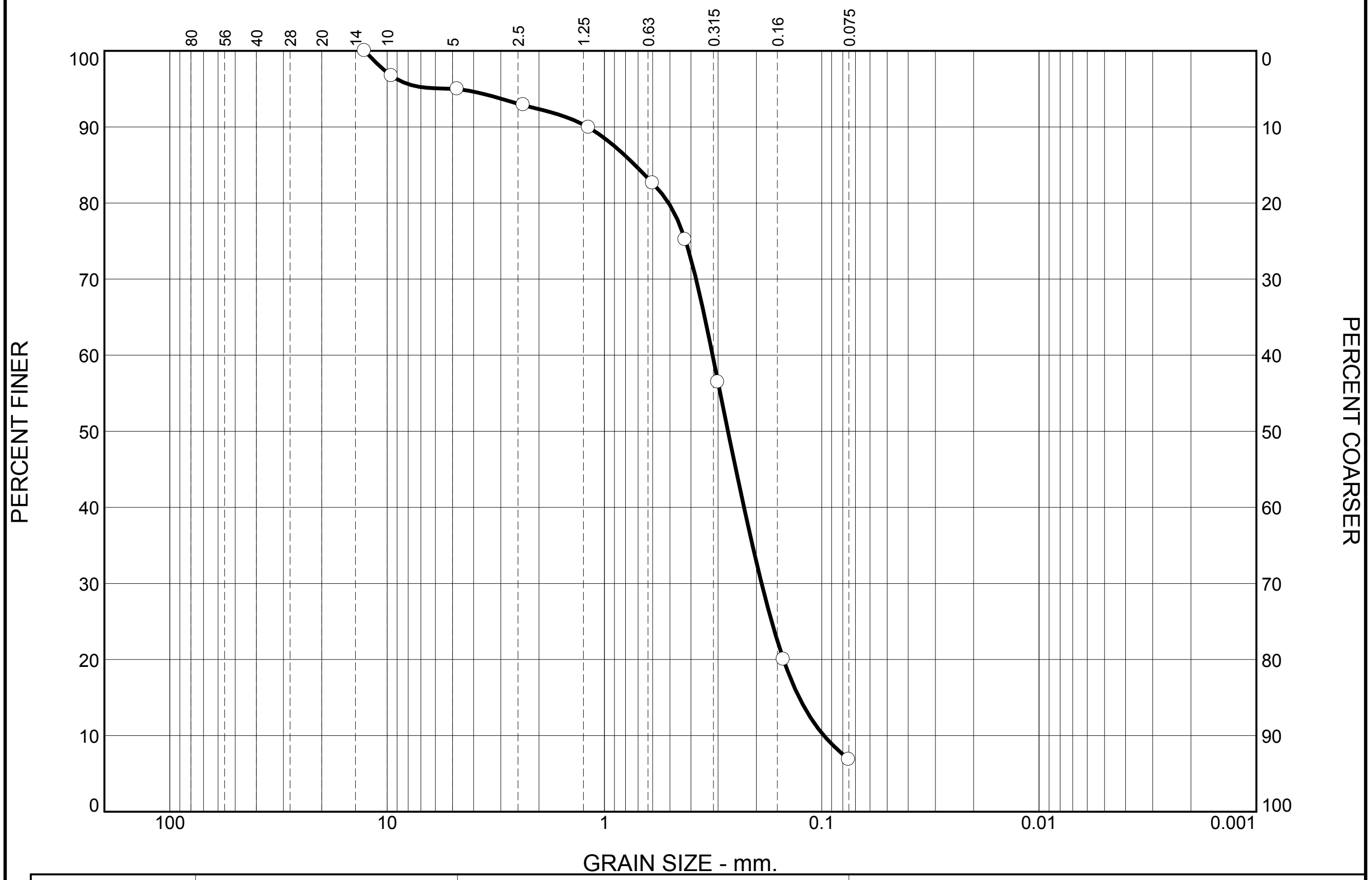
Remarks:

alston associates inc.
consulting engineers

Figure 3

Tested By: GL **Checked By:** JB

Grain Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0	0	5	3	17	68	7	

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.7244	0.3179	0.2700	0.1892	0.1270	0.0978	1.15	3.25

Material Description	USCS	AASHTO
○ SAND, trace silt, trace gravel		

Project No. 12-055 **Client:** R.J. Burnside & Associates Limited

Project: Burnside File 300030932.0000

Heritage Heights Site

○ **Sample Number:** MW8 Sa2

K = 1.0 x 10^-2 cm/sec

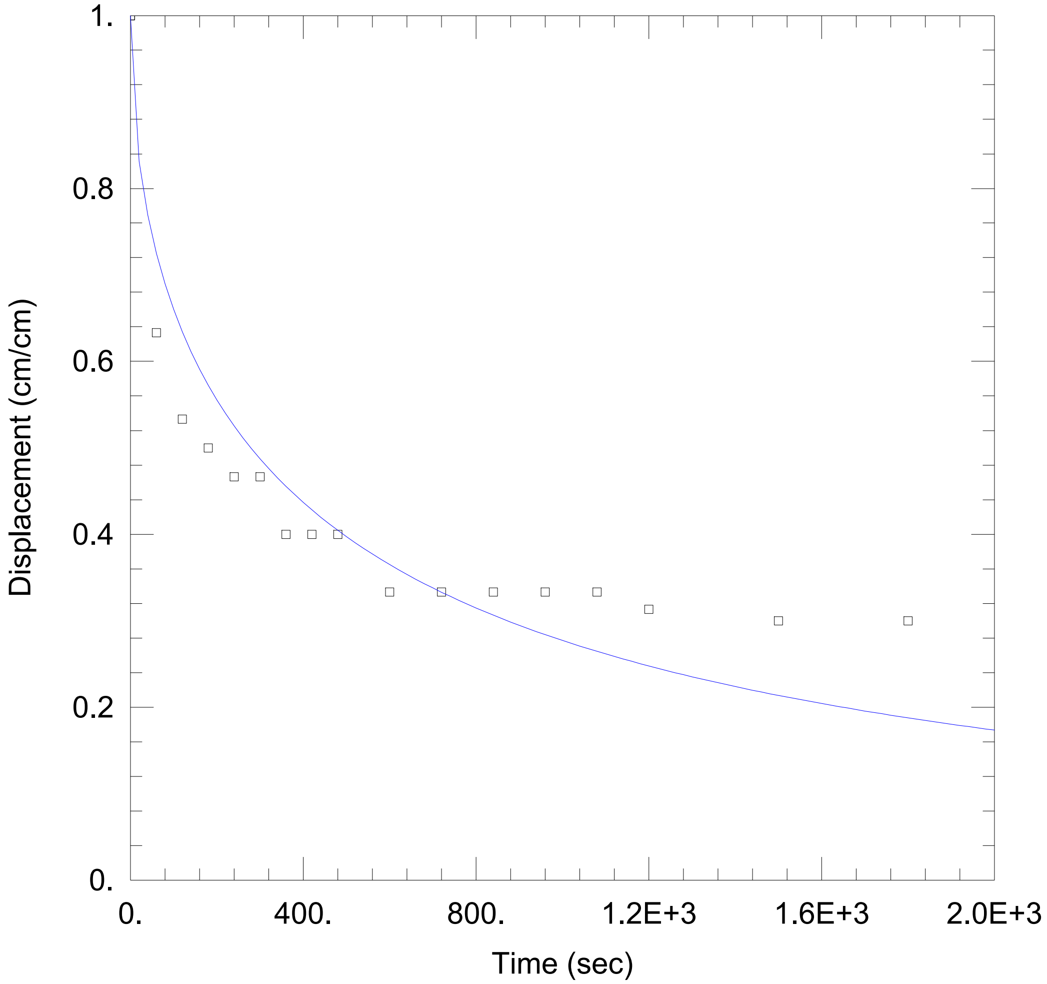
Remarks:

alston associates inc.
consulting engineers

Figure 4

Tested By: GL **Checked By:** JB

B-4 Hydraulic Conductivity and Infiltration Tests



HYDRAULIC CONDUCTIVITY TEST AT MW1

PROJECT INFORMATION

Company: RJ Burnside
Client: Heritage Heights
Project: 300030932
Location: Brampton
Test Well: MW1
Test Date: July 20, 2012

AQUIFER DATA

Saturated Thickness: 246. cm

WELL DATA (MW1)

Initial Displacement: 15. cm
Total Well Penetration Depth: 246. cm
Casing Radius: 2.54 cm
Well Skin Radius: 7.62 cm

Static Water Column Height: 246. cm
Screen Length: 152. cm
Well Radius: 7.62 cm

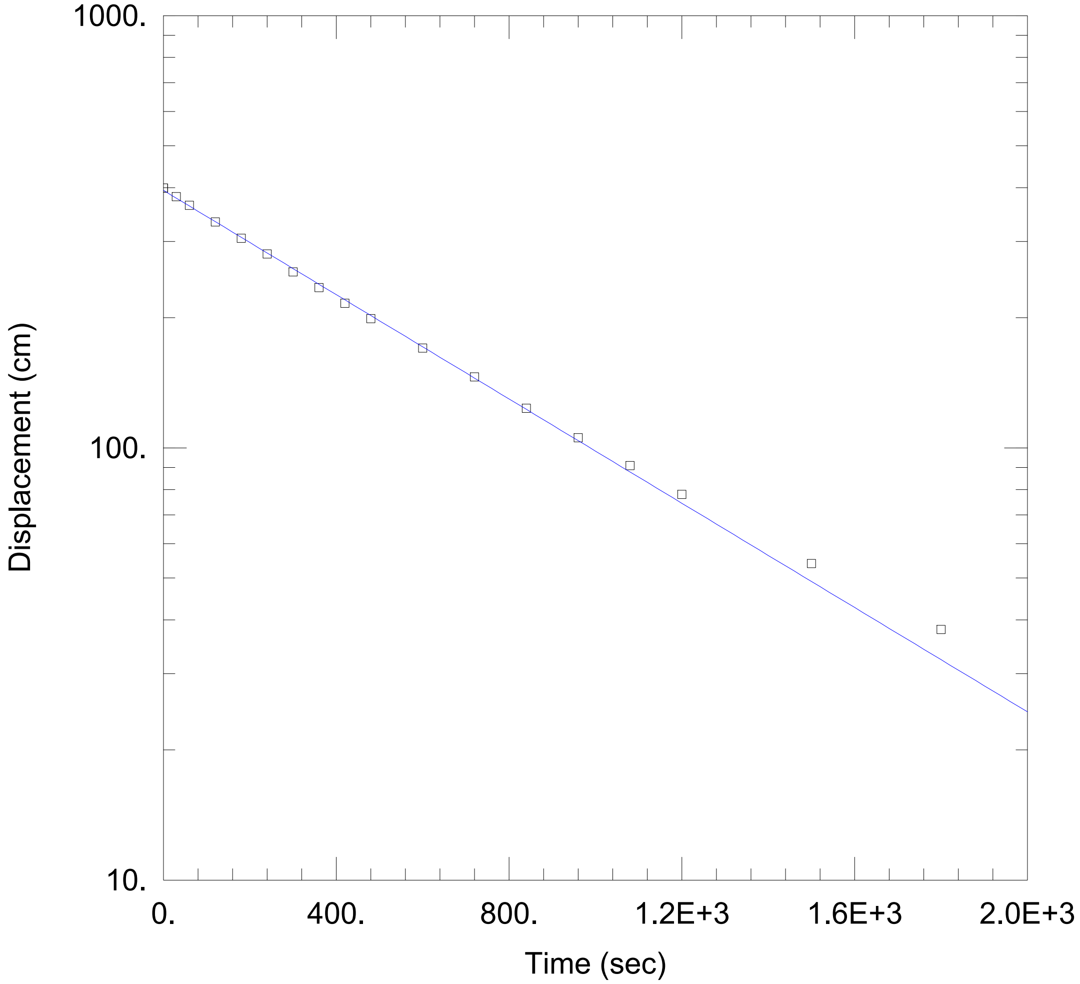
SOLUTION

Aquifer Model: Unconfined

Kr = 2.492E-5 cm/sec
Kz/Kr = 1.
Ss' = 1.0E-10 cm^{-1}

Solution Method: KGS Model w/skin

Ss = 0.0004065 cm^{-1}
Kr' = 3.769E-7 cm/sec
Kz/Kr' = 0.001



HYDRAULIC CONDUCTIVITY TEST AT MW2

PROJECT INFORMATION

Company: R.J. Burnside
Client: Heritage Heights
Project: 300030932
Location: Brampton
Test Well: MW2
Test Date: July 18, 2012

AQUIFER DATA

Saturated Thickness: 617. cm
Anisotropy Ratio (Kz/Kr): 1.

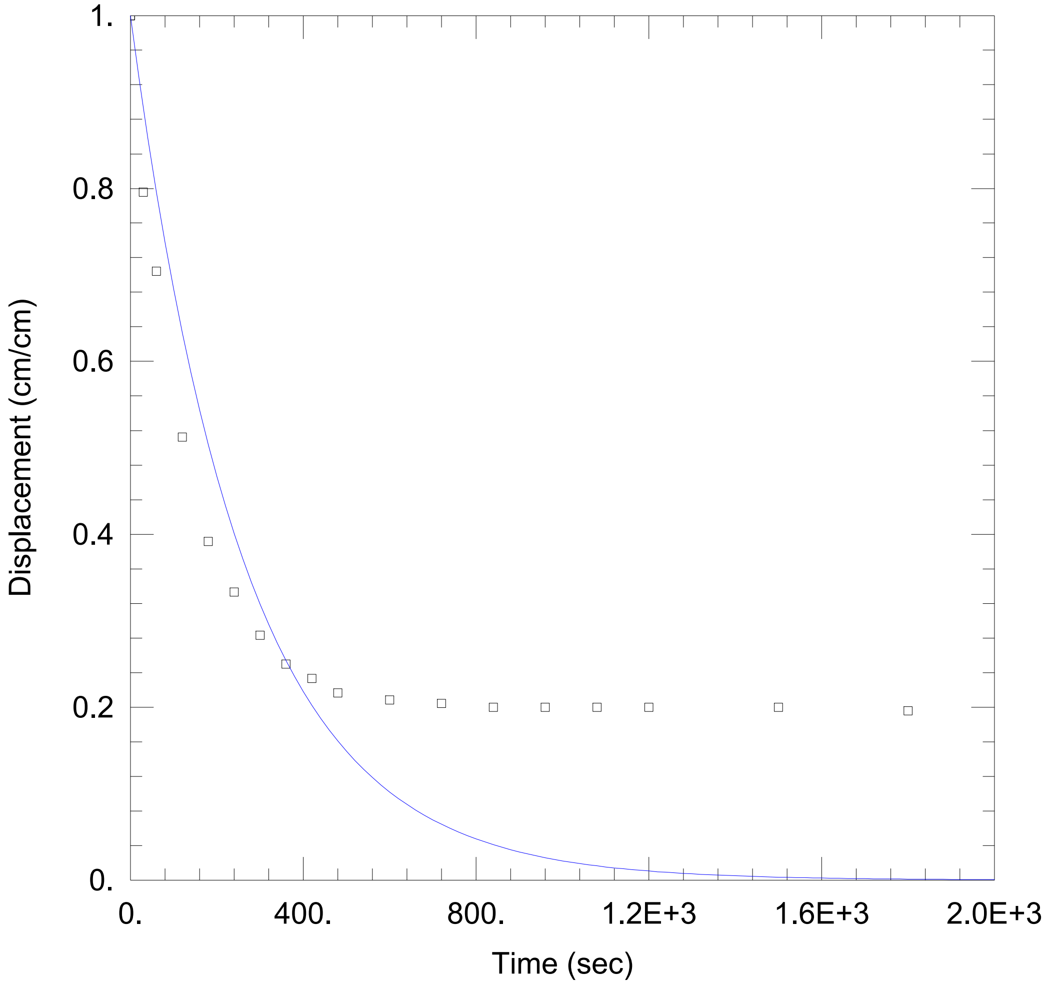
WELL DATA (MW2)

Initial Displacement: 399. cm
Total Well Penetration Depth: 617. cm
Casing Radius: 2.54 cm
Static Water Column Height: 617. cm
Screen Length: 152. cm
Well Radius: 7.62 cm

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 0.0001087 cm/sec
y0 = 394.1 cm



HYDRAULIC CONDUCTIVITY TEST AT MW4

PROJECT INFORMATION

Company: R.J. Burnside
Client: Heritage Heights
Project: 300030932
Location: Brampton
Test Well: MW4
Test Date: July 18, 2012

AQUIFER DATA

Saturated Thickness: 270. cm
Anisotropy Ratio (Kz/Kr): 1.

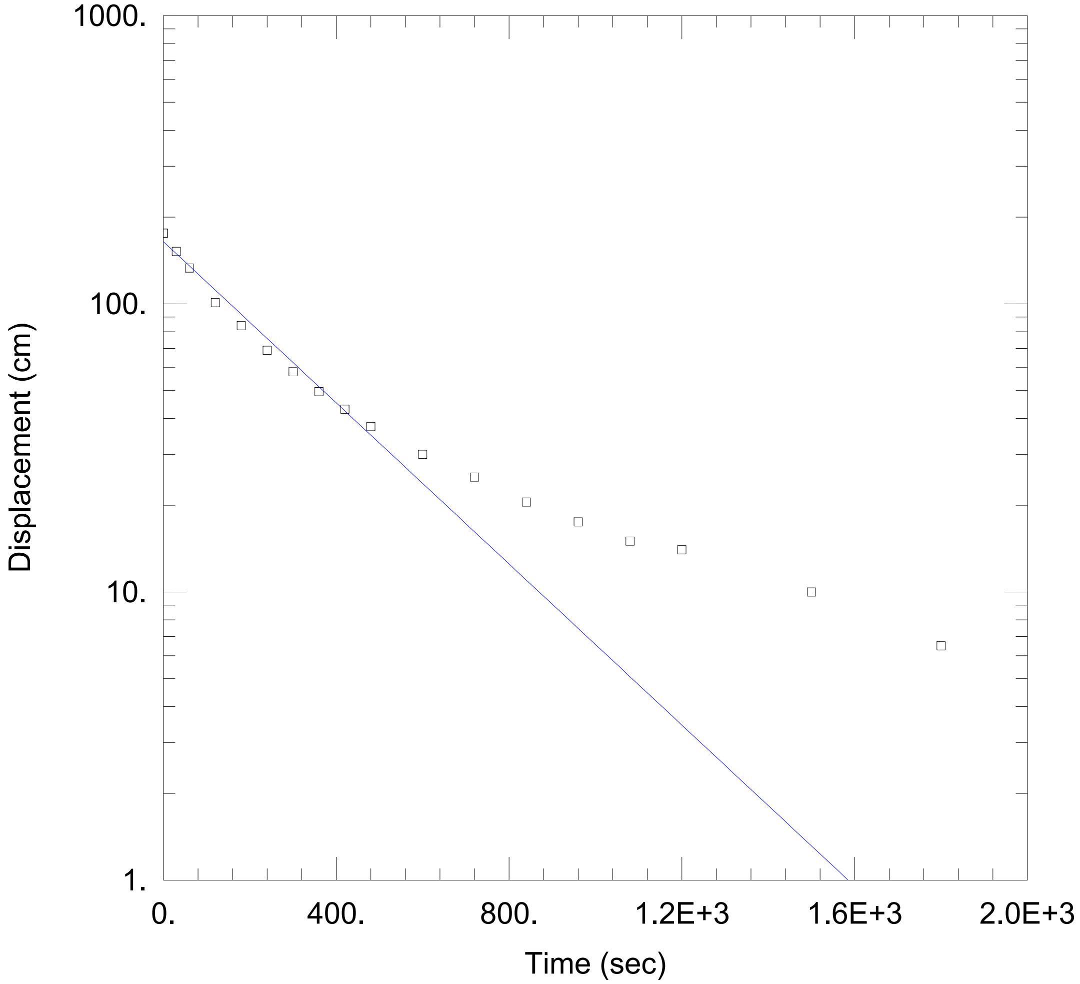
WELL DATA (MW4)

Initial Displacement: 120. cm
Total Well Penetration Depth: 270. cm
Casing Radius: 2.54 cm
Static Water Column Height: 270. cm
Screen Length: 152. cm
Well Radius: 7.62 cm

SOLUTION

Aquifer Model: Unconfined
Solution Method: Springer-Gelhar

K = 0.0002064 cm/sec
Le = 0.1 cm



HYDRAULIC CONDUCTIVITY TEST AT MW7S

PROJECT INFORMATION

Company: R.J. Burnside
Client: Heritage Heights
Project: 300030932
Location: Brampton
Test Well: MW7s
Test Date: July 20, 2012

AQUIFER DATA

Saturated Thickness: 598. cm
Anisotropy Ratio (Kz/Kr): 1.

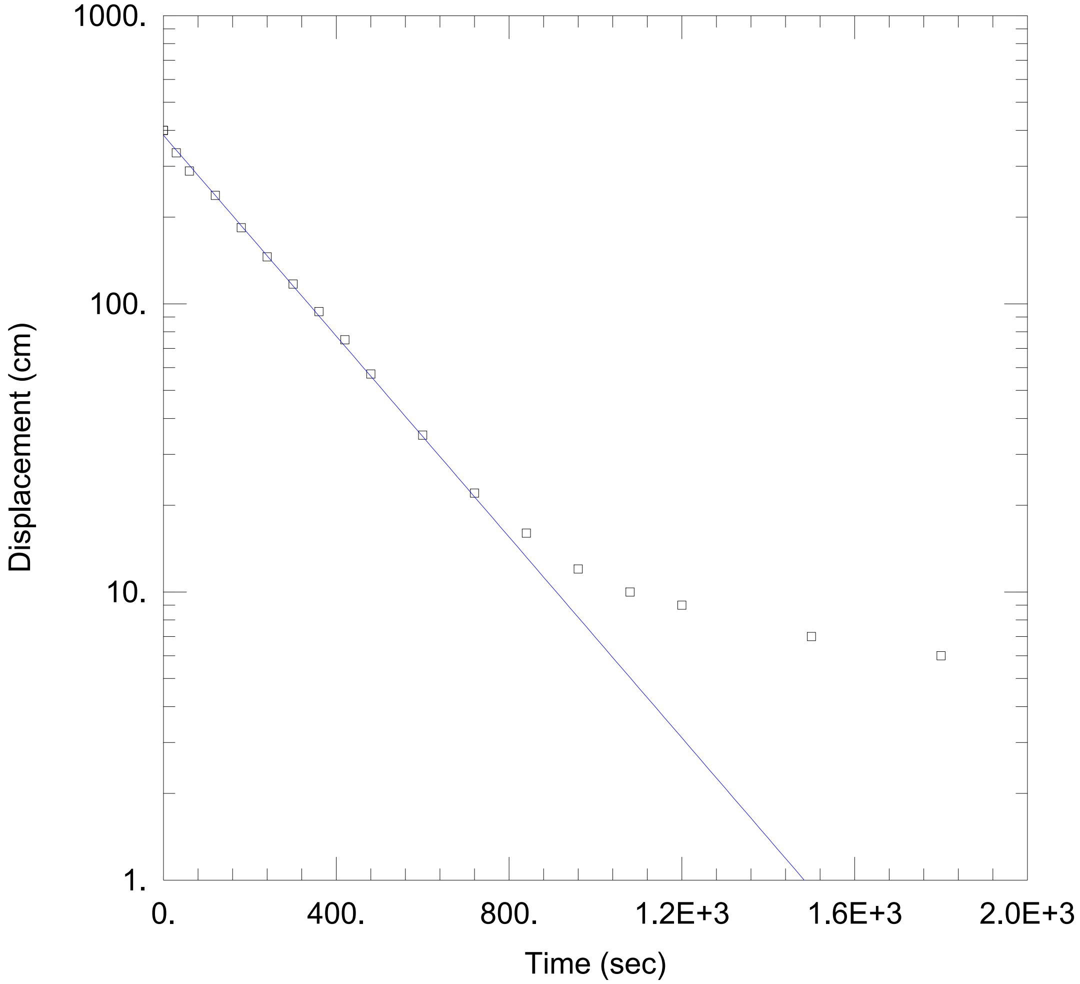
WELL DATA (MW7s)

Initial Displacement: 176. cm
Total Well Penetration Depth: 598. cm
Casing Radius: 2.54 cm
Static Water Column Height: 598. cm
Screen Length: 152. cm
Well Radius: 7.62 cm

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 0.0002518 cm/sec
y0 = 164. cm



HYDRAULIC CONDUCTIVITY TEST AT MW7D

PROJECT INFORMATION

Company: R.J. Burnside
Client: Heritage Heights
Project: 300030932
Location: Brampton
Test Well: MW7d
Test Date: July 20, 2012

AQUIFER DATA

Saturated Thickness: 1530. cm
Anisotropy Ratio (Kz/Kr): 1.

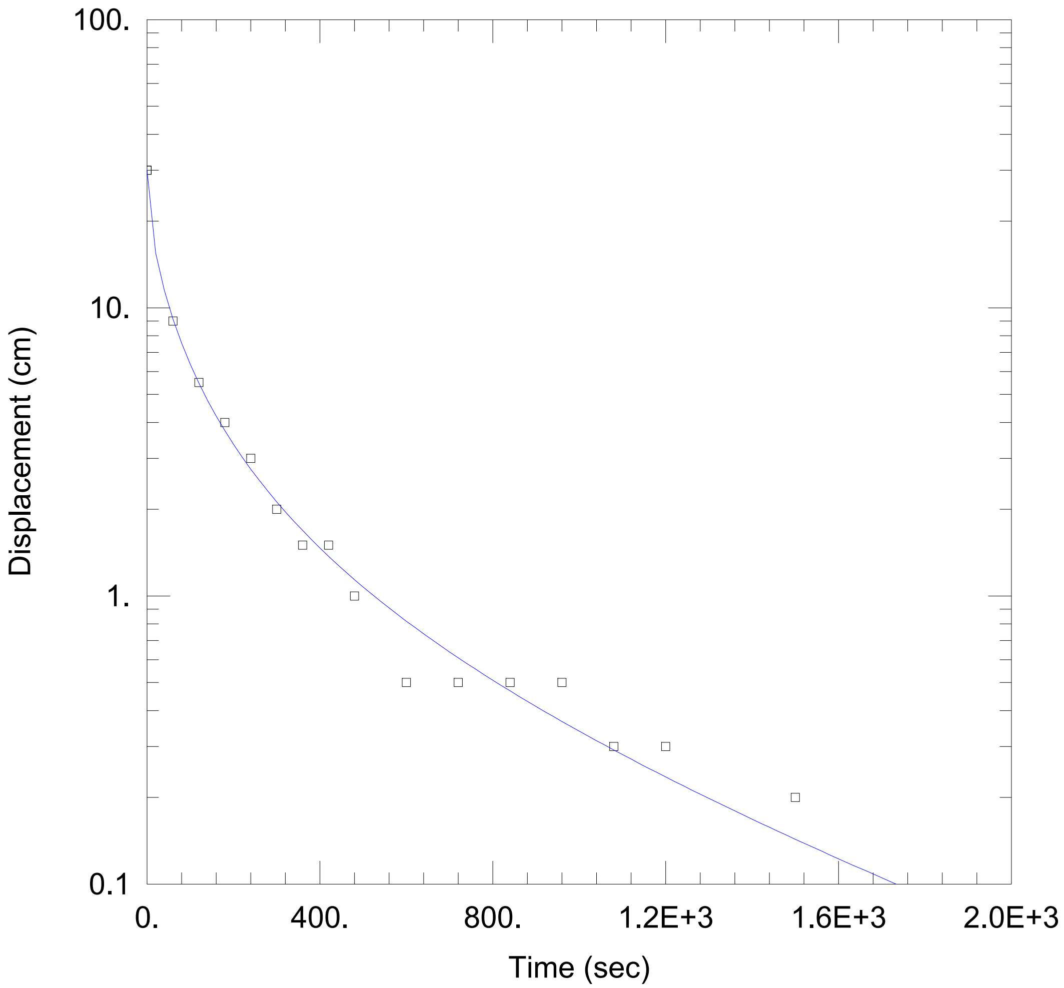
WELL DATA (MW7d)

Initial Displacement: 400. cm
Static Water Column Height: 1530. cm
Total Well Penetration Depth: 1530. cm
Screen Length: 152. cm
Casing Radius: 2.54 cm
Well Radius: 7.62 cm

SOLUTION

Aquifer Model: Unconfined
Solution Method: Hvorslev

K = 0.000314 cm/sec
y0 = 384.4 cm



HYDRAULIC CONDUCTIVITY TEST AT MW8

PROJECT INFORMATION

Company: R.J. Burnside
Client: Heritage Heights
Project: 300030932
Location: Brampton
Test Well: MW8
Test Date: July 19, 2012

AQUIFER DATA

Saturated Thickness: 62. cm

WELL DATA (MW8)

Initial Displacement: 30. cm
Total Well Penetration Depth: 152. cm
Casing Radius: 2.54 cm

Static Water Column Height: 62. cm
Screen Length: 152. cm
Well Radius: 7.62 cm

SOLUTION

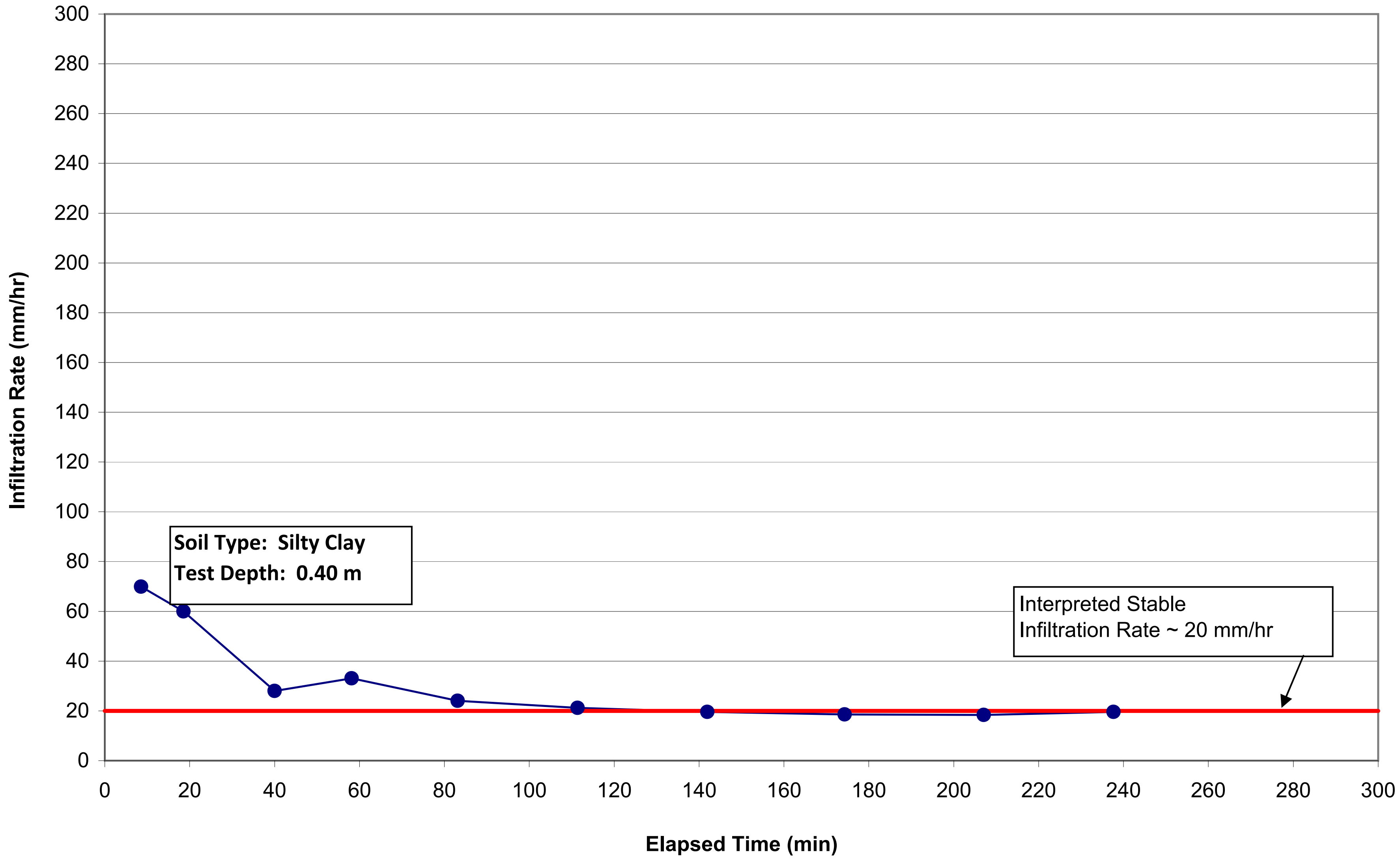
Aquifer Model: Unconfined

Solution Method: KGS Model

Kr = 0.0009468 cm/sec
Kz/Kr = 1.

Ss = 0.0006585 cm^{-1}

Infiltration Rate at IF1
Heritage Heights

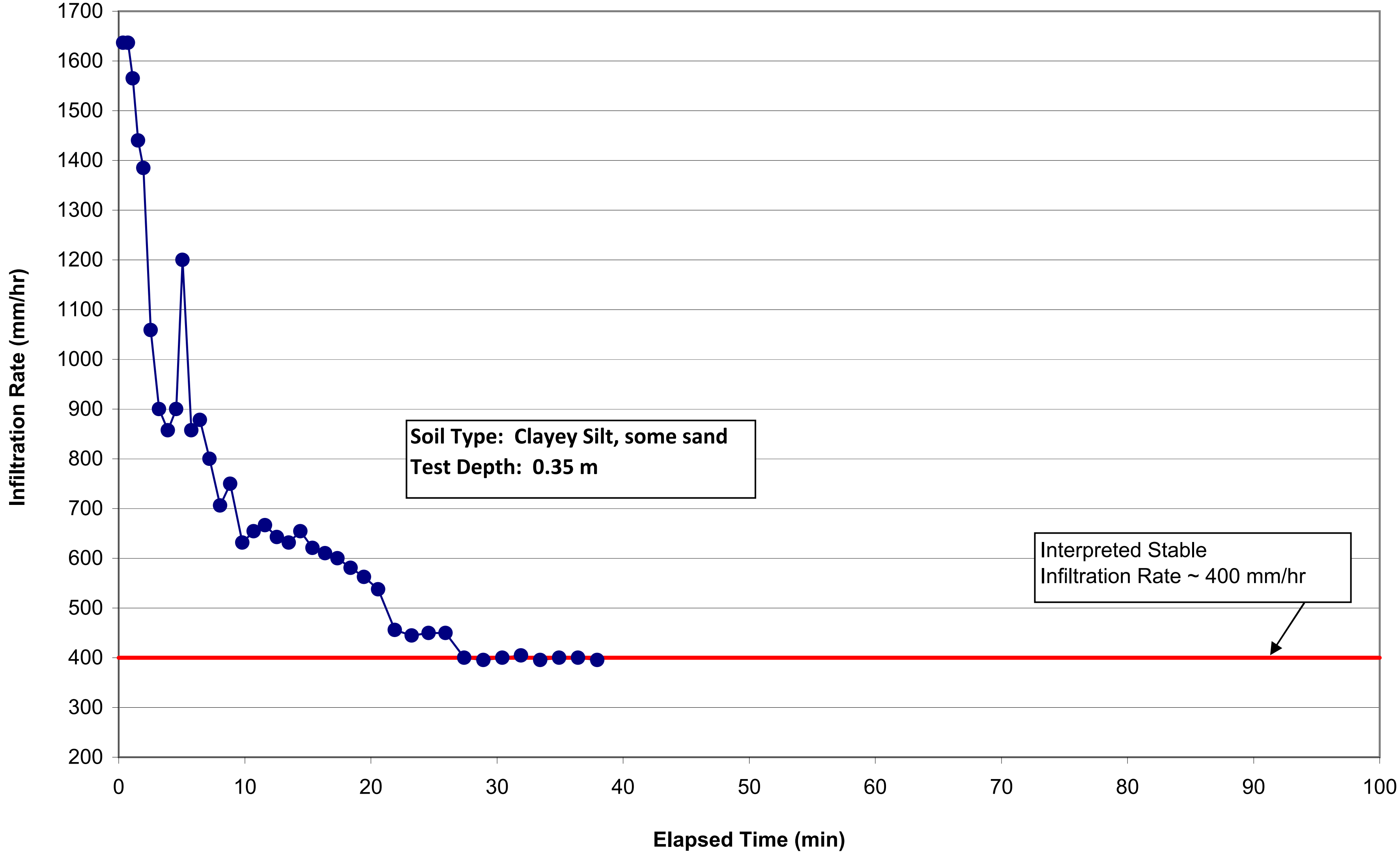


Soil Type: Silty Clay
Test Depth: 0.40 m

Interpreted Stable
Infiltration Rate ~ 20 mm/hr

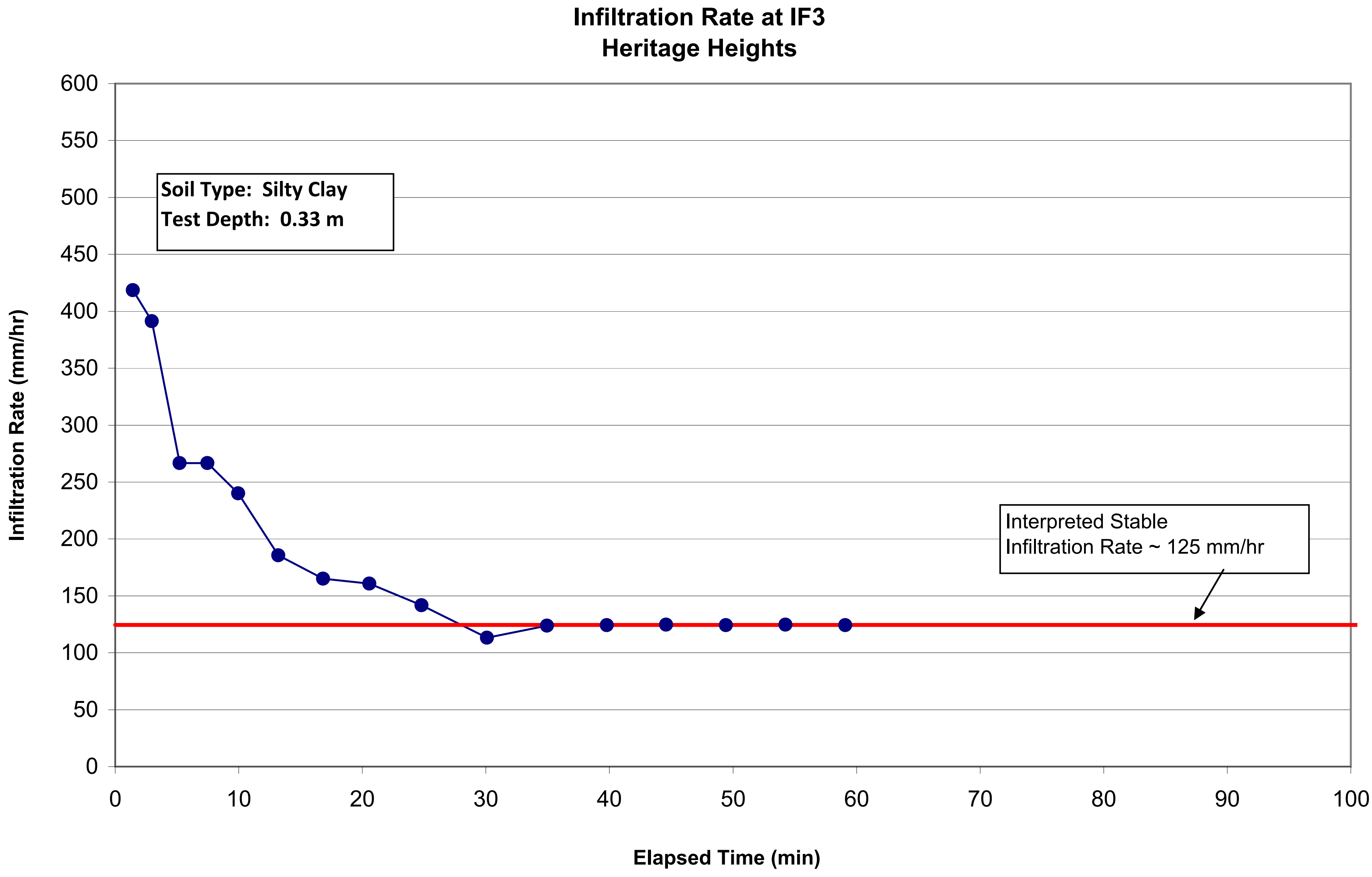
Figure C-1

Infiltration Rate at IF2
Heritage Heights



R.J. Burnside & Associates Limited
300030932

Figure C-2



R.J. Burnside & Associates Limited
300030932

Figure C-3

Infiltration Rate at IF4
Heritage Heights

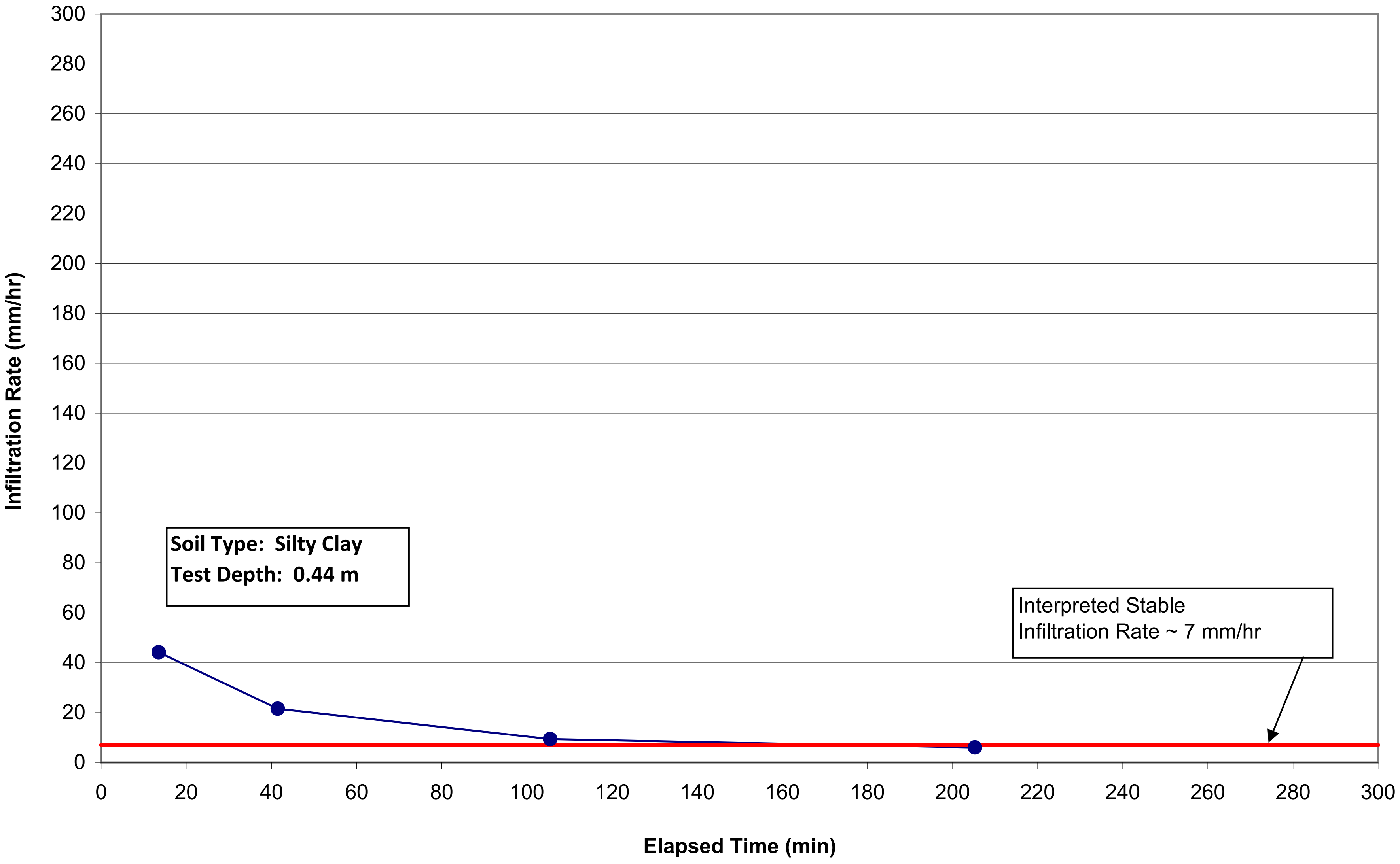
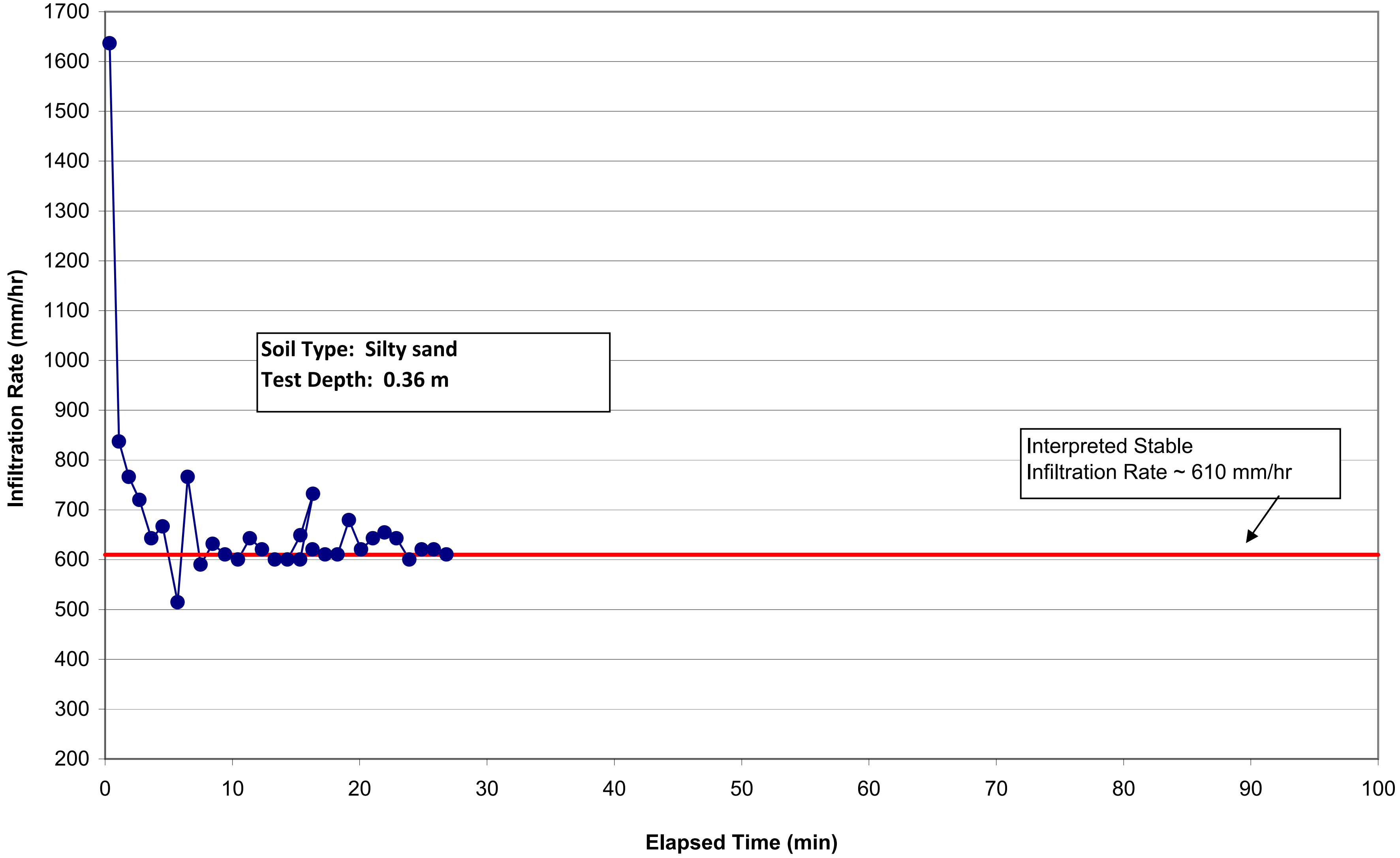


Figure C-4

Infiltration Rate at IF5
Heritage Heights

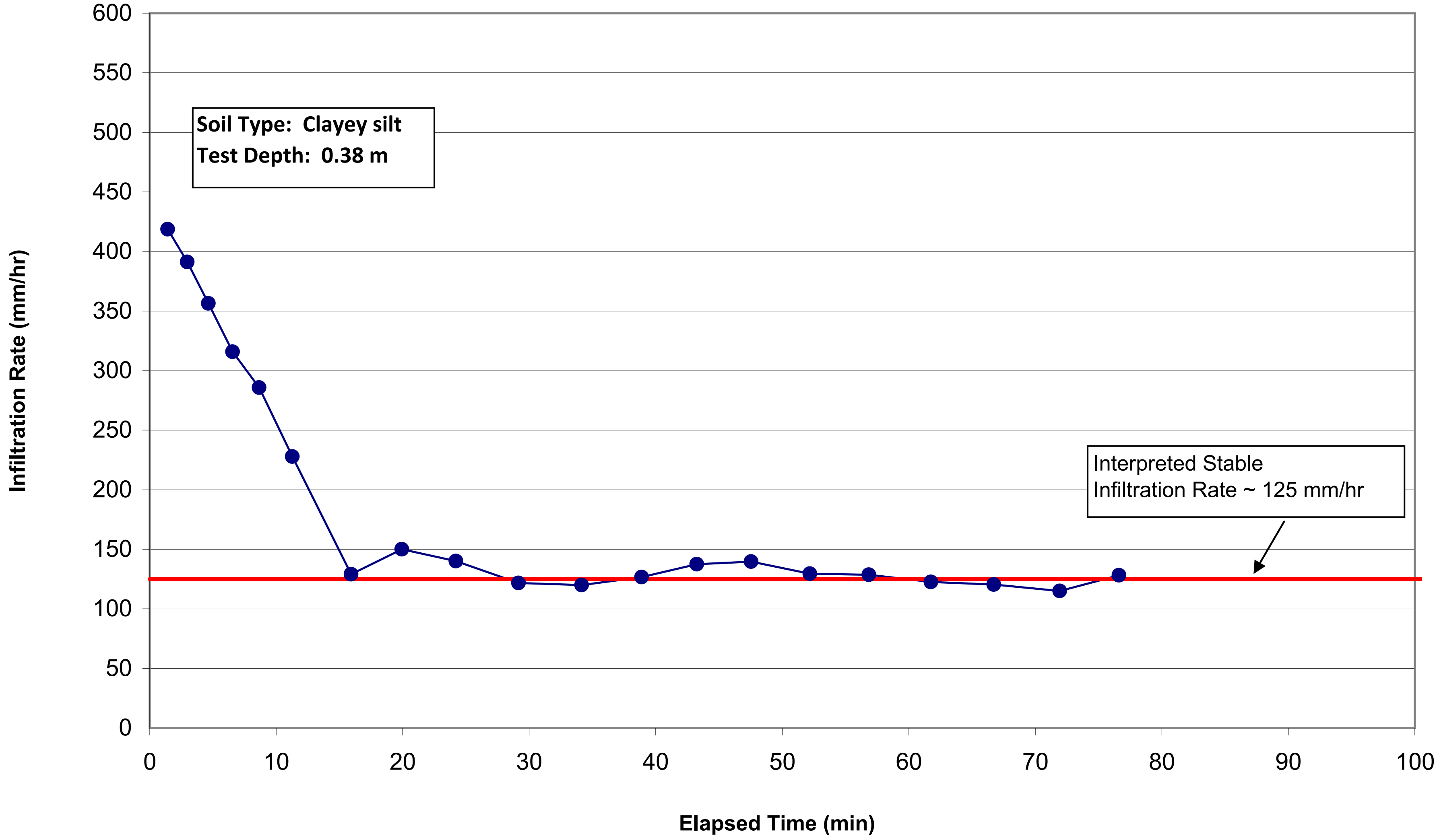


Soil Type: Silty sand
Test Depth: 0.36 m

Interpreted Stable
Infiltration Rate ~ 610 mm/hr

Figure C-5

Infiltration Rate at IF6
Heritage Heights



R.J. Burnside & Associates Limited
300030932

Figure C-6

B-5 Groundwater Elevations and Hydrographs

Table D-1
Groundwater Level Monitoring
Heritage Heights

Well	Well Depth (mbgl)	Casing Stick up (m)	Ground Elevation (masl)	Measuring Point Elevation (masl)	June 30, 2010		July 27, 2010		August 31, 2010		September 20, 2010		October 25, 2010		November 18, 2010		December 20, 2010	
					Water Level Depth (mbmp)	Elevation (masl)	Water Level Depth (mbmp)	Elevation (masl)	Water Level Depth (mbmp)	Elevation (masl)	Water Level Depth (mbmp)	Elevation (masl)	Water Level Depth (mbmp)	Elevation (masl)	Water Level Depth (mbmp)	Elevation (masl)	Water Level Depth (mbmp)	Elevation (masl)
MW1	**6.60**	**1.02**	**265.85**	**266.88**	2.88	264.00	3.42	263.46	3.74	263.14	3.95	262.93	3.42	263.46	3.24	263.64	3.01	263.87
MW2	**7.62**	**1.04**	**250.09**	**251.13**	0.68	250.45	0.82	250.31	1.69	249.44	1.84	249.29	0.75	250.38	0.91	250.22	1.04	250.09
MW3	**6.10**	**0.92**	**245.49**	**246.41**	2.99	243.42	3.11	243.30	3.34	243.07	3.34	243.07	3.15	243.26	3.37	243.04	3.13	243.28
MW4	**12.19**	**1.14**	**250.49**	**251.63**	8.61	243.02	8.78	242.85	9.17	242.46	9.25	242.38	9.05	242.58	8.98	242.65	8.88	242.75
MW5	**6.10**	**0.90**	**235.18**	**236.08**	1.36	234.72	1.55	234.53	2.61	233.47	2.44	233.64	1.33	234.76	1.15	234.93	1.33	234.75
MW6	**6.10**	**0.91**	**232.30**	**233.21**	2.98	230.24	3.48	229.73	3.91	229.30	3.96	229.25	4.00	229.21	3.90	229.31	3.54	229.67
MW7s	**7.50**	**0.75**	**240.03**	**240.78**	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MW7d	**16.80**	**0.94**	**239.92**	**240.86**	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MW8	**4.43**	**0.93**	**216.22**	**217.15**	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PZ1s	**1.38**	**0.60**	**252.12**	**252.72**	0.56	252.16	0.54	252.19	1.52	251.20	dry	dry	1.00	251.73	0.65	252.07	frozen	frozen
PZ1i	**1.37**	**0.59**	**252.07**	**252.66**	0.94	251.72	-	-	-	-	1.68	250.98	1.60	251.06	1.15	251.51	0.75	251.91
PZ1d	**1.63**	**1.28**	**252.04**	**253.32**	1.30	252.02	1.40	251.92	-	-	2.61	250.71	1.84	251.48	1.35	251.97	frozen	frozen
PZ2	**2.01**	**0.95**	**249.74**	**250.69**	0.87	249.82	1.07	249.63	1.63	249.06	1.82	248.87	0.90	249.79	0.90	249.79	frozen	frozen
PZ2A	**1.33**	**0.59**	***249.80***	***250.39***	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PZ3	**0.85**	**1.05**	**243.63**	**244.67**	0.95	243.72	1.20	243.48	1.50	243.18	1.63	243.05	1.15	243.52	1.27	243.40	1.11	243.56
PZ4	**1.29**	**0.59**	**241.77**	**242.36**	1.05	241.31	0.75	241.61	0.71	241.65	0.74	241.62	0.69	241.67	0.63	241.73	frozen	frozen
PZ5	**1.34**	**0.63**	**241.05**	**241.69**	0.49	241.20	0.56	241.13	0.66	241.03	0.65	241.04	0.55	241.14	0.49	241.20	frozen	frozen
PZ6	**0.91**	**0.92**	**232.05**	**232.97**	dry	dry	dry	dry	1.69	231.28	dry	dry	1.81	231.16	1.71	231.26	frozen	frozen
PZ7	**0.70**	**1.12**	**226.74**	**227.86**	1.32	226.54	1.35	226.51	1.53	226.33	1.34	226.52	1.26	226.60	1.29	226.57	frozen	frozen
PZ8s	**1.25**	**0.62**	**244.89**	**245.51**	0.77	244.74	0.77	244.73	1.14	244.37	1.48	244.03	0.68	244.83	0.66	244.85	0.71	244.80
PZ8d	**1.90**	**1.03**	**244.75**	**245.78**	0.83	244.95	1.00	244.78	1.27	244.51	1.24	244.54	1.22	244.56	1.00	244.78	frozen	frozen
PZ9	**1.20**	**0.78**	**247.22**	**248.00**	0.90	247.10	0.90	247.10	1.67	246.33	1.80	246.21	0.77	247.23	0.73	247.27	0.82	247.18
PZ10	**1.25**	**0.70**	**240.26**	**240.96**	0.81	240.15	1.00	239.96	1.69	239.27	1.82	239.14	1.42	239.54	1.38	239.58	frozen	frozen
PZ11s	**1.41**	**0.62**	**252.24**	**252.86**	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PZ11d	**1.84**	**1.11**	**252.24**	**253.35**	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PZ12s	**1.04**	**0.56**	**252.19**	**252.75**	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PZ12d	**1.84**	**0.99**	**252.19**	**253.18**	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PZ13	**1.35**	**0.55**	***251.50***	***252.05***	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PZ13a	**1.17**	**0.74**	***251.00***	***251.74***	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PZ14	**1.72**	**1.05**	**248.50**	**249.55**	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PZ15	**1.31**	**0.49**	**245.26**	**245.75**	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PZ16	**1.34**	**0.56**	**239.56**	**240.12**	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PZ17	**1.36**	**0.53**	**226.90**	**227.43**	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PZ18	**1.37**	**0.53**	**217.90**	**218.43**	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Note: mbmp - water levels measured below measuring point

'-' denotes data which is unavailable

italics - estimated from topographic mapping

*Water levels were taken immediately after installation

Table D-1
Groundwater Level Monitoring
Heritage Heights

Well	Well Depth (mbgl)	Casing Stick up (m)	Ground Elevation (masl)	Measuring Point Elevation (masl)	January 13, 2011		February 23, 2011		March 28, 2011		April 13, 2011		May 10, 2011		July 26, 2011	
					Water Level Depth (mbmp)	Elevation (masl)	Water Level Depth (mbmp)	Elevation (masl)	Water Level Depth (mbmp)	Elevation (masl)	Water Level Depth (mbmp)	Elevation (masl)	Water Level Depth (mbmp)	Elevation (masl)	Water Level Depth (mbmp)	Elevation (masl)
MW1	**6.60**	**1.02**	**265.85**	**266.88**	3.15	263.73	2.94	263.94	2.42	264.46	2.22	264.66	2.38	264.50	3.43	263.45
MW2	**7.62**	**1.04**	**250.09**	**251.13**	frozen	frozen	frozen	frozen	-	-	0.53	250.60	0.74	250.39	1.75	249.38
MW3	**6.10**	**0.92**	**245.49**	**246.41**	3.22	243.19	3.15	243.26	2.71	243.70	2.59	243.82	2.57	243.84	3.00	243.41
MW4	**12.19**	**1.14**	**250.49**	**251.63**	8.99	242.64	8.84	242.79	8.62	243.01	8.51	243.13	8.53	243.10	9.19	242.44
MW5	**6.10**	**0.90**	**235.18**	**236.08**	1.43	234.65	1.26	234.82	1.03	235.05	0.94	235.14	1.23	234.85	2.28	233.80
MW6	**6.10**	**0.91**	**232.30**	**233.21**	3.70	229.51	3.71	229.50	2.51	230.71	2.38	230.83	2.12	231.09	3.24	229.97
MW7s	**7.50**	**0.75**	**240.03**	**240.78**	-	-	-	-	-	-	-	-	-	-	-	-
MW7d	**16.80**	**0.94**	**239.92**	**240.86**	-	-	-	-	-	-	-	-	-	-	-	-
MW8	**4.43**	**0.93**	**216.22**	**217.15**	-	-	-	-	-	-	-	-	-	-	-	-
PZ1s	**1.38**	**0.60**	**252.12**	**252.72**	frozen	frozen	frozen	frozen	frozen	frozen	0.46	252.26	0.47	252.25	1.86	250.86
PZ1i	**1.37**	**0.59**	**252.07**	**252.66**	0.65	252.01	0.55	252.11	frozen	frozen	0.51	252.16	0.41	252.25	1.53	251.13
PZ1d	**1.63**	**1.28**	**252.04**	**253.32**	frozen	frozen	frozen	frozen	frozen	frozen	0.99	252.33	1.08	252.24	2.52	250.80
PZ2	**2.01**	**0.95**	**249.74**	**250.69**	frozen	frozen	frozen	frozen	0.77	249.93	0.74	249.95	0.90	249.80	0.79	249.90
PZ2A	**1.33**	**0.59**	***249.80***	***250.39***	-	-	-	-	-	-	-	-	-	-	-	-
PZ3	**0.85**	**1.05**	**243.63**	**244.67**	1.15	243.52	frozen	frozen	frozen	frozen	1.63	243.04	1.01	243.66	1.49	243.18
PZ4	**1.29**	**0.59**	**241.77**	**242.36**	frozen	frozen	frozen	frozen	frozen	frozen	0.38	241.98	0.30	242.06	0.56	241.80
PZ5	**1.34**	**0.63**	**241.05**	**241.69**	frozen	frozen	frozen	frozen	frozen	frozen	0.59	241.10	0.59	241.10	0.62	241.07
PZ6	**0.91**	**0.92**	**232.05**	**232.97**	dry	dry	1.71	231.26	1.09	231.88	1.07	231.90	0.99	231.98	1.71	231.26
PZ7	**0.70**	**1.12**	**226.74**	**227.86**	1.35	226.51	1.32	226.54	1.32	226.54	1.31	226.55	1.33	226.53	1.55	226.31
PZ8s	**1.25**	**0.62**	**244.89**	**245.51**	0.96	244.55	frozen	frozen	0.63	244.88	0.68	244.83	0.74	244.77	1.10	244.41
PZ8d	**1.90**	**1.03**	**244.75**	**245.78**	frozen	frozen	frozen	frozen	0.82	244.96	0.87	244.91	0.82	244.96	0.96	244.82
PZ9	**1.20**	**0.78**	**247.22**	**248.00**	frozen	frozen	frozen	frozen	0.60	247.40	0.53	247.47	0.71	247.29	1.70	246.30
PZ10	**1.25**	**0.70**	**240.26**	**240.96**	0.83	240.13	0.82	240.14	0.85	240.11	0.85	240.11	0.70	240.26	1.78	239.18
PZ11s	**1.41**	**0.62**	**252.24**	**252.86**	-	-	-	-	-	-	-	-	-	-	-	-
PZ11d	**1.84**	**1.11**	**252.24**	**253.35**	-	-	-	-	-	-	-	-	-	-	-	-
PZ12s	**1.04**	**0.56**	**252.19**	**252.75**	-	-	-	-	-	-	-	-	-	-	-	-
PZ12d	**1.84**	**0.99**	**252.19**	**253.18**	-	-	-	-	-	-	-	-	-	-	-	-
PZ13	**1.35**	**0.55**	***251.50***	***252.05***	-	-	-	-	-	-	-	-	-	-	-	-
PZ13a	**1.17**	**0.74**	***251.00***	***251.74***	-	-	-	-	-	-	-	-	-	-	-	-
PZ14	**1.72**	**1.05**	**248.50**	**249.55**	-	-	-	-	-	-	-	-	-	-	-	-
PZ15	**1.31**	**0.49**	**245.26**	**245.75**	-	-	-	-	-	-	-	-	-	-	-	-
PZ16	**1.34**	**0.56**	**239.56**	**240.12**	-	-	-	-	-	-	-	-	-	-	-	-
PZ17	**1.36**	**0.53**	**226.90**	**227.43**	-	-	-	-	-	-	-	-	-	-	-	-
PZ18	**1.37**	**0.53**	**217.90**	**218.43**	-	-	-	-	-	-	-	-	-	-	-	-

Note: mbmp - water levels measured below measuring point

'-' denotes data which is unavailable

italics - estimated from topographic mapping

*Water levels were taken immediately after installation

Table D-1
Groundwater Level Monitoring
Heritage Heights

Well	Well Depth (mbgl)	Casing Stick up (m)	Ground Elevation (masl)	Measuring Point Elevation (masl)	September 12/19, 2011		November 8, 2011		March 7, 2012		April 19, 2012		June 5, 2012		June 15, 2012*	
					Water Level Depth (mbmp)	Elevation (masl)	Water Level Depth (mbmp)	Elevation (masl)	Water Level Depth (mbmp)	Elevation (masl)	Water Level Depth (mbmp)	Elevation (masl)	Water Level Depth (mbmp)	Elevation (masl)	Water Level Depth (mbmp)	Elevation (masl)
MW1	**6.60**	**1.02**	**265.85**	**266.88**	4.12	262.76	3.08	263.80	2.48	264.40	-	-	3.19	263.69	-	-
MW2	**7.62**	**1.04**	**250.09**	**251.13**	2.59	248.54	0.81	250.32	frozen	frozen	-	-	1.03	250.10	-	-
MW3	**6.10**	**0.92**	**245.49**	**246.41**	3.36	243.05	2.82	243.59	2.61	243.80	-	-	3.07	243.34	-	-
MW4	**12.19**	**1.14**	**250.49**	**251.63**	9.26	242.37	8.59	243.04	8.72	242.91	-	-	9.20	242.43	-	-
MW5	**6.10**	**0.90**	**235.18**	**236.08**	2.75	233.33	1.21	234.87	1.05	235.03	-	-	1.54	234.55	-	-
MW6	**6.10**	**0.91**	**232.30**	**233.21**	3.60	229.61	2.59	230.62	1.86	231.35	-	-	2.86	230.35	-	-
MW7s	**7.50**	**0.75**	**240.03**	**240.78**	-	-	-	-	-	-	1.16	239.62	1.17	239.62	-	-
MW7d	**16.80**	**0.94**	**239.92**	**240.86**	-	-	-	-	-	-	-	-	0.79	240.07	-	-
MW8	**4.43**	**0.93**	**216.22**	**217.15**	-	-	-	-	-	-	4.35	212.80	4.50	212.66		-
PZ1s	**1.38**	**0.60**	**252.12**	**252.72**	dry	dry	0.52	252.20	0.41	252.31	-		0.72	252.00	-	-
PZ1i	**1.37**	**0.59**	**252.07**	**252.66**	dry	dry	0.61	252.05	0.38	252.28	-	-	0.84	251.83	-	-
PZ1d	**1.63**	**1.28**	**252.04**	**253.32**	dry	dry	1.15	252.17	1.01	252.31	-	-	1.45	251.87	-	-
PZ2	**2.01**	**0.95**	**249.74**	**250.69**	dry	dry	0.93	249.77	frozen	frozen	-	-	0.97	249.72	-	-
PZ2A	**1.33**	**0.59**	***249.80***	***250.39***	-	-	-	-	-	-	-	-	-	-	-	-
PZ3	**0.85**	**1.05**	**243.63**	**244.67**	dry	dry	1.09	243.58	1.02	243.65	-	-	1.23	243.44	-	-
PZ4	**1.29**	**0.59**	**241.77**	**242.36**	0.74	241.62	0.42	241.94	frozen	frozen	-	-	0.62	241.74	-	-
PZ5	**1.34**	**0.63**	**241.05**	**241.69**	0.69	241.00	0.56	241.13	0.59	241.10	-	-	0.70	240.99	-	-
PZ6	**0.91**	**0.92**	**232.05**	**232.97**	dry	dry	dry	dry	1.05	231.92	-	-	1.49	231.48	-	-
PZ7	**0.70**	**1.12**	**226.74**	**227.86**	1.37	226.49	1.32	226.54	1.32	226.54	-	-	1.36	226.50	-	-
PZ8s	**1.25**	**0.62**	**244.89**	**245.51**	1.53	243.98	0.78	244.73	0.72	244.79	-	-	0.91	244.60	-	-
PZ8d	**1.90**	**1.03**	**244.75**	**245.78**	1.14	244.64	0.98	244.80	0.92	244.86	-	-	1.01	244.77	-	-
PZ9	**1.20**	**0.78**	**247.22**	**248.00**	dry	dry	1.14	246.86	0.70	247.30	-	-	1.14	246.86	-	-
PZ10	**1.25**	**0.70**	**240.26**	**240.96**	dry	dry	1.13	239.83	0.78	240.18	-	-	0.91	240.05	-	-
PZ11s	**1.41**	**0.62**	**252.24**	**252.86**	-	-	-	-	-	-	-	-	-	-	dry	dry
PZ11d	**1.84**	**1.11**	**252.24**	**253.35**	-	-	-	-	-	-	-	-	-	-	dry	dry
PZ12s	**1.04**	**0.56**	**252.19**	**252.75**	-	-	-	-	-	-	-	-	-	-	dry	dry
PZ12d	**1.84**	**0.99**	**252.19**	**253.18**	-	-	-	-	-	-	-	-	-	-	dry	dry
PZ13	**1.35**	**0.55**	***251.50***	***252.05***	-	-	-	-	-	-	-	-	-	-	dry	dry
PZ13a	**1.17**	**0.74**	***251.00***	***251.74***	-	-	-	-	-	-	-	-	-	-	-	-
PZ14	**1.72**	**1.05**	**248.50**	**249.55**	-	-	-	-	-	-	-	-	-	-	dry	dry
PZ15	**1.31**	**0.49**	**245.26**	**245.75**	-	-	-	-	-	-	-	-	-	-	dry	dry
PZ16	**1.34**	**0.56**	**239.56**	**240.12**	-	-	-	-	-	-	-	-	-	-	0.68	239.44
PZ17	**1.36**	**0.53**	**226.90**	**227.43**	-	-	-	-	-	-	-	-	-	-	dry	dry
PZ18	**1.37**	**0.53**	**217.90**	**218.43**	-	-	-	-	-	-	-	-	-	-	dry	dry

Note: mbmp - water levels measured below measuring point

'-' denotes data which is unavailable

italics - estimated from topographic mapping

*Water levels were taken immediately after installation

Table D-1
Groundwater Level Monitoring
Heritage Heights

Well	Well Depth (mbgl)	Casing Stick up (m)	Ground Elevation (masl)	Measuring Point Elevation (masl)	July 18-20, 2012		September 12, 2012		October 24, 2012		December 11, 2012		July 10, 2013		October 8, 2013	
					Water Level Depth (mbmp)	Elevation (masl)	Water Level Depth (mbmp)	Elevation (masl)	Water Level Depth (mbmp)	Elevation (masl)	Water Level Depth (mbmp)	Elevation (masl)	Water Level Depth (mbmp)	Elevation (masl)	Water Level Depth (mbmp)	Elevation (masl)
MW1	**6.60**	**1.02**	**265.85**	**266.88**	3.88	263.00	4.27	262.61	4.41	262.47	-	-	2.37	264.51	3.56	263.32
MW2	**7.62**	**1.04**	**250.09**	**251.13**	2.06	249.07	2.61	248.52	1.58	249.55	-	-	0.75	250.38	1.63	249.50
MW3	**6.10**	**0.92**	**245.49**	**246.41**	-	-	3.54	242.87	3.43	242.98	-	-	2.20	244.21	3.22	243.19
MW4	**12.19**	**1.14**	**250.49**	**251.63**	9.60	242.03	9.87	241.76	9.74	241.89	-	-	8.26	243.37	9.31	242.32
MW5	**6.10**	**0.90**	**235.18**	**236.08**	-	-	2.75	233.34	1.54	234.54	-	-	0.96	235.12	1.30	234.78
MW6	**6.10**	**0.91**	**232.30**	**233.21**	-	-	3.36	229.85	2.79	230.42	-	-	1.72	231.49	2.98	230.23
MW7s	**7.50**	**0.75**	**240.03**	**240.78**	2.24	238.54	2.83	237.95	2.09	238.70	-	-	0.67	240.12	1.62	239.16
MW7d	**16.80**	**0.94**	**239.92**	**240.86**	2.01	238.85	2.66	238.20	2.21	238.65	-	-	0.15	240.71	1.41	239.45
MW8	**4.43**	**0.93**	**216.22**	**217.15**	4.74	212.41	4.89	212.26	4.91	212.24	-	-	4.32	212.83	4.48	212.67
PZ1s	**1.38**	**0.60**	**252.12**	**252.72**	-	-	dry	dry	dry	dry	0.47	252.25	0.51	252.21	0.57	252.16
PZ1i	**1.37**	**0.59**	**252.07**	**252.66**	-	-	dry	dry	dry	dry	0.45	252.22	0.71	251.95	1.08	251.59
PZ1d	**1.63**	**1.28**	**252.04**	**253.32**	-	-	dry	dry	dry	dry	1.11	252.21	1.36	251.96	1.51	251.81
PZ2	**2.01**	**0.95**	**249.74**	**250.69**	-	-	missing	missing	missing	missing	-	-	-	-	-	-
PZ2A	**1.33**	**0.59**	***249.80***	***250.39***	-	-	-	-	-	-	-	-	dry	-	0.84	249.55
PZ3	**0.85**	**1.05**	**243.63**	**244.67**	-	-	dry	dry	1.31	243.36	1.10	243.57	1.41	243.26	0.92	243.75
PZ4	**1.29**	**0.59**	**241.77**	**242.36**	-	-	1.05	241.31	0.97	241.39	0.68	241.68	0.44	241.92	0.65	241.71
PZ5	**1.34**	**0.63**	**241.05**	**241.69**	-	-	0.75	240.94	0.68	241.01	-	-	0.35	241.34	0.65	241.04
PZ6	**0.91**	**0.92**	**232.05**	**232.97**	-	-	dry	dry	dry	dry	-	-	1.57	231.40	dry	-
PZ7	**0.70**	**1.12**	**226.74**	**227.86**	-	-	1.37	226.49	1.32	226.54	-	-	1.31	226.55	1.37	226.49
PZ8s	**1.25**	**0.62**	**244.89**	**245.51**	-	-	dry	dry	1.52	243.99	-	-	0.66	244.85	0.77	244.74
PZ8d	**1.90**	**1.03**	**244.75**	**245.78**	-	-	1.54	244.24	1.91	243.87	-	-	0.90	244.89	1.32	244.46
PZ9	**1.20**	**0.78**	**247.22**	**248.00**	-	-	dry	dry	0.98	247.02	-	-	1.46	246.54	0.66	247.34
PZ10	**1.25**	**0.70**	**240.26**	**240.96**	-	-	dry	dry	dry	dry	-	-	0.71	240.25	1.41	239.55
PZ11s	**1.41**	**0.62**	**252.24**	**252.86**	-	-	dry	dry	dry	dry	-	-	1.07	251.79	dry	-
PZ11d	**1.84**	**1.11**	**252.24**	**253.35**	-	-	dry	dry	dry	dry	-	-	1.48	251.87	dry	-
PZ12s	**1.04**	**0.56**	**252.19**	**252.75**	-	-	dry	dry	dry	dry	-	-	0.66	252.09	1.01	251.74
PZ12d	**1.84**	**0.99**	**252.19**	**253.18**	-	-	dry	dry	2.82	250.36	-	-	1.30	251.88	1.48	251.70
PZ13	**1.35**	**0.55**	***251.50***	***252.05***	-	-	missing	missing	missing	missing	-	-	-	-	-	-
PZ13a	**1.17**	**0.74**	***251.00***	***251.74***	-	-	-	-	-	-	-	-	dry	-	1.15	250.59
PZ14	**1.72**	**1.05**	**248.50**	**249.55**	-	-	dry	dry	dry	dry	-	-	1.21	248.35	1.40	248.15
PZ15	**1.31**	**0.49**	**245.26**	**245.75**	-	-	dry	dry	1.78	243.97	-	-	0.82	244.94	0.85	244.90
PZ16	**1.34**	**0.56**	**239.56**	**240.12**	-	-	0.69	239.43	0.52	239.60	0.47	239.66	0.30	239.82	0.63	239.49
PZ17	**1.36**	**0.53**	**226.90**	**227.43**	-	-	1.60	225.84	1.00	226.43	-	-	0.54	226.90	0.68	226.75
PZ18	**1.37**	**0.53**	**217.90**	**218.43**	-	-	0.96	217.47	0.77	217.66	0.67	217.76	0.63	217.80	0.62	217.81

Note: mbmp - water levels measured below measuring point

'-' denotes data which is unavailable

italics - estimated from topographic mapping

*Water levels were taken immediately after installation

Table D-1
Groundwater Level Monitoring
Heritage Heights

Well	Well Depth (mbgl)	Casing Stick up (m)	Ground Elevation (masl)	Measuring Point Elevation (masl)	November 20, 2013		April 28, 2014		August 7, 2014		December 1, 2014		November 25, 2015		July 19, 2017	
					Water Level Depth (mbmp)	Elevation (masl)	Water Level Depth (mbmp)	Elevation (masl)	Water Level Depth (mbmp)	Elevation (masl)	Water Level Depth (mbmp)	Elevation (masl)	Water Level Depth (mbmp)	Elevation (masl)	Water Level Depth (mbmp)	Elevation (masl)
MW1	**6.60**	**1.02**	**265.85**	**266.88**	2.80	264.08	2.10	264.78	2.38	264.50	2.98	263.90	4.24	262.64	4.09	262.79
MW2	**7.62**	**1.04**	**250.09**	**251.13**	0.86	250.27	0.53	250.60	1.37	249.76	0.78	250.35	1.62	249.51	1.29	249.84
MW3	**6.10**	**0.92**	**245.49**	**246.41**	3.27	243.14	-	-	3.41	243.00	3.53	242.88	3.77	242.64	3.26	243.15
MW4	**12.19**	**1.14**	**250.49**	**251.63**	9.07	242.56	9.02	242.61	9.59	242.04	9.20	242.44	9.96	241.67	9.65	241.98
MW5	**6.10**	**0.90**	**235.18**	**236.08**	1.23	234.85	0.86	235.22	1.83	234.25	1.08	235.00	2.05	234.03	1.97	234.11
MW6	**6.10**	**0.91**	**232.30**	**233.21**	2.54	230.67	1.67	231.55	3.49	229.72	2.32	230.89	3.07	230.14	2.93	230.28
MW7s	**7.50**	**0.75**	**240.03**	**240.78**	0.97	239.81	0.56	240.22	1.81	238.97	1.05	239.73	1.75	239.03	1.39	239.39
MW7d	**16.80**	**0.94**	**239.92**	**240.86**	0.63	240.23	0.13	240.73	1.65	239.21	0.38	240.48	1.66	239.20	1.03	239.83
MW8	**4.43**	**0.93**	**216.22**	**217.15**	4.20	212.95	4.09	213.06	4.64	212.51	4.60	212.55	4.70	212.45	4.32	212.83
PZ1s	**1.38**	**0.60**	**252.12**	**252.72**	0.47	252.25	0.50	252.22	dry	dry	0.57	252.15	-	-	1.47	251.25
PZ1i	**1.37**	**0.59**	**252.07**	**252.66**	0.67	251.99	0.44	252.23	1.38	251.28	1.78	250.88	-	-	1.67	250.99
PZ1d	**1.63**	**1.28**	**252.04**	**253.32**	1.09	252.23	1.10	252.22	2.71	250.61	1.90	251.42	-	-	1.92	251.40
PZ2	**2.01**	**0.95**	**249.74**	**250.69**	-	-	-	-	-	-	-	-	-	-	-	-
PZ2A	**1.33**	**0.59**	***249.80***	***250.39***	0.55	249.84	0.44	249.95	0.92	249.47	0.73	249.66	-	-	missing	-
PZ3	**0.85**	**1.05**	**243.63**	**244.67**	0.81	243.86	0.94	243.73	1.17	243.51	1.03	243.64	-	-	1.18	243.49
PZ4	**1.29**	**0.59**	**241.77**	**242.36**	0.43	241.93	0.44	241.92	0.89	241.47	0.90	241.46	-	-	0.97	241.39
PZ5	**1.34**	**0.63**	**241.05**	**241.69**	0.63	241.06	0.71	240.98	0.62	241.07	0.63	241.06	-	-	-	-
PZ6	**0.91**	**0.92**	**232.05**	**232.97**	dry	-	1.54	231.43	dry	dry	dry	dry	-	-	dry	-
PZ7	**0.70**	**1.12**	**226.74**	**227.86**	1.41	226.45	missing	missing	-	-	-	-	-	-	-	-
PZ8s	**1.25**	**0.62**	**244.89**	**245.51**	0.79	244.72	0.75	244.76	1.13	244.38	0.77	244.74	-	-	1.16	244.35
PZ8d	**1.90**	**1.03**	**244.75**	**245.78**	1.00	244.78	0.92	244.86	1.14	244.64	0.97	244.82	-	-	0.96	244.82
PZ9	**1.20**	**0.78**	**247.22**	**248.00**	1.34	246.66	0.73	247.28	1.53	246.47	0.82	247.19	-	-	missing	-
PZ10	**1.25**	**0.70**	**240.26**	**240.96**	0.83	240.13	0.72	240.24	1.62	239.34	1.06	239.90	-	-	1.04	239.92
PZ11s	**1.41**	**0.62**	**252.24**	**252.86**	0.67	252.19	0.55	252.31	2.01	250.85	2.00	250.86	-	-	1.52	251.34
PZ11d	**1.84**	**1.11**	**252.24**	**253.35**	1.92	251.43	0.98	252.37	2.07	251.28	2.70	250.65	-	-	1.49	251.86
PZ12s	**1.04**	**0.56**	**252.19**	**252.75**	0.68	252.07	0.68	252.07	1.20	251.55	0.70	252.05	-	-	1.30	251.45
PZ12d	**1.84**	**0.99**	**252.19**	**253.18**	1.34	251.84	1.08	252.10	1.25	251.93	1.31	251.87	-	-	1.43	251.75
PZ13	**1.35**	**0.55**	***251.50***	***252.05***	-	-	-	-	-	-	-	-	-	-	-	-
PZ13a	**1.17**	**0.74**	***251.00***	***251.74***	0.85	250.89	0.70	251.04	0.90	250.84	0.83	250.91	-	-	1.03	250.71
PZ14	**1.72**	**1.05**	**248.50**	**249.55**	1.68	247.87	1.11	248.44	1.58	247.97	1.36	248.19	-	-	1.42	248.13
PZ15	**1.31**	**0.49**	**245.26**	**245.75**	0.91	244.84	na	na	1.05	244.70	0.86	244.89	-	-	missing	-
PZ16	**1.34**	**0.56**	**239.56**	**240.12**	0.56	239.56	0.64	239.48	0.70	239.42	0.62	239.50	-	-	0.62	239.50
PZ17	**1.36**	**0.53**	**226.90**	**227.43**	0.63	226.80	0.55	226.89	0.72	226.71	0.78	226.65	-	-	0.79	226.64
PZ18	**1.37**	**0.53**	**217.90**	**218.43**	0.58	217.85	0.59	217.84	0.79	217.64	0.60	217.83	-	-	0.59	217.84

Note: mbmp - water levels measured below measuring point

'-' denotes data which is unavailable

italics - estimated from topographic mapping

*Water levels were taken immediately after installation

Table D-1
Groundwater Level Monitoring
Heritage Heights

Well	Well Depth (mbgl)	Casing Stick up (m)	Ground Elevation (masl)	Measuring Point Elevation (masl)	September 14, 2017		October 5, 2017		November 9, 2017		December 8, 2017	
					Water Level Depth (mbmp)	Elevation (masl)	Water Level Depth (mbmp)	Elevation (masl)	Water Level Depth (mbmp)	Elevation (masl)	Water Level Depth (mbmp)	Elevation (masl)
MW1	6.60	1.02	265.85	266.88	4.56	262.32	4.82	262.06	4.93	261.95	5.07	261.81
MW2	7.62	1.04	250.09	251.13	2.21	248.92	2.51	248.62	2.45	248.68	2.17	248.96
MW3	6.10	0.92	245.49	246.41	3.55	242.86	3.67	242.74	3.66	242.75	3.72	242.69
MW4	12.19	1.14	250.49	251.63	9.84	241.79	9.93	241.71	9.88	241.75	9.88	241.75
MW5	6.10	0.90	235.18	236.08	3.03	233.05	3.50	232.58	2.94	233.14	2.70	233.38
MW6	6.10	0.91	232.30	233.21	3.25	229.97	3.37	229.84	3.22	229.99	na	-
MW7s	7.50	0.75	240.03	240.78	2.28	238.50	2.52	238.26	2.47	238.31	2.21	238.57
MW7d	16.80	0.94	239.92	240.86	2.09	238.77	2.38	238.48	2.40	238.46	2.14	238.72
MW8	4.43	0.93	216.22	217.15	4.63	212.52	4.73	212.42	4.73	212.42	4.79	212.36
PZ1s	1.38	0.60	252.12	252.72	dry	-	dry	-	dry	-	dry	-
PZ1i	1.37	0.59	252.07	252.66	1.64	251.02	1.64	251.02	1.64	251.03	1.64	251.02
PZ1d	1.63	1.28	252.04	253.32	dry	-	dry	-	dry	-	dry	-
PZ2	2.01	0.95	249.74	250.69	-	-	-	-	-	-	-	-
PZ2A	1.33	0.59	*249.80*	*250.39*	-	-	-	-	-	-	-	-
PZ3	0.85	1.05	243.63	244.67	1.25	243.43	1.55	243.12	1.40	243.27	1.21	243.46
PZ4	1.29	0.59	241.77	242.36	1.20	241.16	1.28	241.08	1.27	241.09	1.24	241.12
PZ5	1.34	0.63	241.05	241.69	0.83	240.86	0.84	240.85	dry	-	0.88	240.81
PZ6	0.91	0.92	232.05	232.97	dry	-	dry	-	1.90	231.07	na	-
PZ7	0.70	1.12	226.74	227.86	-	-	-	-	-	-	-	-
PZ8s	1.25	0.62	244.89	245.51	1.61	243.90	dry	-	dry	-	1.82	243.69
PZ8d	1.90	1.03	244.75	245.78	1.19	244.59	1.59	244.19	2.13	243.65	2.22	243.56
PZ9	1.20	0.78	247.22	248.00	-	-	-	-	-	-	-	-
PZ10	1.25	0.70	240.26	240.96	1.22	239.74	dry	-	dry	-	dry	-
PZ11s	1.41	0.62	252.24	252.86	1.68	251.19	1.74	251.12	1.74	251.12	1.75	251.11
PZ11d	1.84	1.11	252.24	253.35	dry	-	dry	-	dry	-	dry	-
PZ12s	1.04	0.56	252.19	252.75	dry	-	dry	-	dry	-	dry	-
PZ12d	1.84	0.99	252.19	253.18	1.95	251.23	2.20	250.98	2.72	250.46	dry	-
PZ13	1.35	0.55	*251.50*	*252.05*	-	-	-	-	-	-	-	-
PZ13a	1.17	0.74	*251.00*	*251.74*	1.37	250.37	1.57	250.17	1.62	250.12	1.40	250.34
PZ14	1.72	1.05	248.50	249.55	1.52	248.03	dry	-	dry	-	dry	-
PZ15	1.31	0.49	245.26	245.75	-	-	-	-	-	-	-	-
PZ16	1.34	0.56	239.56	240.12	0.68	239.44	0.70	239.42	0.68	239.45	0.70	239.42
PZ17	1.36	0.53	226.90	227.43	1.29	226.14	1.54	225.89	dry	-	1.45	225.98
PZ18	1.37	0.53	217.90	218.43	0.72	217.71	0.88	217.55	0.90	217.53	0.87	217.56

Note: mbmp - water levels measured below measuring point

'-' denotes data which is unavailable

italics - estimated from topographic mapping

*Water levels were taken immediately after installation

Groundwater Elevation Hydrograph - MW1
Heritage Heights

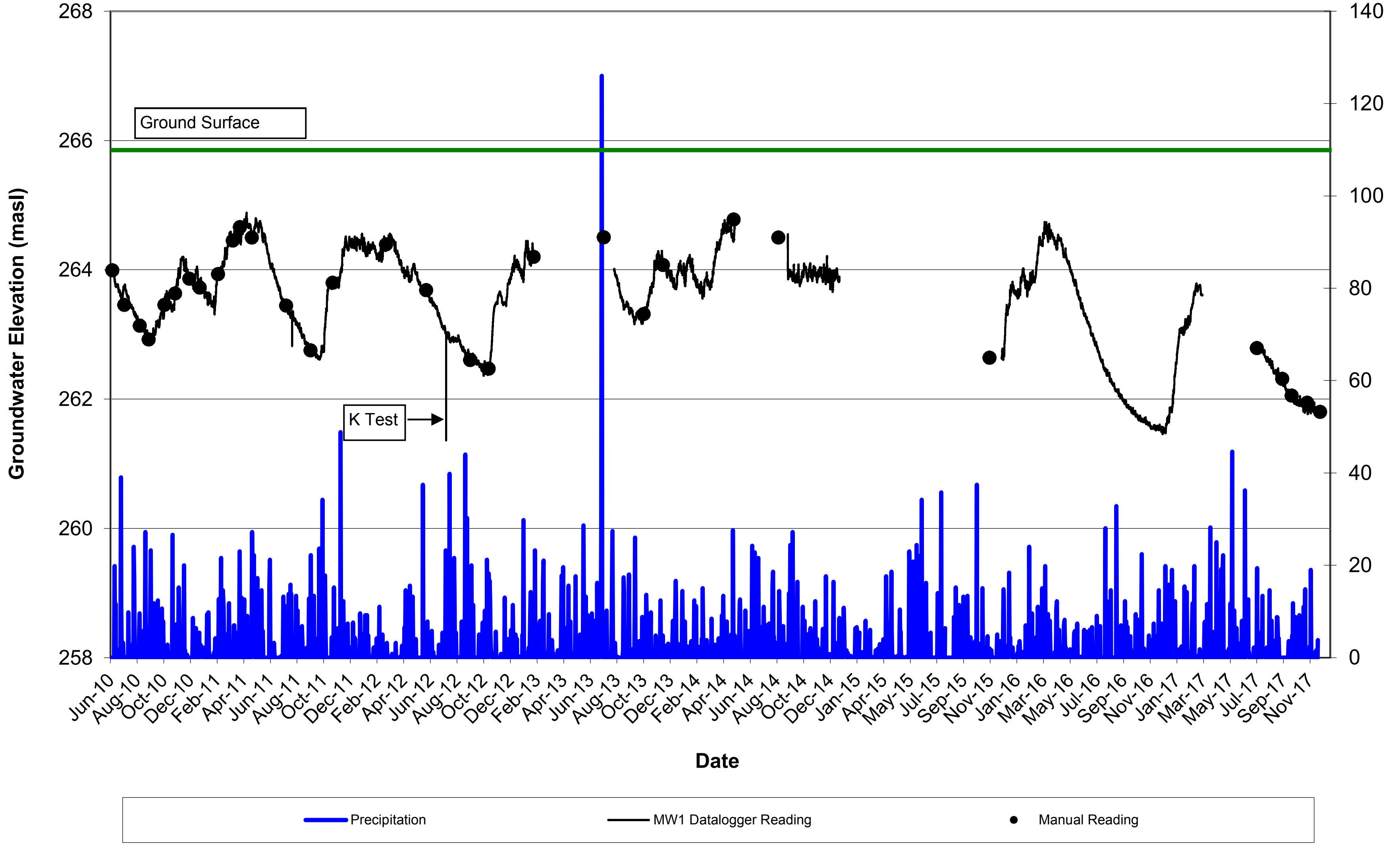


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Figure D-1

Groundwater Elevation Hydrograph - MW2
Heritage Heights

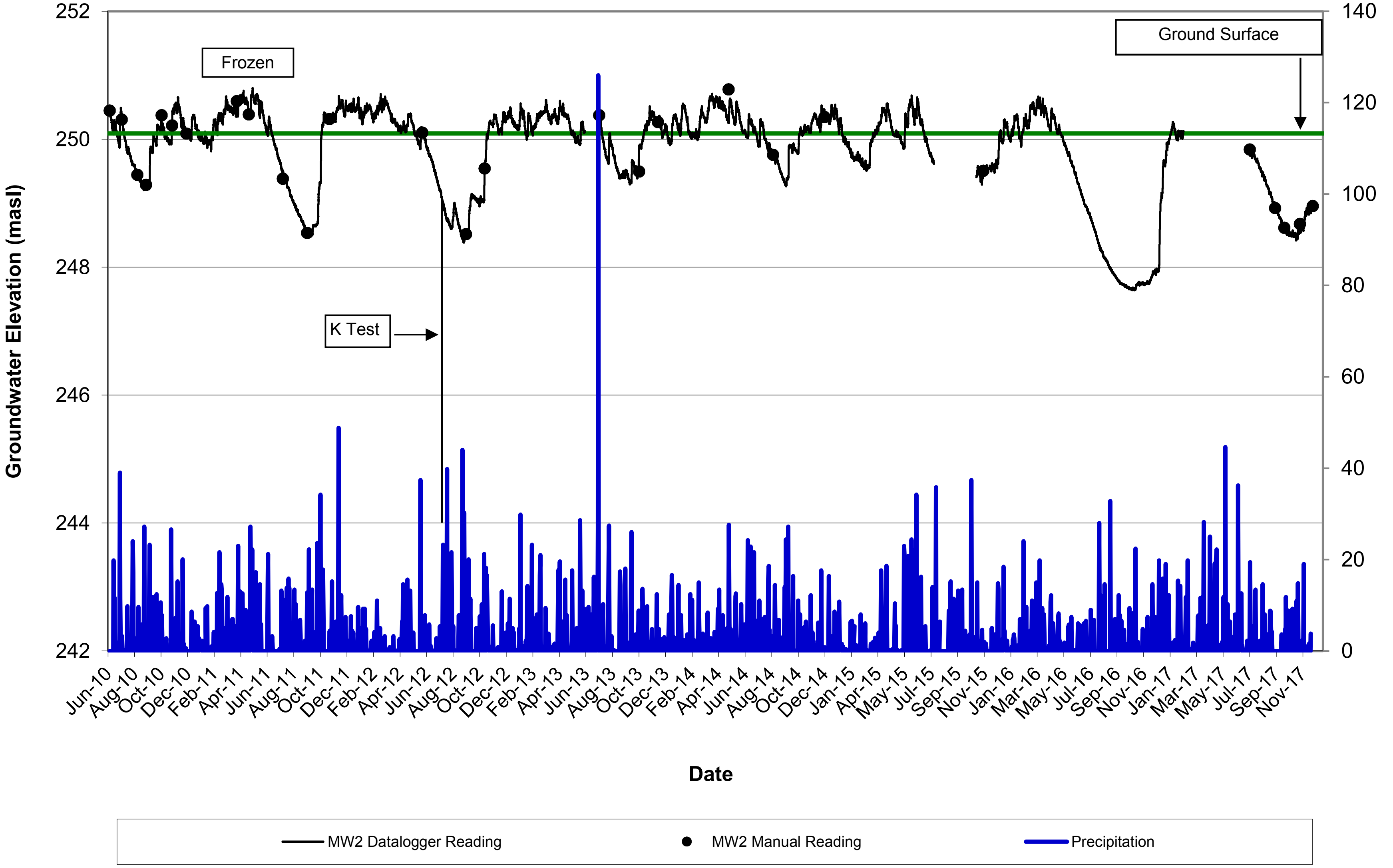

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Figure D-2

Groundwater Elevation Hydrograph - MW3
Heritage Heights

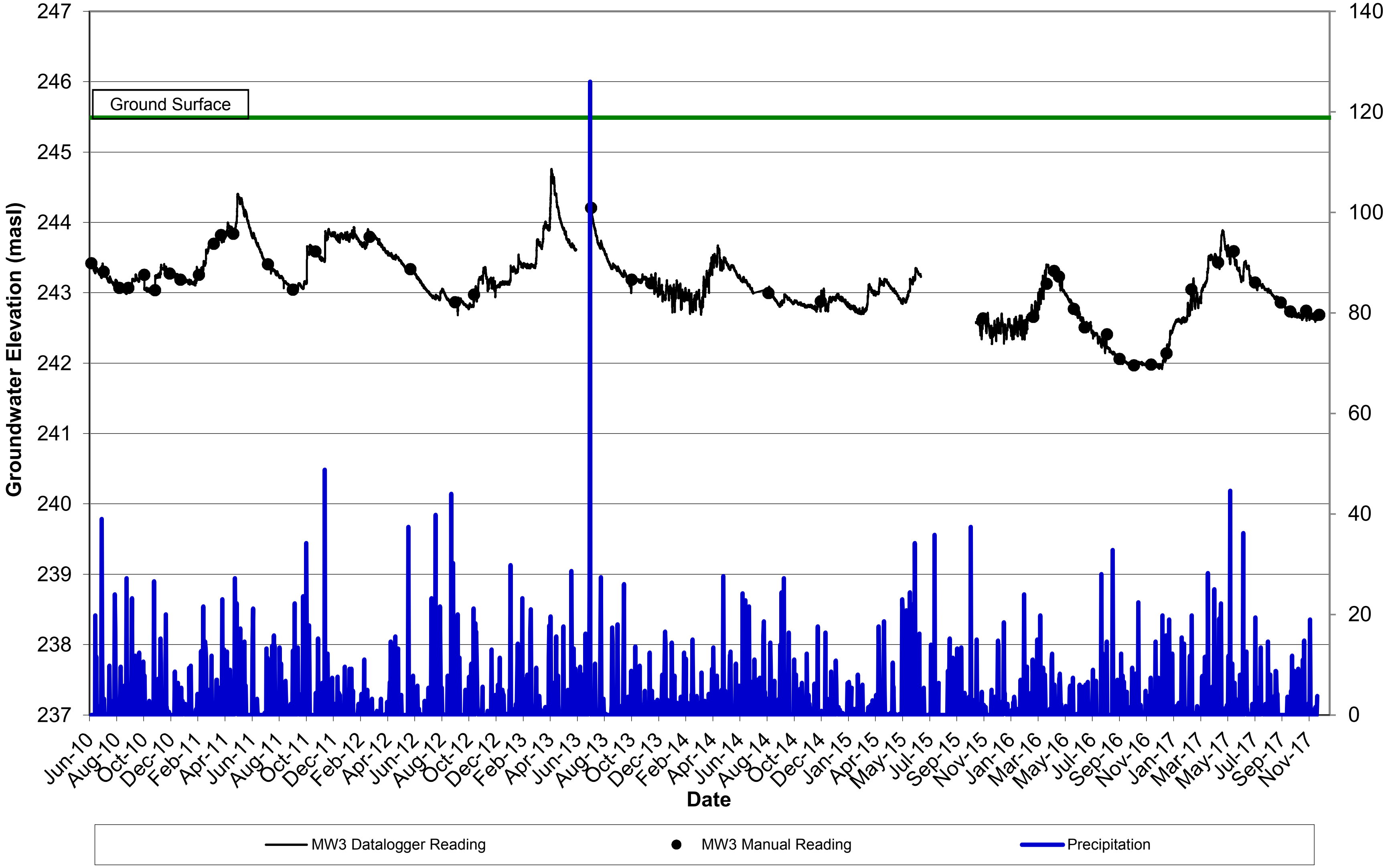

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Figure D-3

Groundwater Elevation Hydrograph - MW4
Heritage Heights

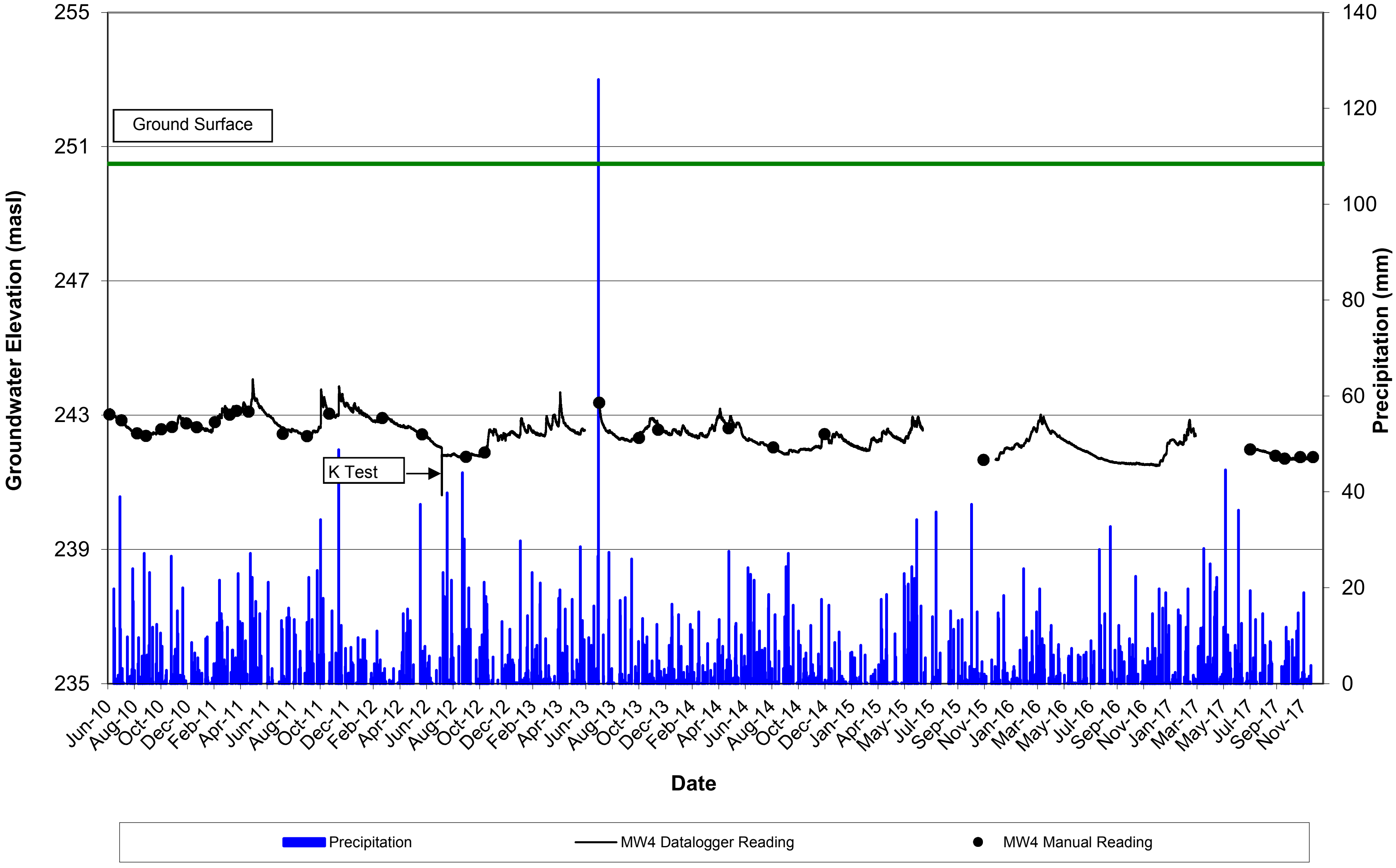

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Figure D-4

Groundwater Elevation Hydrograph - MW5
Heritage Heights

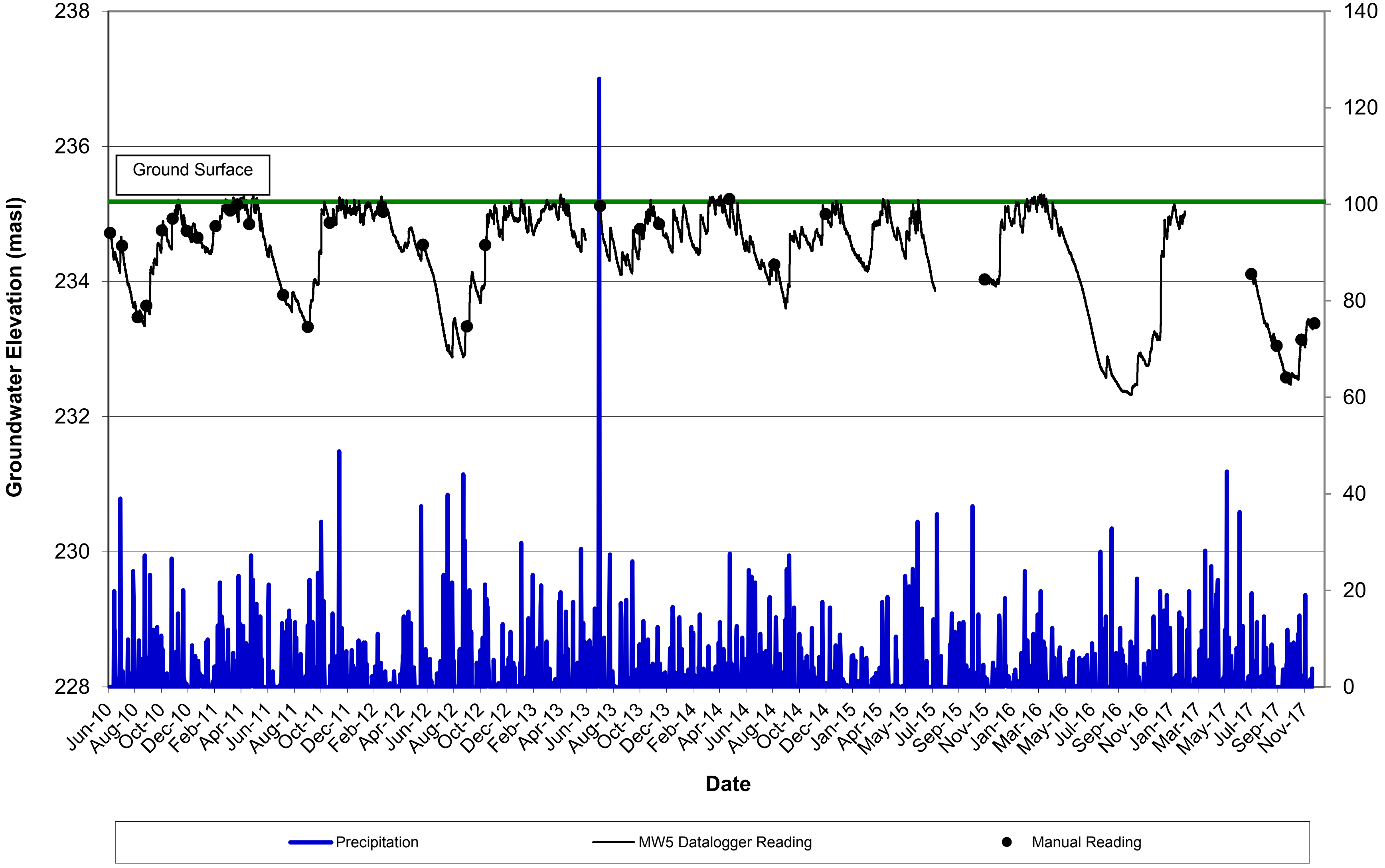

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Figure D-5

Groundwater Elevation Hydrograph - MW6
Heritage Heights

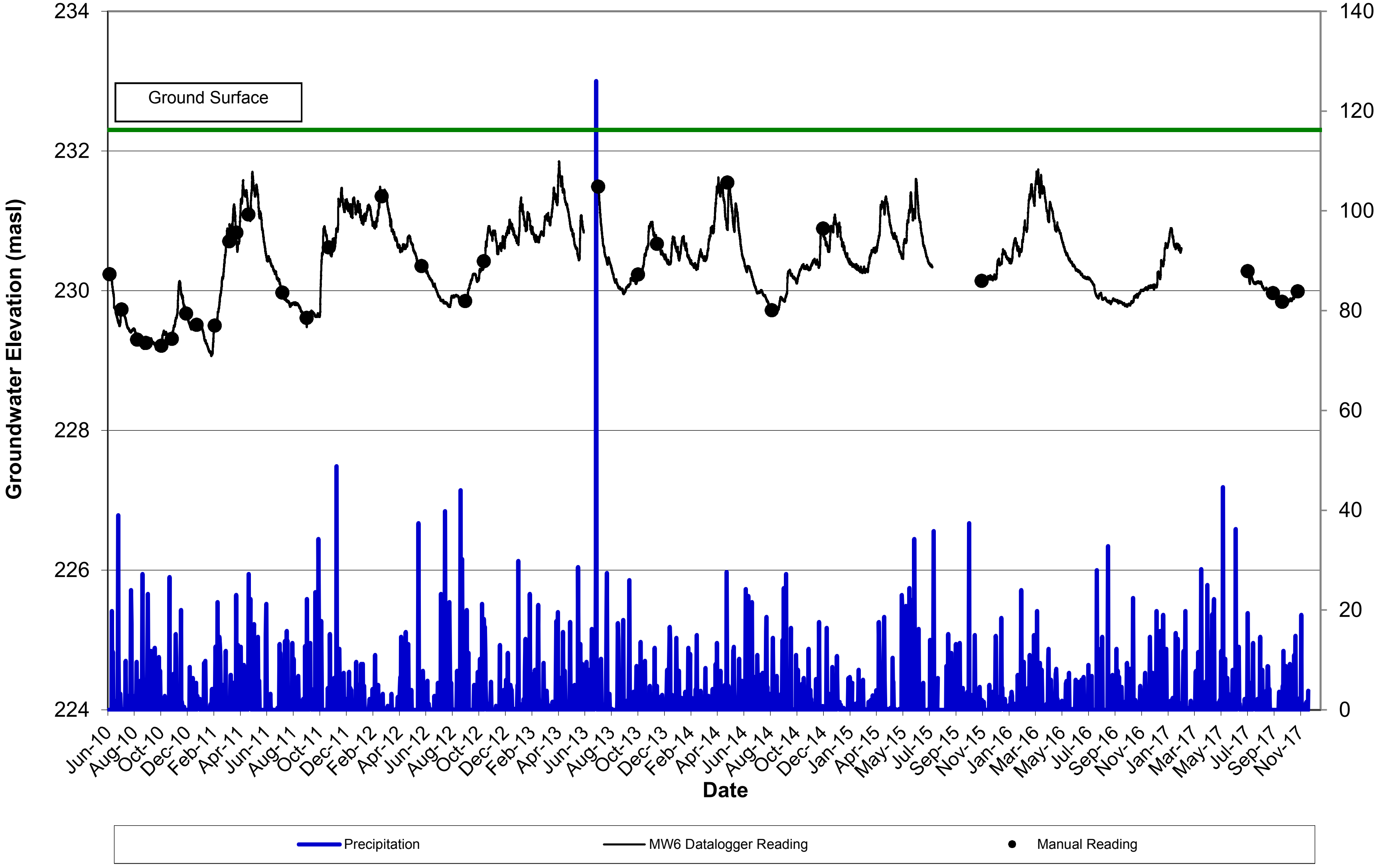

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Figure D-6

Groundwater Elevation Hydrograph - MW7s/d
Heritage Heights

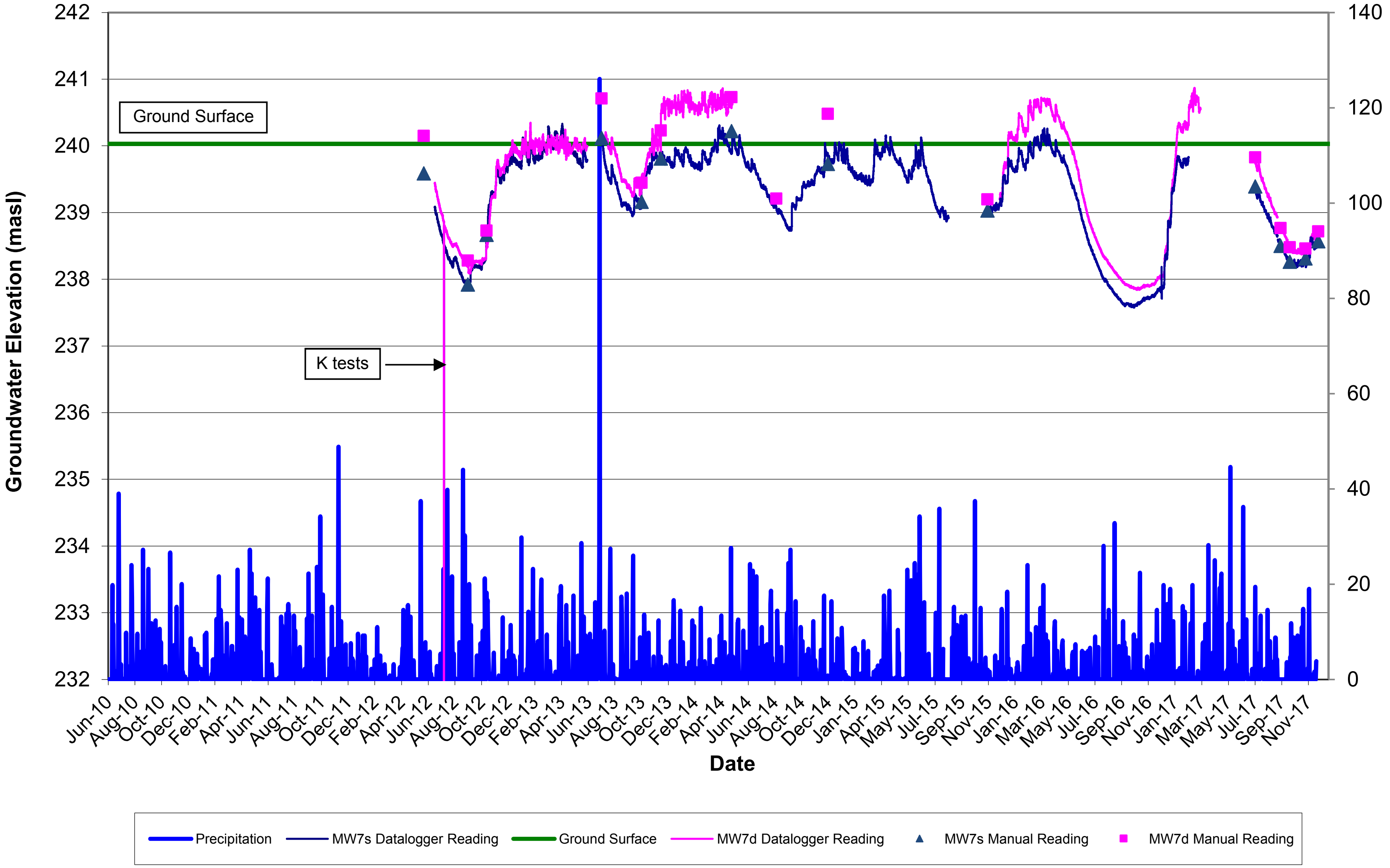

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Figure D-7

Groundwater Elevation Hydrograph - MW8
Heritage Heights

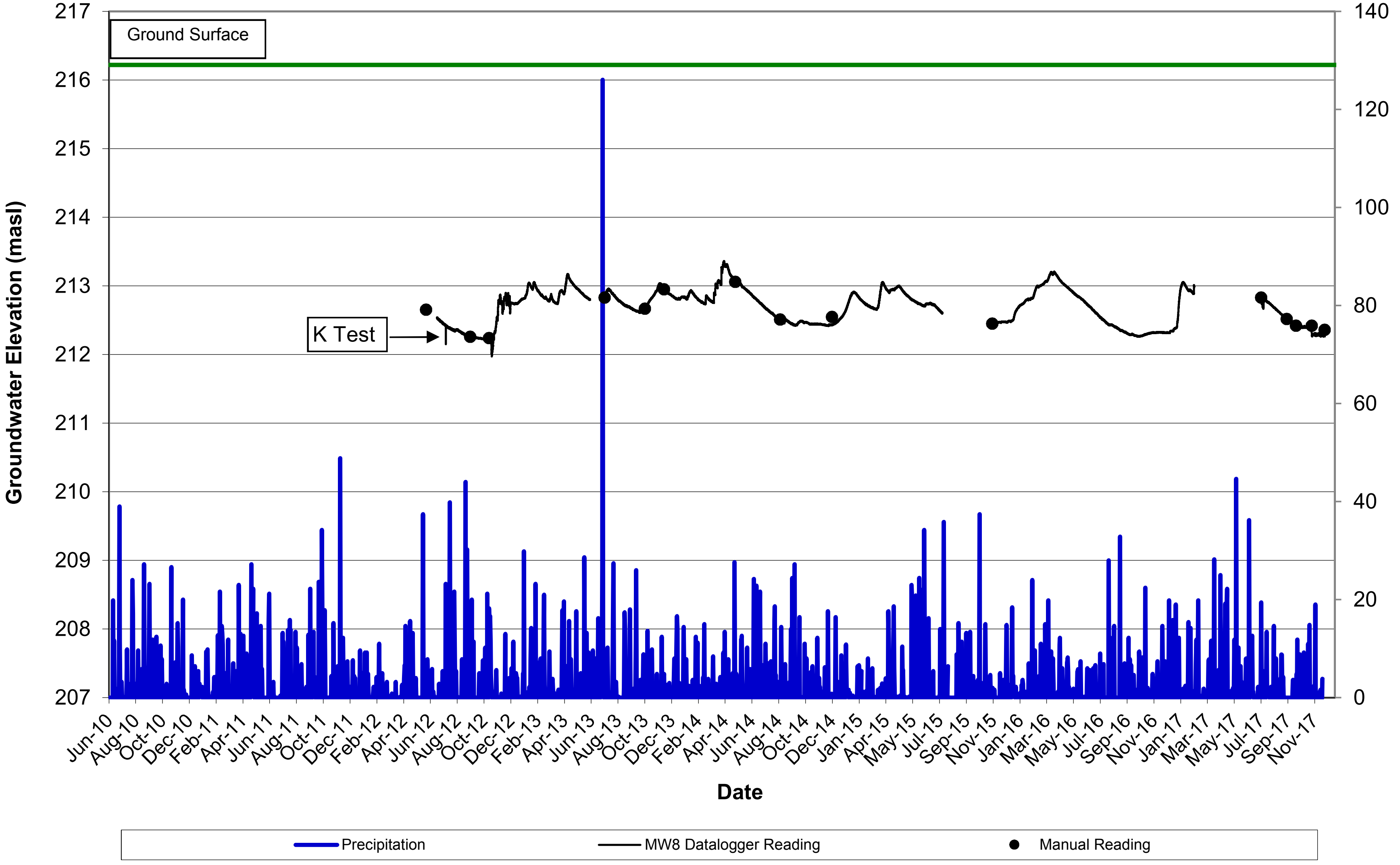

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Figure D-8

Groundwater Elevation Hydrograph - PZ1s/i/d
Heritage Heights

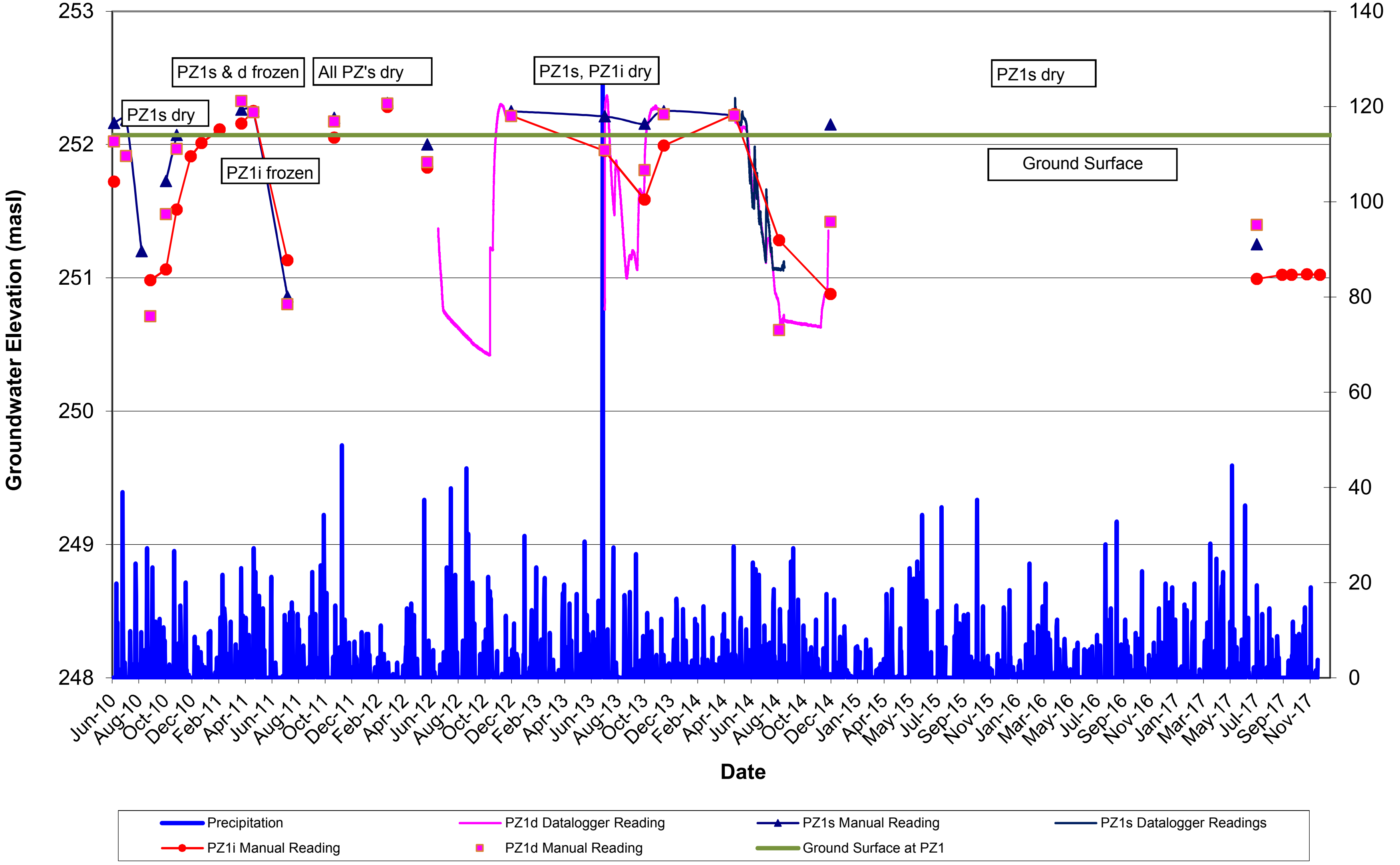

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Figure D-9

Groundwater Elevation Hydrograph - PZ2/PZ2A
Heritage Heights

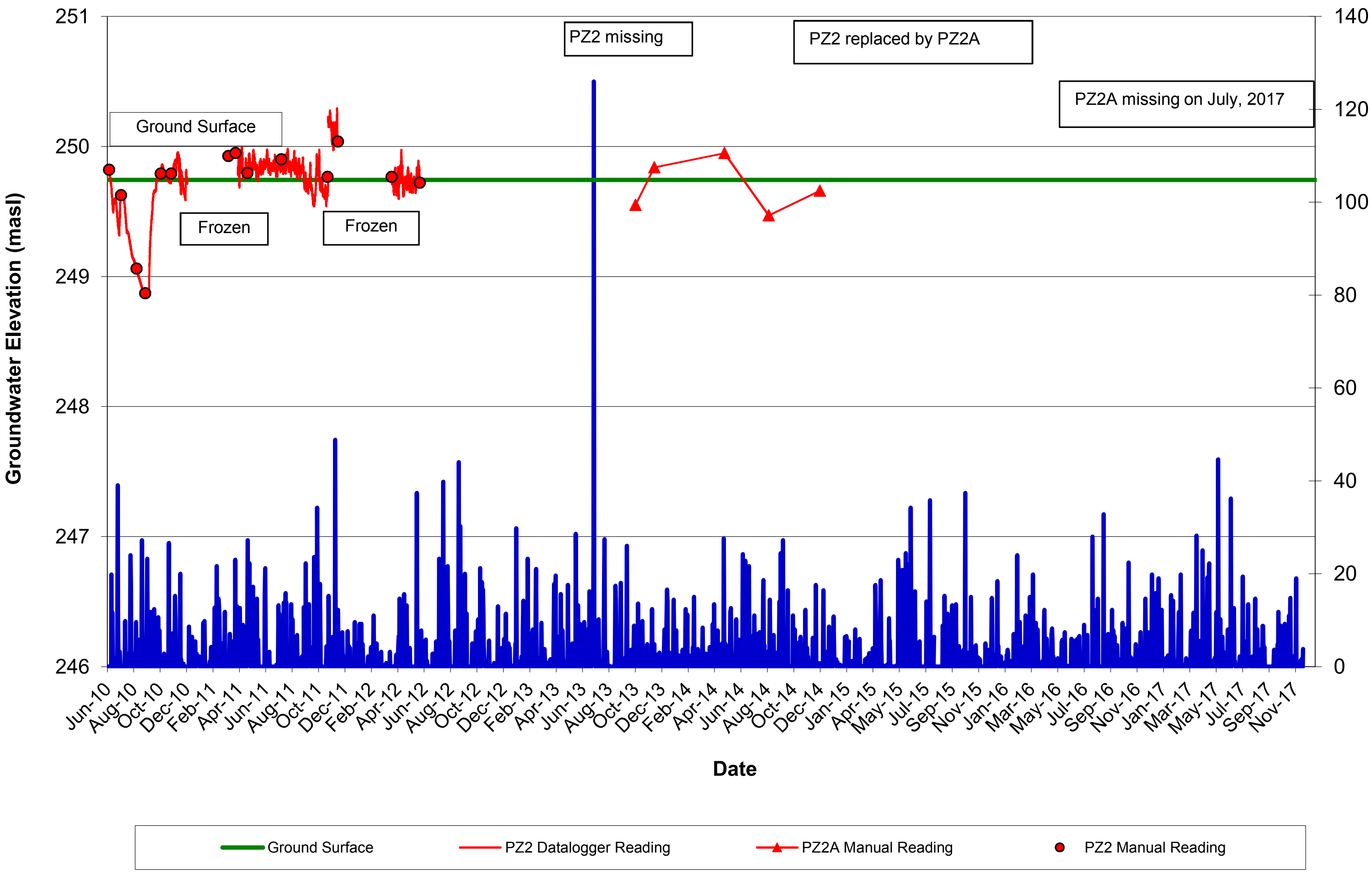

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Figure D-10

Groundwater Elevation Hydrograph - PZ3
Heritage Heights

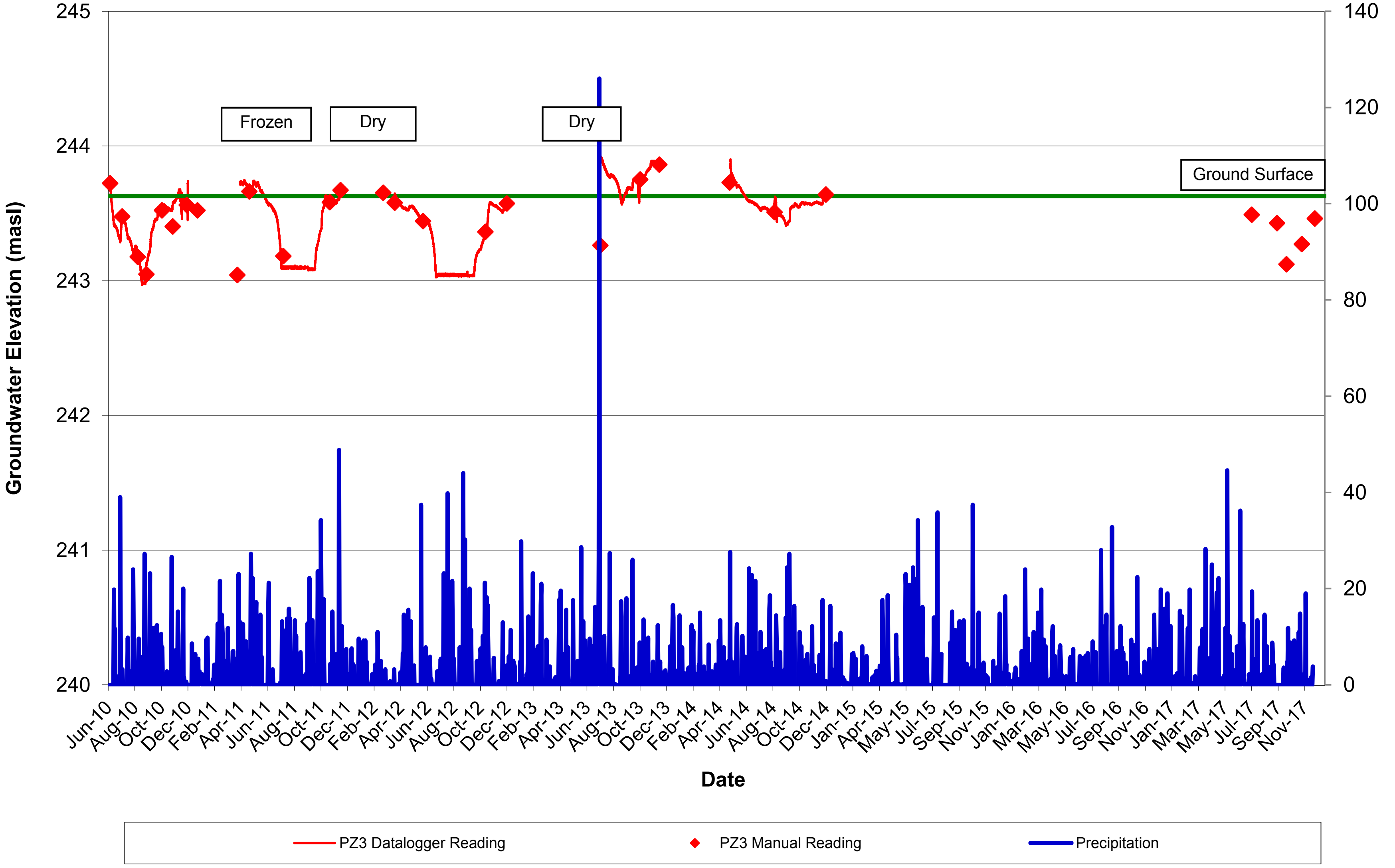

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Figure D-11

Groundwater Elevation Hydrograph - PZ4
Heritage Heights

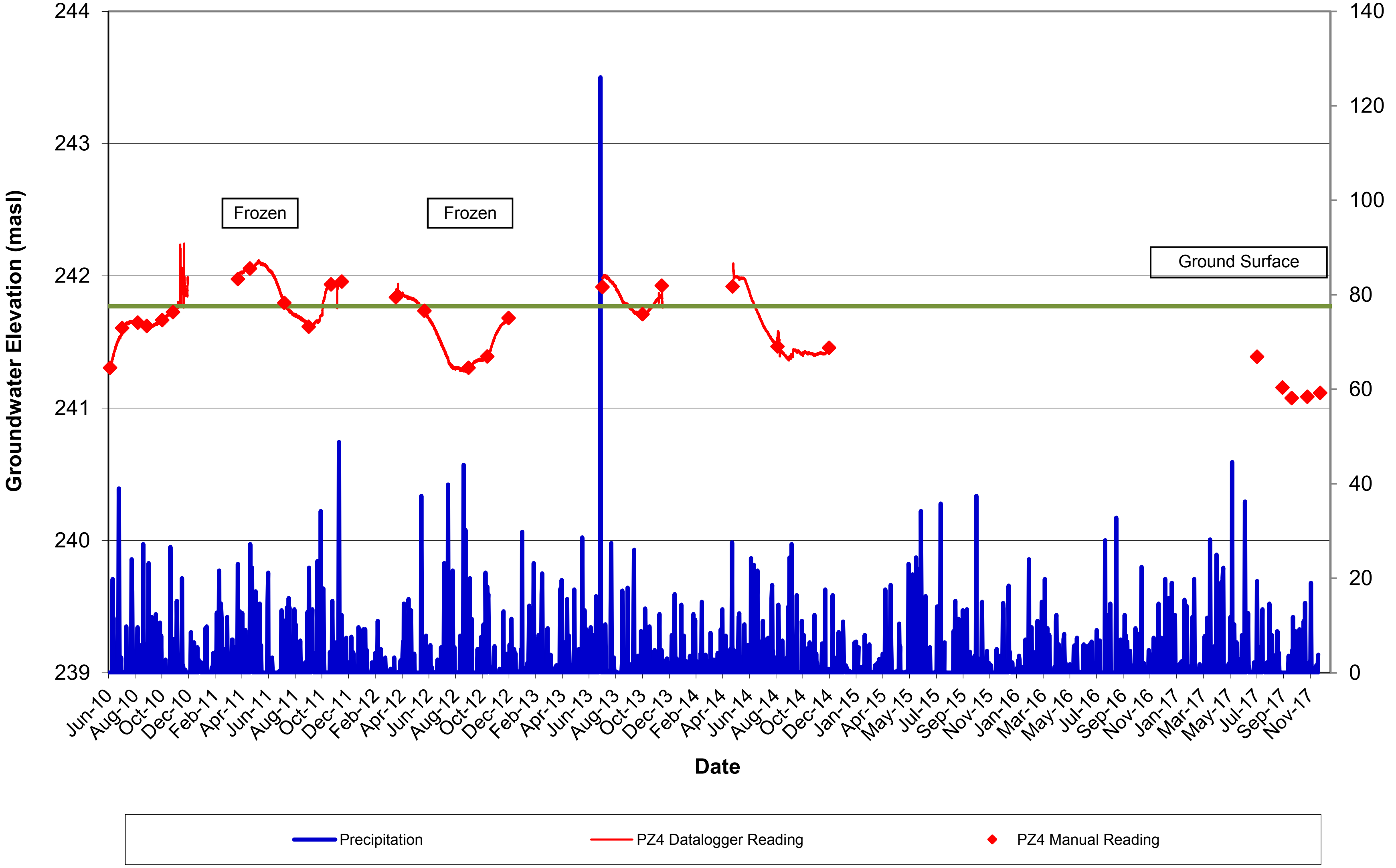

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Figure D-12

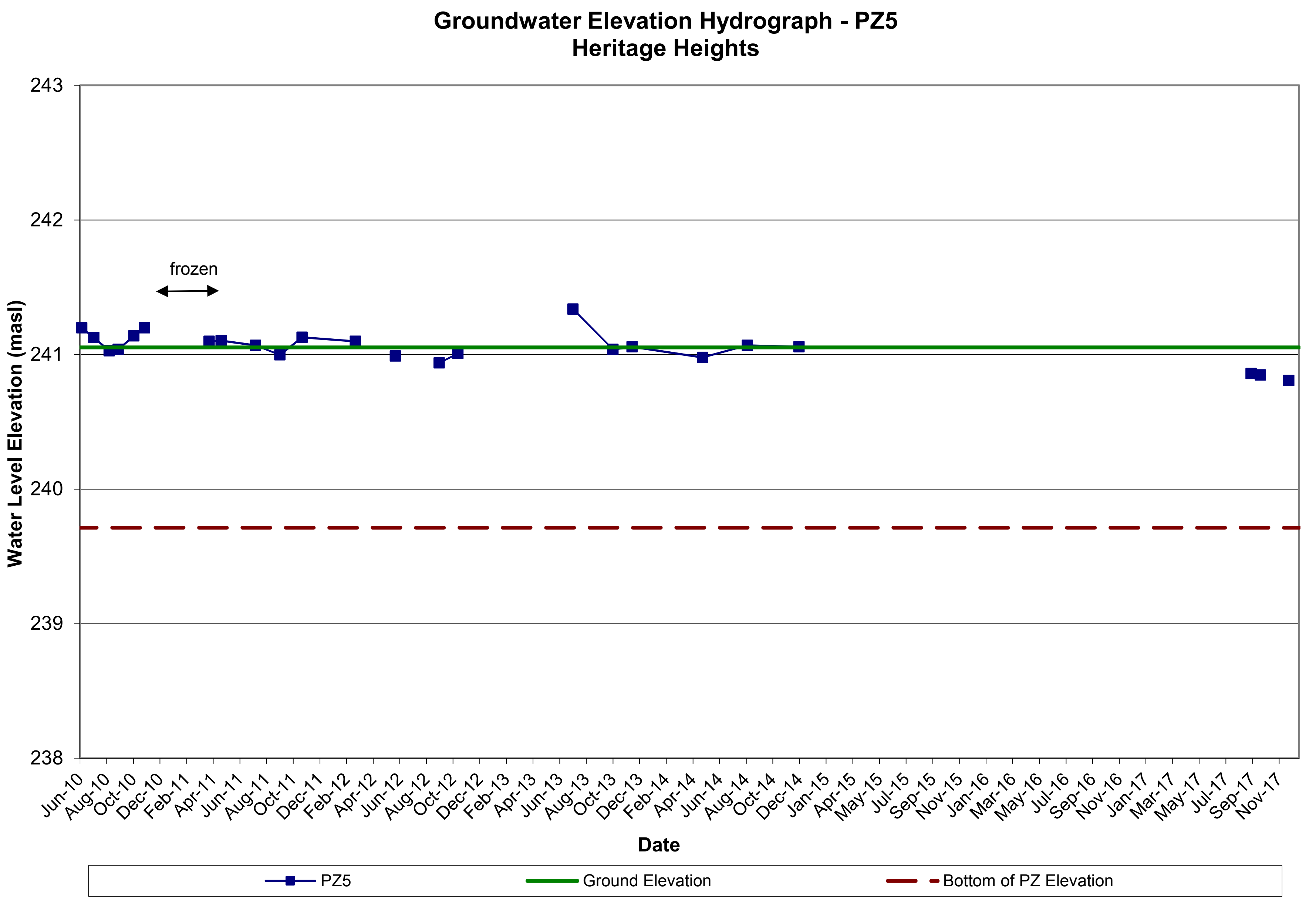

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Figure D-13

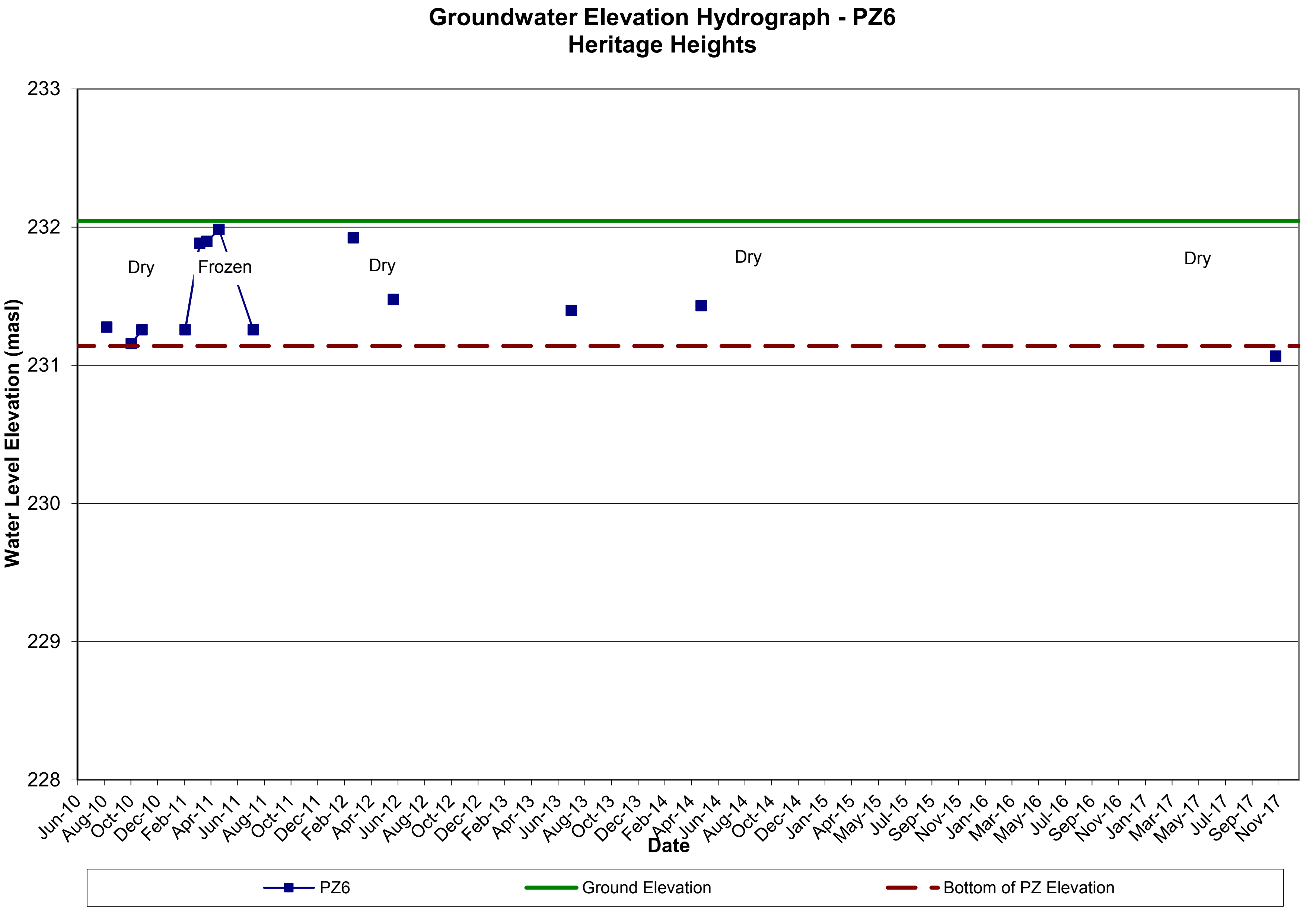

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Figure D-14

Groundwater Elevation Hydrograph - PZ7
Heritage Heights

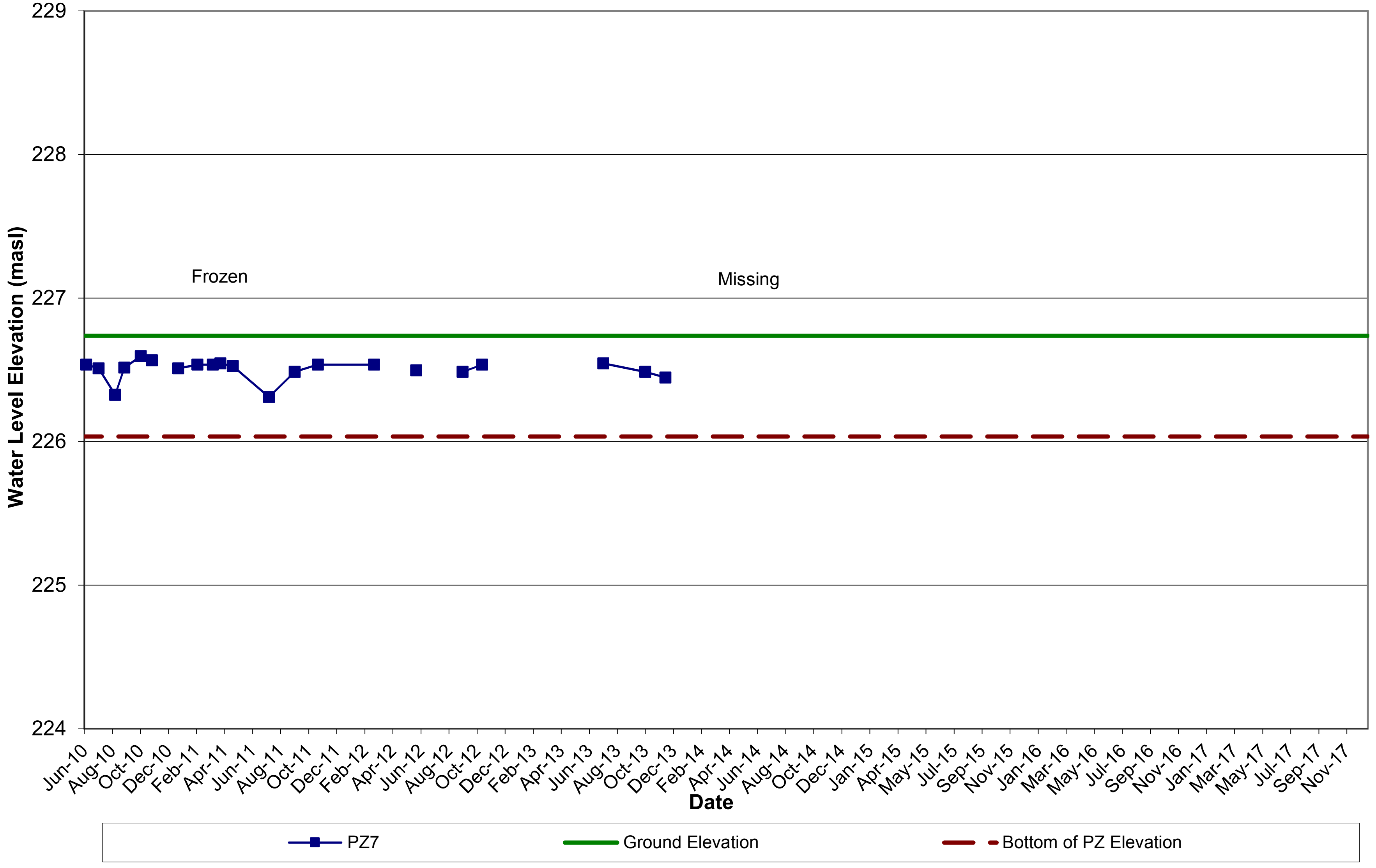

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Figure D-15

Groundwater Elevation Hydrograph - PZ8s/d
Heritage Heights

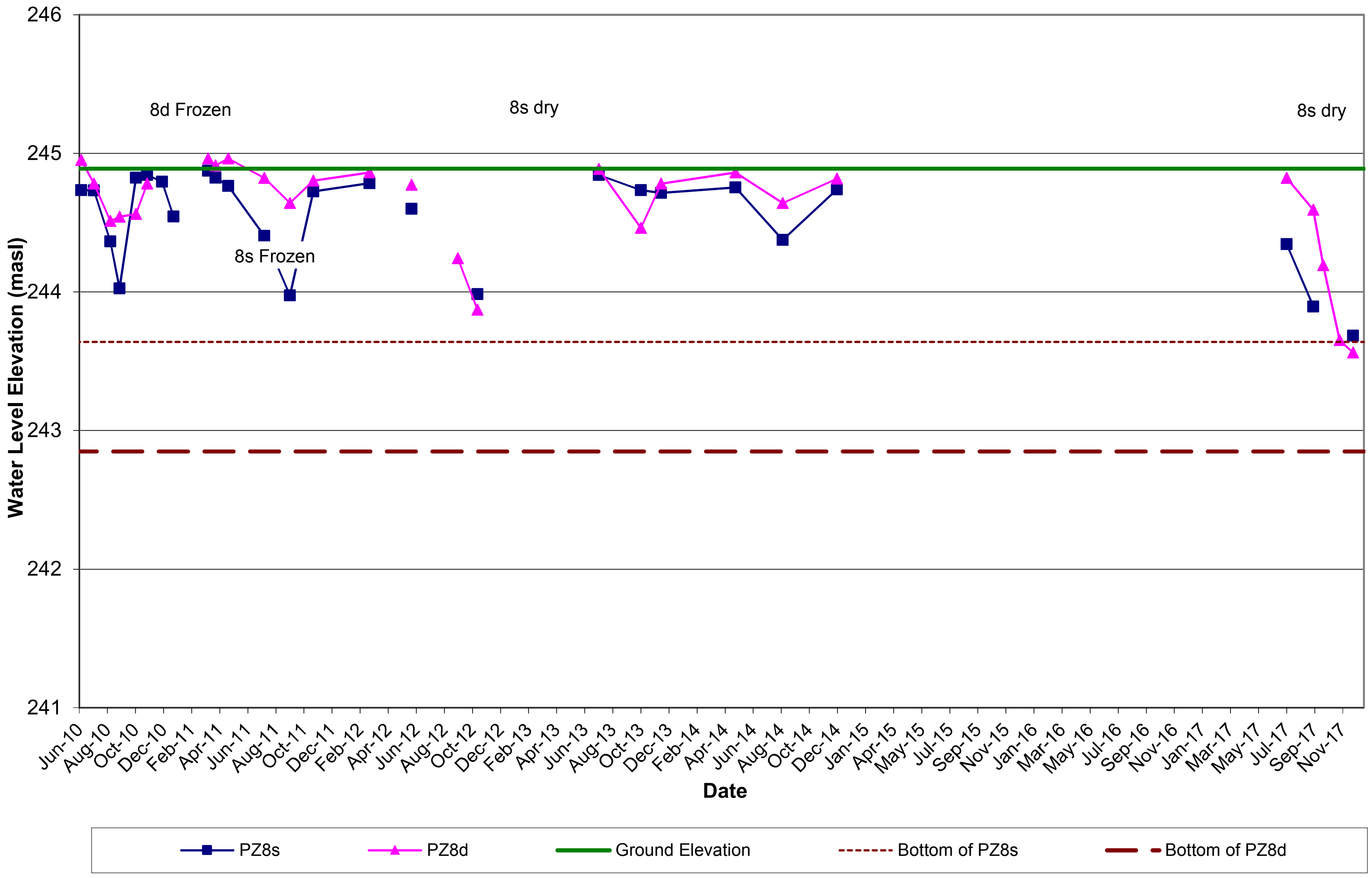

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Figure D-16

Groundwater Elevation Hydrograph - PZ9
Heritage Heights

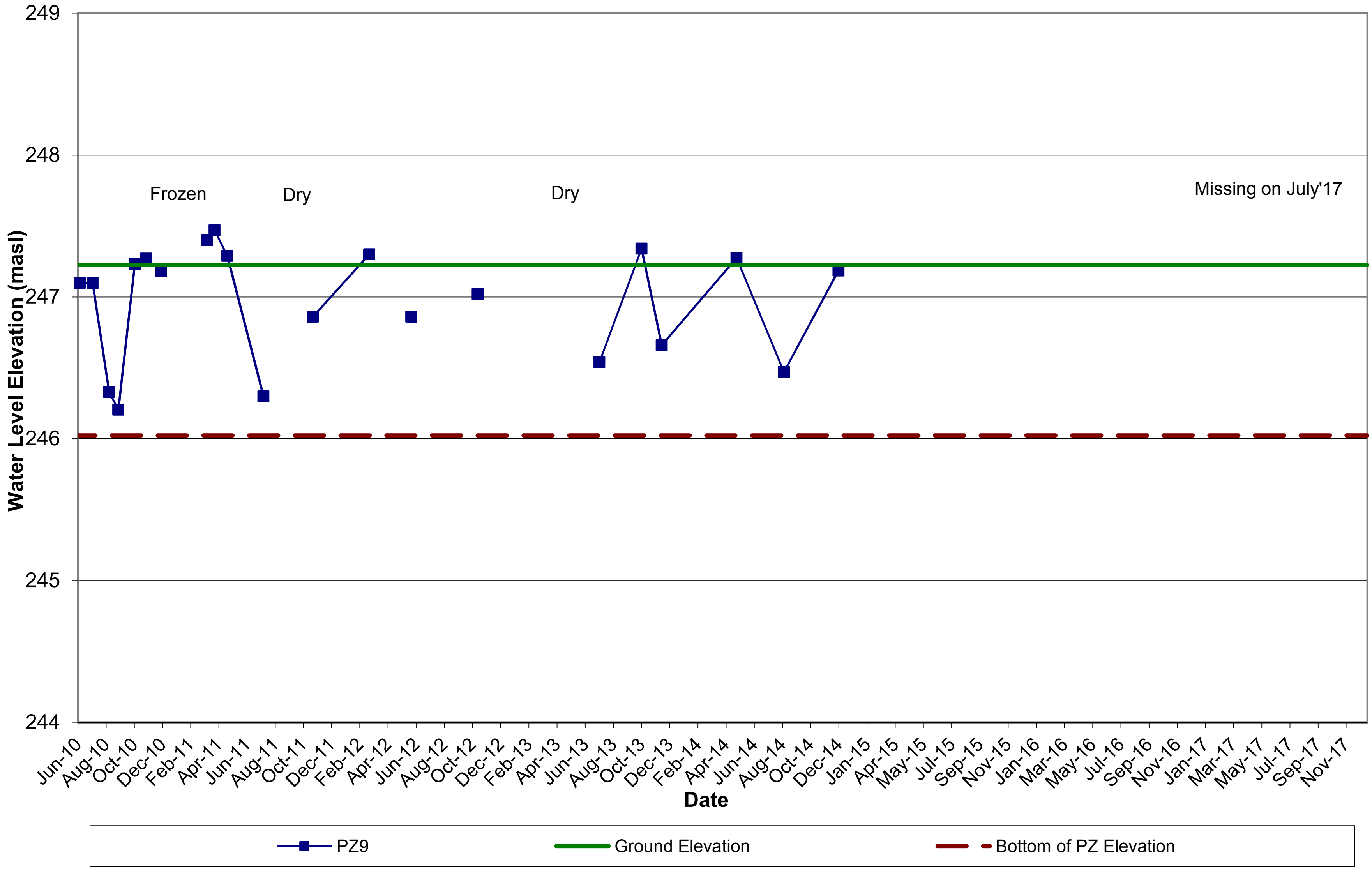

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Figure D-17

Groundwater Elevation Hydrograph - PZ10
Heritage Heights

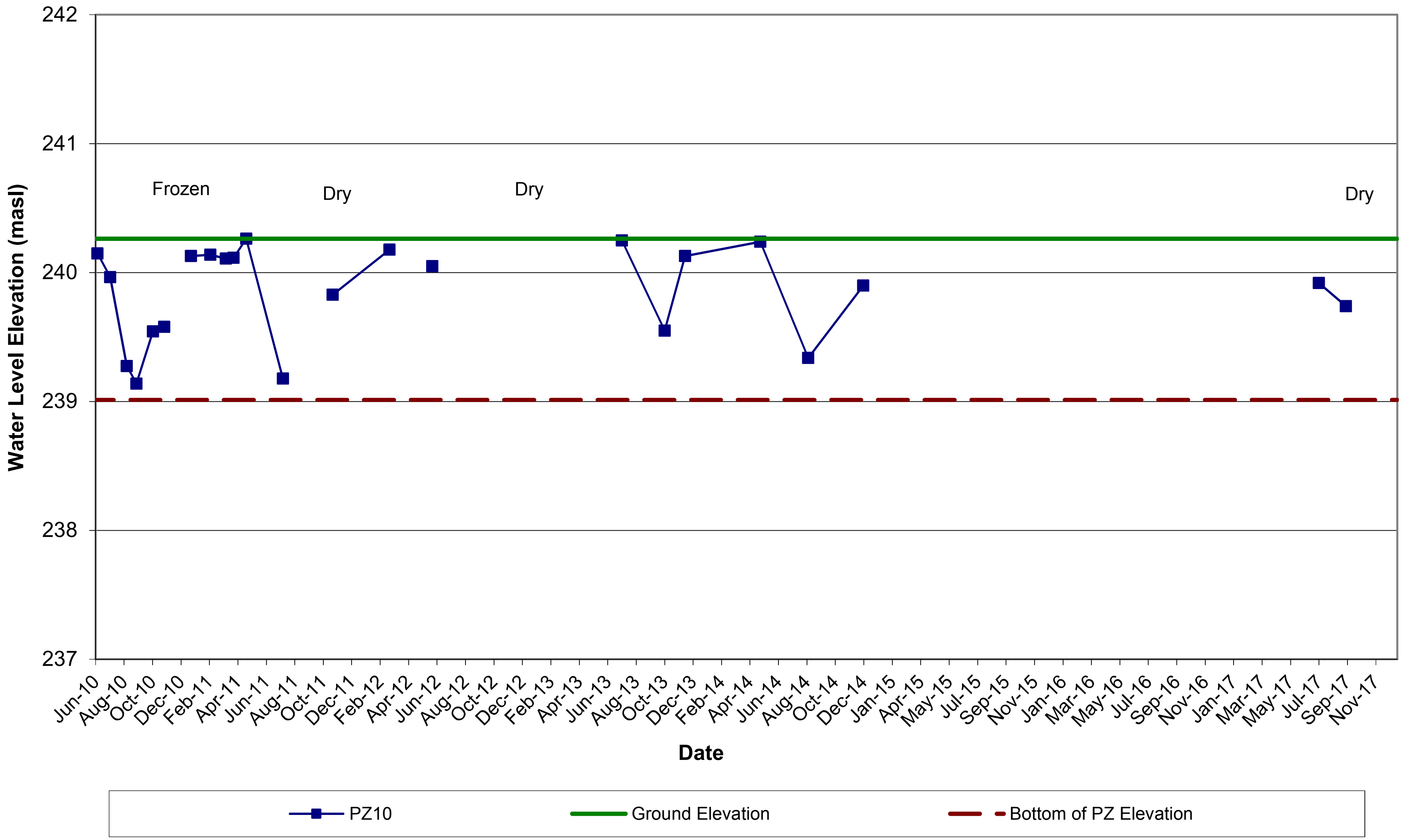

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Figure D-18

Groundwater Elevation Hydrograph - PZ11s/d
Heritage Heights

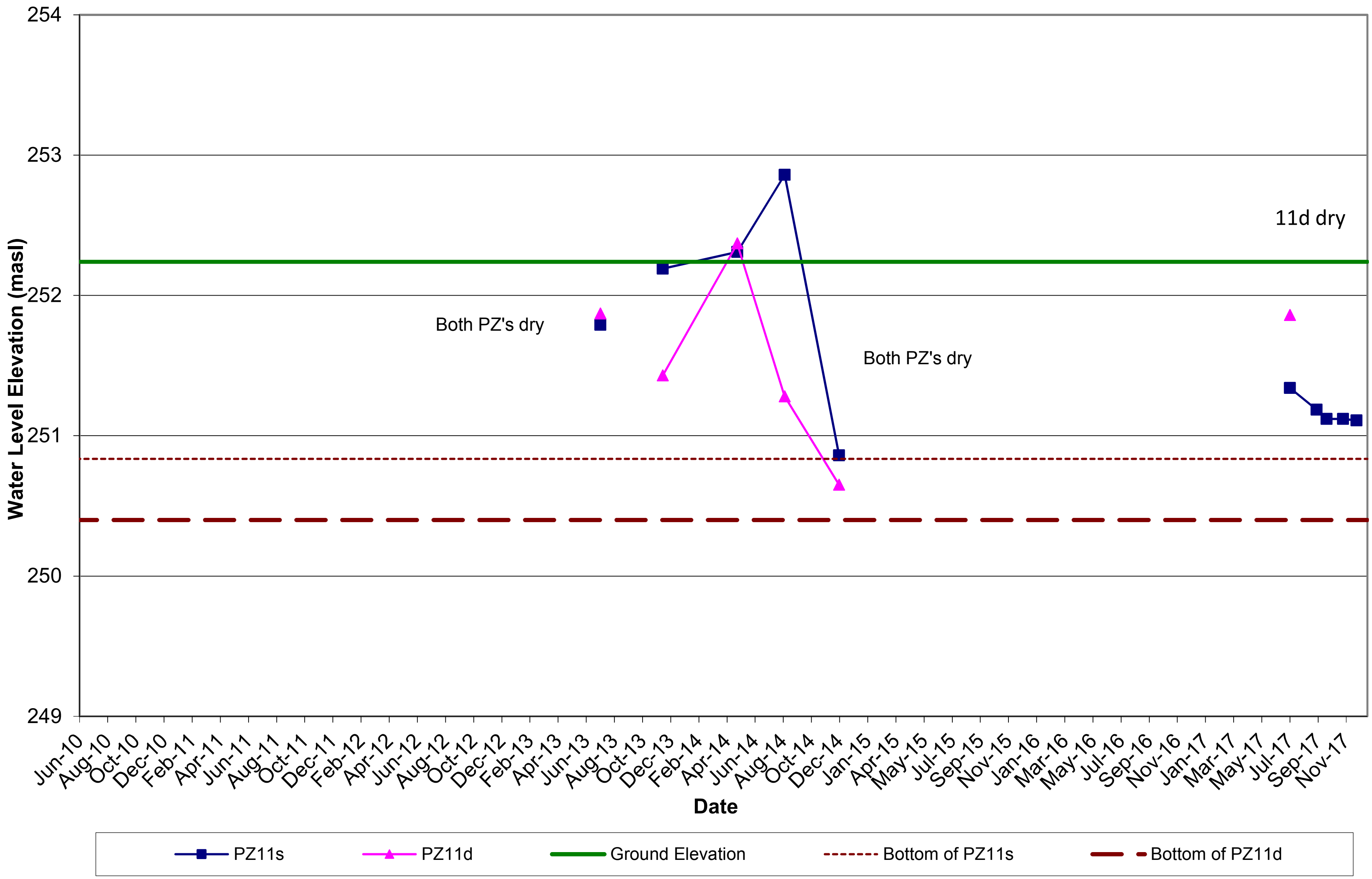

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Figure D-19

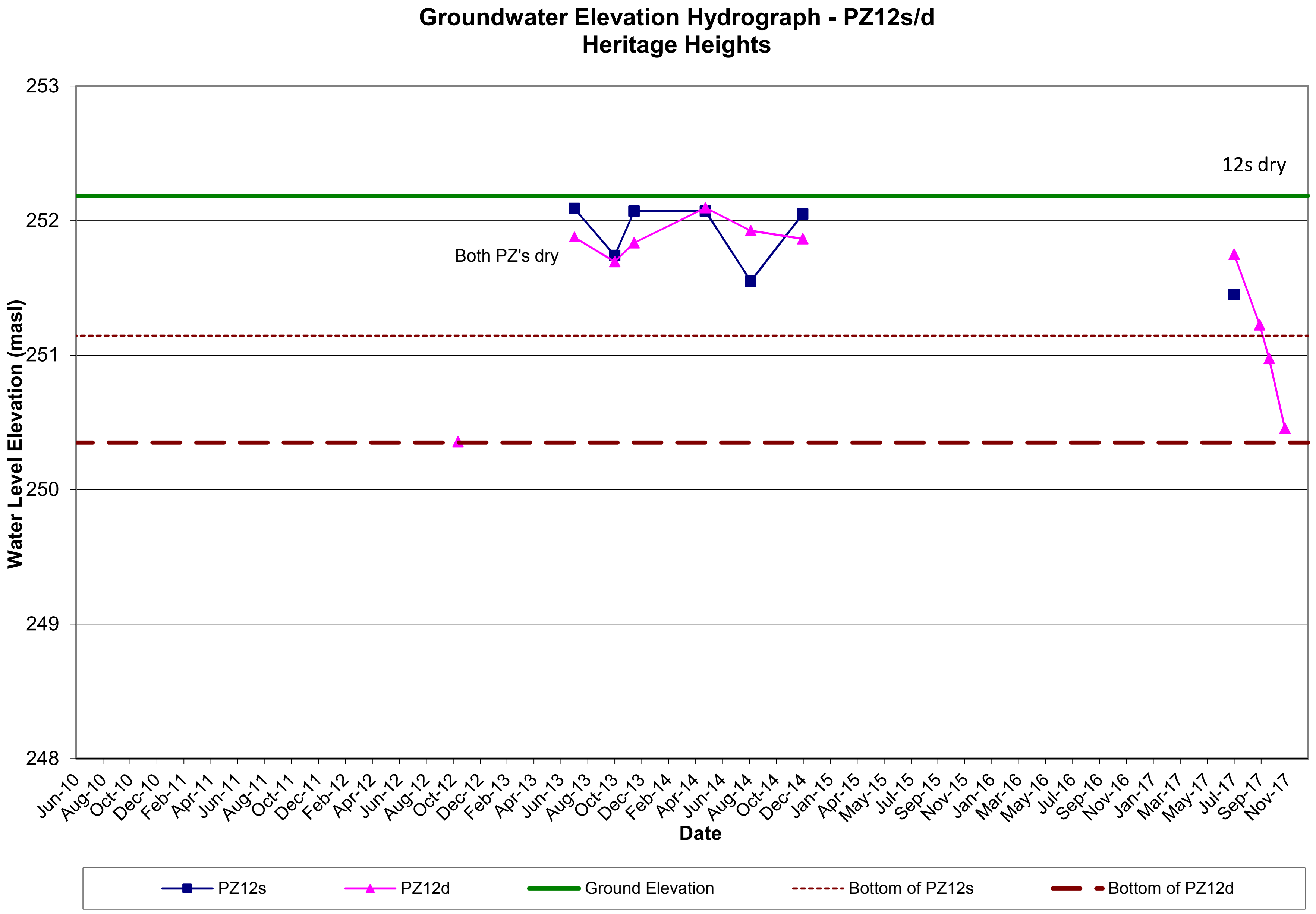

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Figure D-20

Groundwater Elevation Hydrograph - PZ13/PZ13a
Heritage Heights

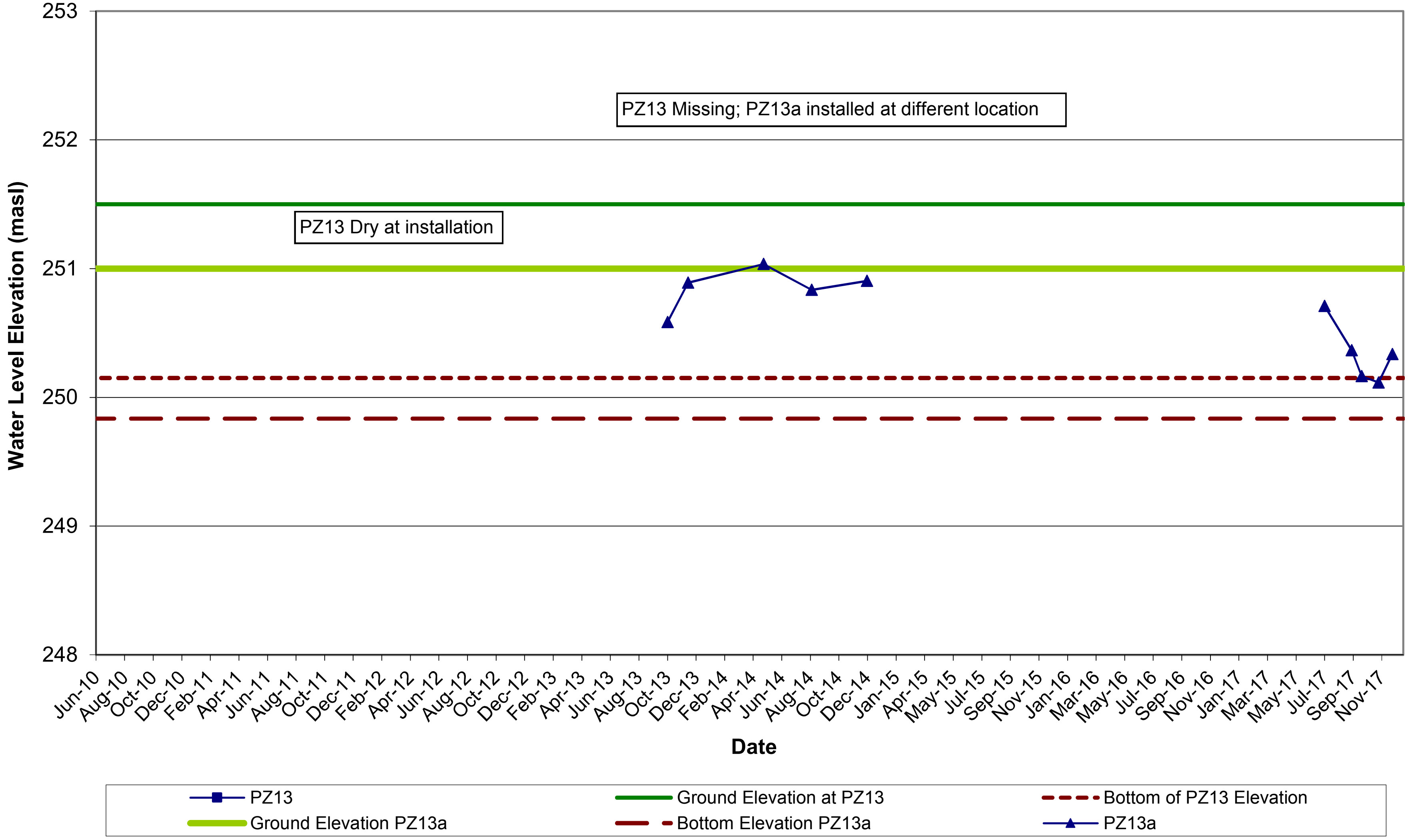

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Figure D-21

Groundwater Elevation Hydrograph - PZ14
Heritage Heights

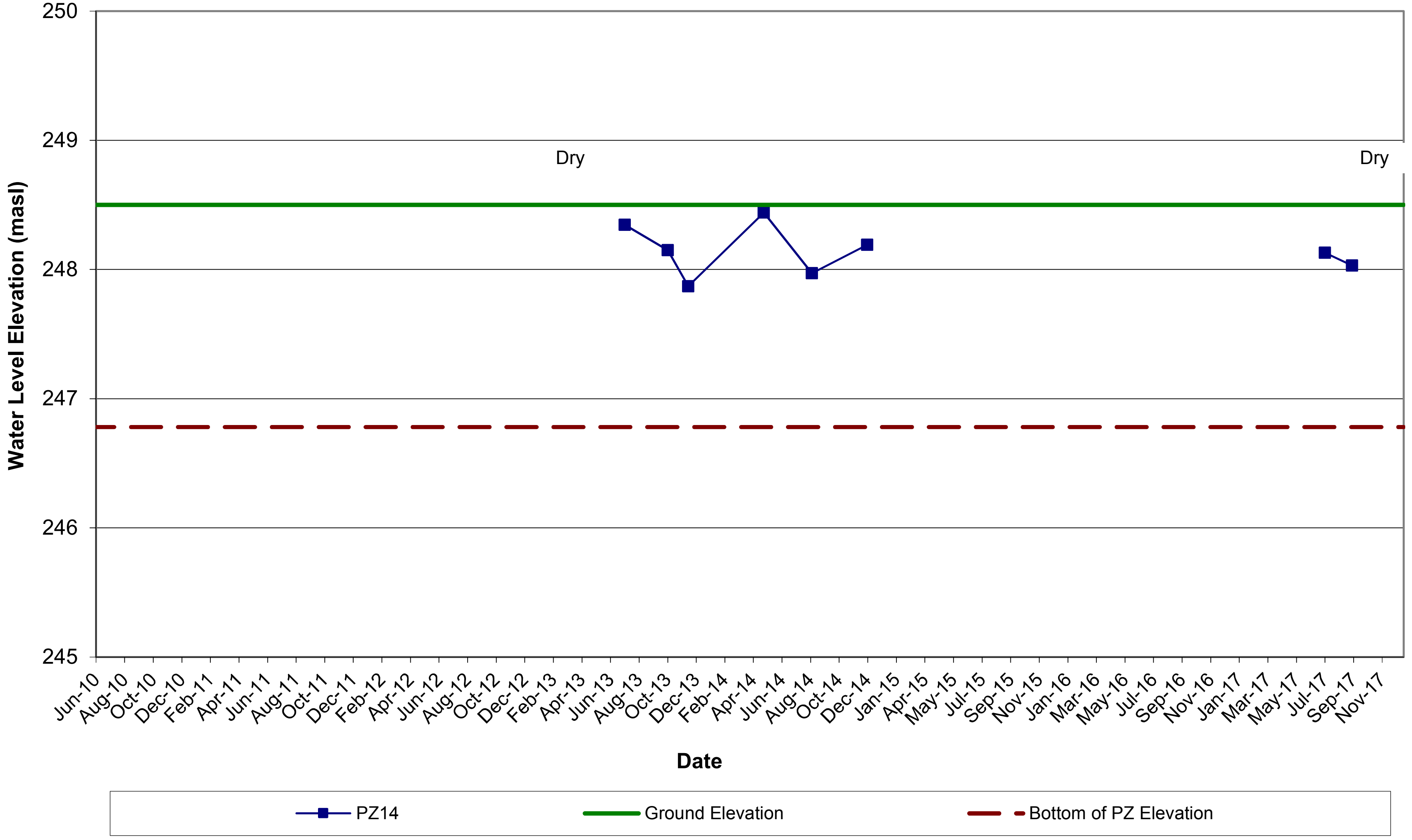

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Figure D-22

Groundwater Elevation Hydrograph - PZ15
Heritage Heights

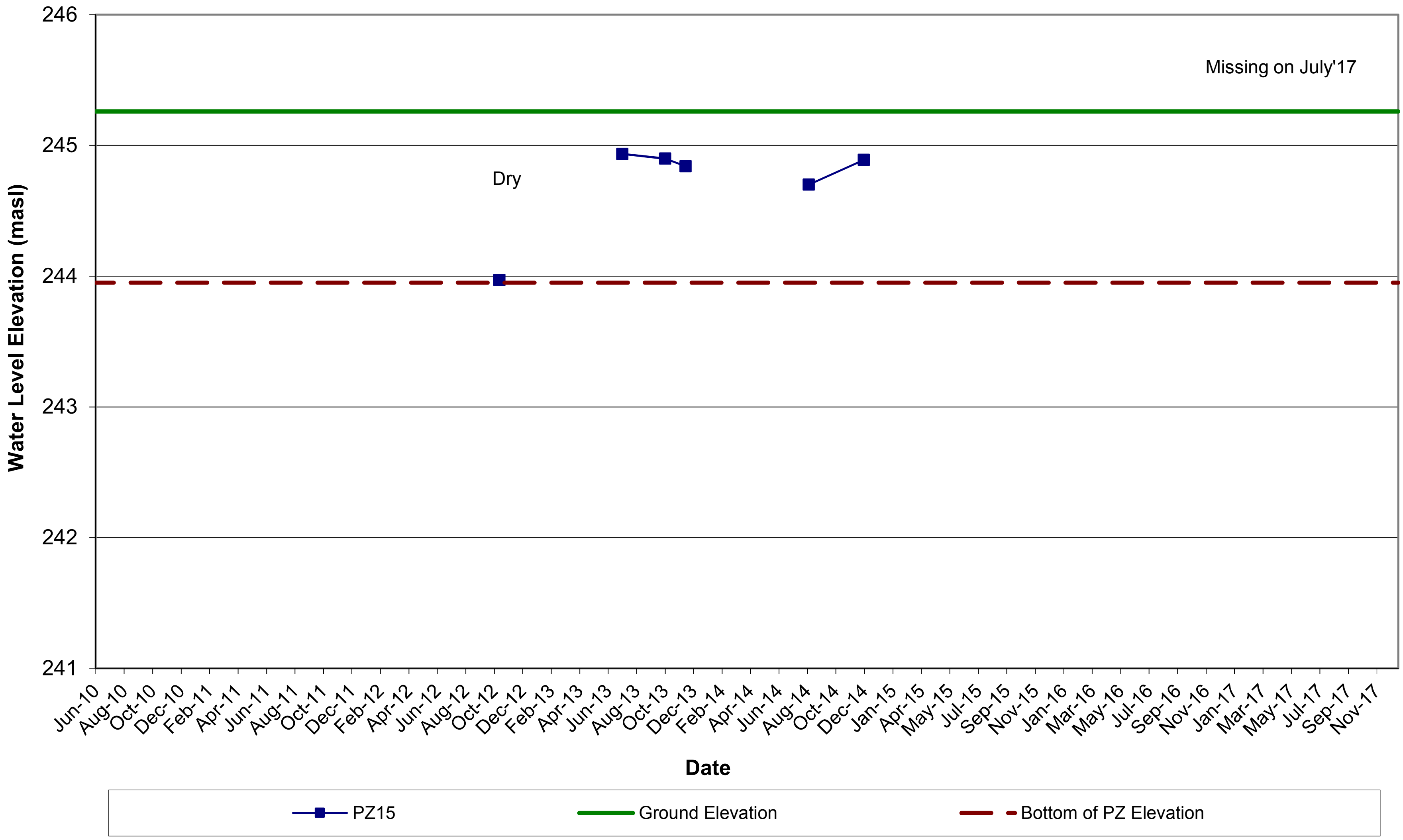

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Figure D-23

Groundwater Elevation Hydrograph - PZ16
Heritage Heights

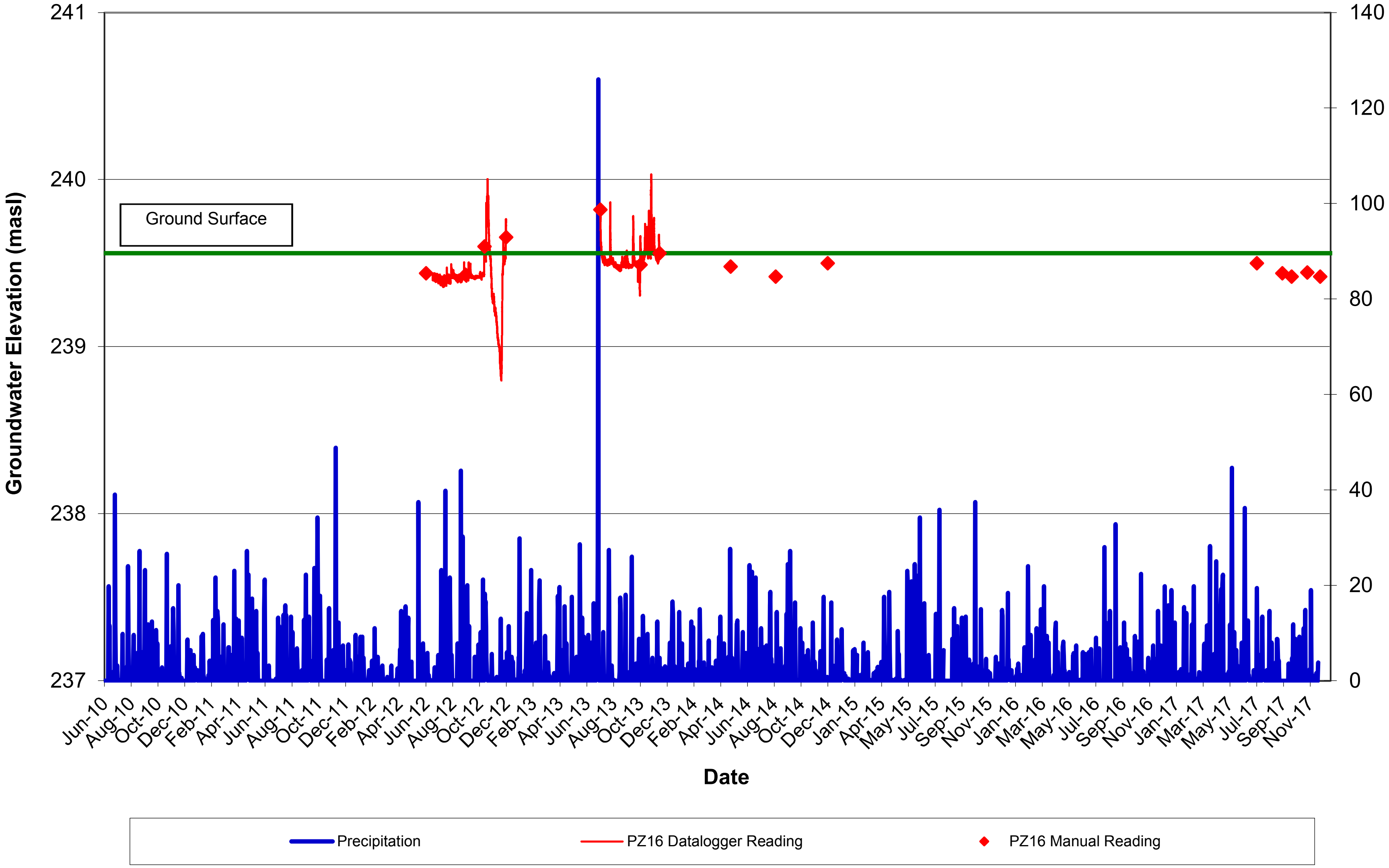

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Figure D-24

Groundwater Elevation Hydrograph - PZ17
Heritage Heights

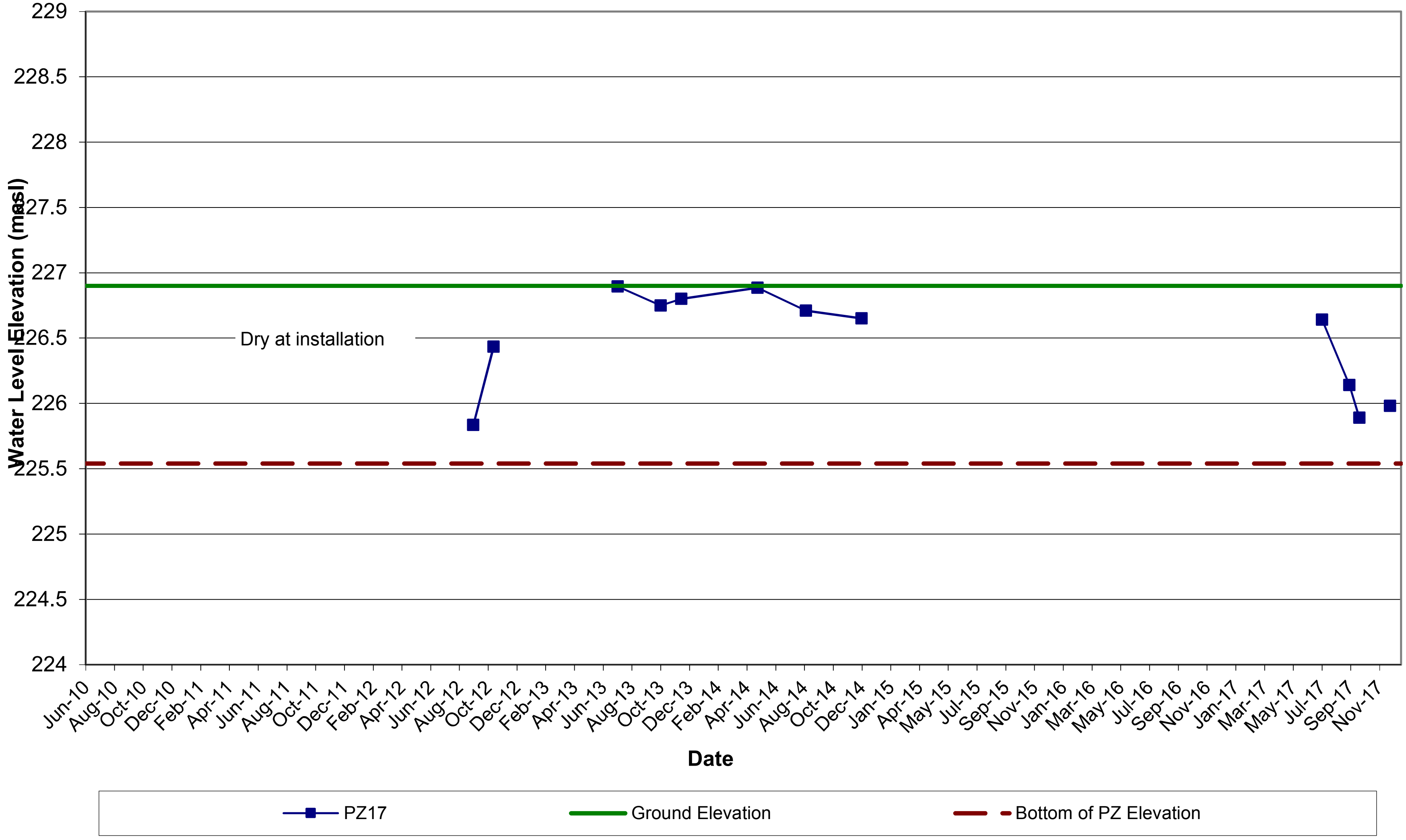

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Figure D-25

Groundwater Elevation Hydrograph - PZ18
Heritage Heights

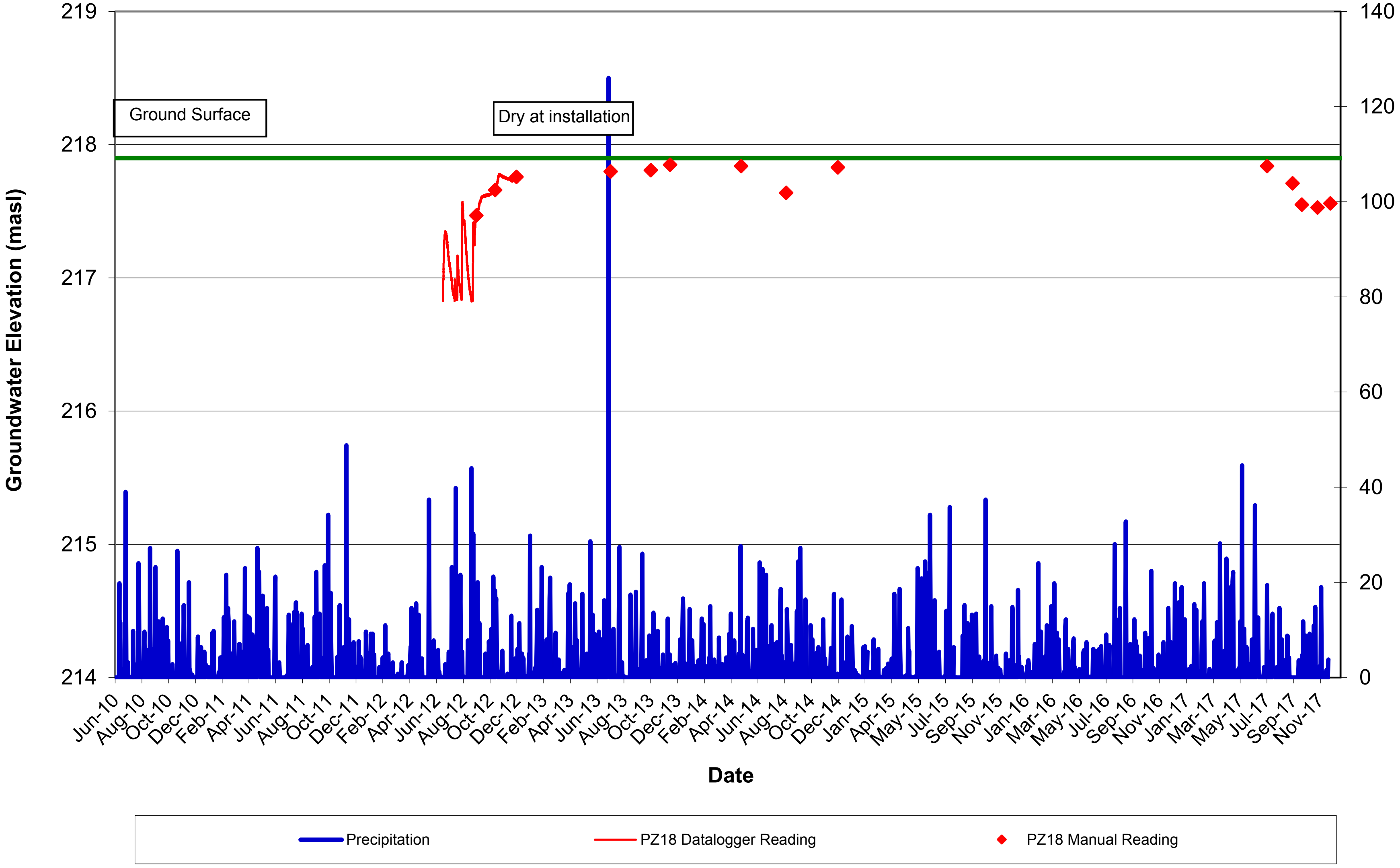

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Figure D-26

B-6 Surface Water Flow

Table E-1
Surface Water Flows
Heritage Heights

Monitoring Station	30-Jun-10	27-Jul-10	31-Aug-10	20-Sep-10	1-Nov-10	19-Nov-10	20-Dec-10
Days Post Rain Event	3	3	6	2	1	1	1
Amount of Precipitation (mm)	53.2	11.4	2.8	0.6	0.4	0.8	0.6
MAY1	no flow	dry	dry	dry	no flow	dry	frozen
MAY2	no flow	no flow	dry	no flow	no flow	no flow	no flow
MAY3	no flow	no flow	dry	no flow	no flow	no flow	no flow
MIS1	no flow	no flow	dry	no flow	no flow	no flow	frozen
MIS2	dry	dry	dry	dry	dry	dry	dry
MIS3	no flow	no flow	dry	no flow	no flow	no flow	frozen
MIS4	dry	dry	dry	dry	dry	no flow	frozen
MIS5	2	5	<0.1	no flow	5	38	6
MIS6	no flow	no flow	dry	dry	<0.1	no flow	no flow
MIS7	8	11	2	3	12	51	no flow
MIS8	no flow	18	no flow	no flow	no flow	no flow	frozen
MIS9	<0.1	<0.1	dry	dry	<0.1	1	1
WAN1	no flow	no flow	dry	dry	no flow	no flow	frozen
WAN2	no flow	no flow	dry	no flow	no flow	no flow	frozen
WAN3	no flow	no flow	dry	no flow	dry	no flow	frozen
BOV1	no flow	no flow	dry	dry	dry	no flow	frozen
BOV2	no flow	no flow	dry	no flow	no flow	no flow	frozen
BOV3	no flow	<0.1	no flow	no flow	no flow	no flow	no flow
BOV4	1	no flow	dry	no flow	no flow	no flow	no flow
HER1	no flow	<0.1	dry	dry	no flow	no flow	frozen
QST1	56	36	<0.1	5	21	141	frozen
RL1	1	1	dry	dry	2	16	2
RL2	no flow	no flow	dry	dry	dry	no flow	dry
RL3	no flow	no flow	dry	dry	<0.1	no flow	frozen
WIN1	dry	no flow	dry	dry	no flow	no flow	frozen
WIN2 (CRT1)	2	<0.1	dry	dry	<0.1	0.2	frozen
CRT2	-	-	-	-	-	-	-
CRT3	-	-	-	-	-	-	-
CRT4	-	-	-	-	-	-	-

All flows shown in L/s
"same day" - data reported by weather office overnight prior to, or post monitoring event

Table E-1
Surface Water Flows
Heritage Heights

Monitoring Station	13-Jan-11	23-Feb-11	22-Mar-11	13-Apr-11	10-May-11	26-Jul-11	12-Sep-11	8-Nov-11
Days Post Rain Event	1	3	1	3	4	1	8	same day
Amount of Precipitation (mm)	1.8	4.2	3.6	5.4	2	11.4	3.4	0.6
MAY1	frozen	frozen	<0.1	no flow	dry	dry	dry	dry
MAY2	frozen	frozen	<0.1	no flow	no flow	dry	dry	dry
MAY3	frozen	partially frozen (no flow under ice)	<0.1	no flow	no flow	dry	dry	<0.1
MIS1	frozen	frozen	4	no flow	dry	dry	dry	no flow
MIS2	frozen	frozen	no flow	no flow	dry	dry	dry	dry
MIS3	frozen	frozen	3	no flow	no flow	no flow	dry	no flow
MIS4	frozen	frozen	no flow	no flow	no flow	dry	dry	dry
MIS5	no flow	frozen	125	1	<0.1	<0.1	1	18
MIS6	no flow	frozen	18	no flow	no flow	dry	dry	no flow
MIS7	frozen	frozen	254	1	1	<0.1	1	31
MIS8	frozen	frozen	30	no flow	no flow	no flow	no flow	no flow
MIS9	frozen	frozen	5	3	3	<0.1	dry	6
WAN1	frozen	frozen	4	no flow	no flow	dry	dry	no flow
WAN2	frozen	frozen	57	no flow	<0.1	dry	dry	no flow
WAN3	frozen	frozen	46	no flow	no flow	dry	dry	no flow
BOV1	frozen	frozen	<0.1	dry	dry	dry	dry	dry
BOV2	frozen	frozen	20	<0.1	no flow	dry	dry	2
BOV3	frozen	partially frozen (<0.1L/s under ice)	4	no flow	no flow	no flow	dry	<0.1
BOV4	no flow	partially frozen (no flow under ice)	2	<0.1	no flow	no flow	dry	1
HER1	frozen	frozen	110	no flow	<0.1	dry	dry	1
QST1	frozen	162	378	1	1	1	2	82
RL1	frozen	frozen	90	1	<0.1	<0.1	1	23
RL2	frozen	frozen	7	no flow	no flow	dry	dry	no flow
RL3	frozen	frozen	24	no flow	no flow	dry	dry	no flow
WIN1	frozen	frozen	2	no flow	no flow	dry	dry	no flow
WIN2 (CRT1)	frozen	frozen	32	0.2	no flow	dry	dry	6
CRT2	-	-	-	-	-	-	-	-
CRT3	-	-	-	-	-	-	-	-
CRT4	-	-	-	-	-	-	-	-

All flows shown in L/s
"same day" - data reported by weather office overnight prior to, or post monitoring event

Table E-1
Surface Water Flows
Heritage Heights

Monitoring Station	7-Mar-12	8-Jun-12	12-Sep-12	6-Nov-12	15-Jul-13	8-Oct-13	20-Nov-13
Days Post Rain Event	4	2	4	4	6	1	3
Amount of Precipitation (mm)	0.2	7.4	30.2	0.8	153.0	3.6	12.4
MAY1	<0.1	<0.1	dry	<0.1	dry	dry	<0.1
MAY2	<0.1	no flow	dry	no flow	dry	dry	no flow
MAY3	no flow	no flow	dry	<0.1	no flow	dry	no flow
MIS1	<0.1	dry	dry	<0.1	no flow	no flow	<0.1
MIS2	dry	dry	dry	dry	dry	dry	no flow
MIS3	frozen	no flow	dry	no flow	no flow	no flow	no flow
MIS4	frozen	no flow	dry	no flow	no flow	na (construction)	no flow
MIS5	15	4	1.4	29.8	4.3	1.6	18.0
MIS6	<0.1	0.70	dry	0.3	no flow	dry	1.1
MIS7	36	9	13	31	38.0	13.0	63.0
MIS8	<0.1	no flow	no flow	no flow	no flow	na (construction)	na (construction)
MIS9	9	<0.5	dry	4.5	2.1	0.2	2.1
WAN1	<0.1	dry	dry	no flow	no flow	no flow	no flow
WAN2	13	no flow	dry	7.73	dry	no flow	0.8
WAN3	11	no flow	dry	no flow	no flow	no flow	3.6
BOV1	dry	no flow	dry	no flow	dry	dry	no flow
BOV2	4	no flow	dry	no flow	no flow	no flow	0.6
BOV3	2	<0.1	dry	<0.1	no flow	no flow	0.9
BOV4	1	<0.1	dry	0.3	no flow	no flow	0.4
HER1	6	no flow	dry	<0.1	2.0	7.3	frozen
QST1	90	33	17	54	70.0	30.0	94.0
RL1	17	4	1	10	3.0	0.3	11.0
RL2	<0.1	no flow	dry	no flow	dry	dry	frozen
RL3	3	no flow	dry	no flow	dry	3.3	frozen
WIN1	1	dry	dry	no flow	dry	1.0	<0.1
WIN2 (CRT1)	15	<0.5	dry	1.5	0.7	14.6	10.3
CRT2	-	-	0.6	13	9.8	2.0	18.1
CRT3	-	-	dry	4	2.0	dry	1.7
CRT4	-	-	1	16	5.1	1.0	6.8

All flows shown in L/s
"same day" - data reported by weather office overnight prior to, or post monitoring event

Table E-1
Surface Water Flows
Heritage Heights

Monitoring Station	28-Apr-14	7-Aug-14	25-Nov-14	19-Jul-17	30-Aug-17	5-Oct-17	8-Nov-17	29-Nov-17
Days Post Rain Event	3	3	2	6	8	1	3	4
Amount of Precipitation (mm)	5.0	3.6	20.6	2.8	8.0	3.6	14.8	1.0
MAY1	<0.5	dry	0.5	no flow	dry	dry	<0.1	<0.5
MAY2	no flow	dry	no flow	dry	dry	dry	dry	dry
MAY3	dry	dry	<0.1	dry	dry	dry	dry	dry
MIS1	<0.5	dry	no flow	no flow	dry	dry	no flow	dry
MIS2	dry	dry	no flow	dry	dry	dry	dry	dry
MIS3	dry	no flow	no flow	no flow	dry	dry	dry	<0.5
MIS4	dry	dry	no flow	dry	dry	dry	dry	dry
MIS5	na (construction)	1.0	13.3	1.1	1.0	0.3	1.9	1.4
MIS6	dry	no flow	17.9	na (construction)	dry	dry	dry	dry
MIS7	53.0	135.0	46.0	28.0	15.0	59.0	64.0	20.0
MIS8	dry	dry	no flow	na (construction)	dry	dry	dry	dry
MIS9	2.1	1.0	7.1	<0.5	dry	na	dry	7.4
WAN1	<0.5	dry	partially frozen	dry	dry	dry	dry	dry
WAN2	<0.5	dry	partially frozen	dry	dry	dry	no flow	no flow
WAN3	no flow	no flow	frozen	dry	dry	dry	no flow	dry
BOV1	dry	dry	<0.1	dry	dry	dry	dry	dry
BOV2	dry	dry	frozen	dry	dry	no flow	dry	no flow
BOV3	<0.5	no flow	0.3	no flow	no flow	no flow	dry	dry
BOV4	dry	dry	0.5	no flow	dry	dry	dry	1.1
HER1	<0.5	dry	frozen	no flow	dry	dry	dry	dry
QST1	76.0	79.0	56.0	86.0	54.0	93.0	198.0	43.0
RL1	4.0	<0.5	5.0	<0.5	dry	0.3	0.8	0.3
RL2	dry	dry	no flow	dry	dry	dry	dry	dry
RL3	no flow	dry	no flow	dry	dry	dry	no flow	dry
WIN1	dry	dry	0.5	dry	dry	dry	dry	dry
WIN2 (CRT1)	1.3	dry	3.3	dry	dry	dry	dry	dry
CRT2	11.4	5.1	31.5	5.0	2.0	1.6	3.0	2.2
CRT3	4.3	dry	2.8	dry	dry	na	no flow	dry
CRT4	8.3	1.1	8.5	na (construction)	na (construction)	4.2	na (construction)	3.8

All flows shown in L/s
"same day" - data reported by weather office overnight prior to, or post monitoring event

Table E-2
Surface Water Levels
Heritage Heights

Date	Days post rain event *	Monitoring Locations									
		SG1 (W34)		**SG2**		**SG3**		**SG4** (W29)		**SG5**	
		Ground Elevation (masl)	*252.03*	Ground Elevation (masl)	*246.00*	Ground Elevation (masl)	*239.00*	Ground Elevation (masl)	*228.00*	Ground Elevation (masl)	*217.00*
		Measured Level (magl)	Water Level Elevation (masl)	Measured Level (magl)	Water Level Elevation (masl)	Measured Level (magl)	Water Level Elevation (masl)	Measured Level (magl)	Water Level Elevation (masl)	Measured Level (magl)	Water Level Elevation (masl)
15-Jun-12	3	dry	dry	0.32	246.32	0.25	239.25	dry	dry	0.25	217.25
12-Sep-12	4	dry	dry	dry	dry	0.25	239.25	dry	dry	dry	dry
24-Oct-12	1	dry	dry	-	-	0.43	239.43	0.06	228.06	0.11	217.11
6-Nov-12	4	-	-	0.11	246.11	0.34	239.34	-	-	-	-
15-Jul-13	7	0.27	252.30	0.53	246.53	0.59	239.59	0.09	228.09	0.11	217.11
8-Oct-13	1	dry	-	0.31	246.31	0.26	239.26	0.09	228.09	0.11	217.11
20-Nov-13	3	0.27	252.30	0.70	246.70	0.41	239.41	0.10	228.10	0.11	217.11
28-Apr-14	3	0.25	252.28	0.80	246.80	0.18	239.18	0.19	228.19	0.15	217.15
7-Aug-14	3	dry	dry	0.45	246.45	0.16	239.16	dry	dry	0.06	217.06
26-Nov-14	2	0.27	252.30	0.79	246.79	0.24	239.24	0.11	228.11	0.11	217.11
19-Jul-17	6	dry	-	0.20	246.20	0.03	239.03	dry	-	0.01	217.01
30-Aug-17	8	dry	-	dry	-	dry	-	dry	-	dry	-
5-Oct-17	1	dry	-	dry	-	0.03	239.03	dry	-	dry	-
8-Nov-17	3	dry	-	dry	-	0.12	239.12	dry	-	0.10	217.10
29-Nov-17	4	dry	-	frozen	-	0.06	239.06	dry	-	frozen	-

Notes: - water levels measured in metres from bottom of gauge where SG installed

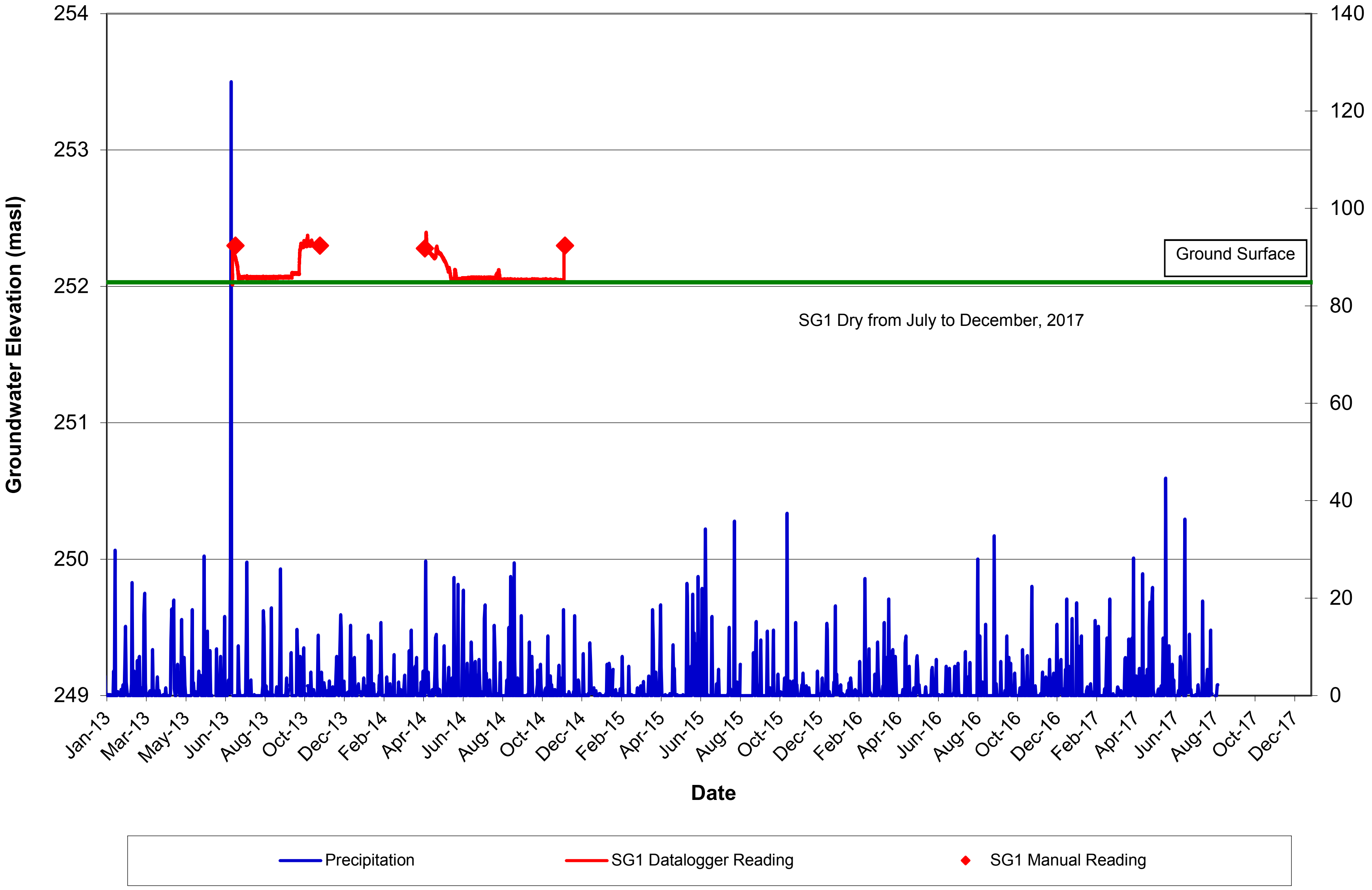
*preferred methodology for monitoring is 2 to 3 days post rain events, however, wet climate conditions may preclude this intent.

italic - estimated ground elevation from topographic mapping

masl - metres above sea level

magl - metres above ground level

Surface Water Elevation Hydrograph - SG1
Heritage Heights



R.J. Burnside & Associates Limited
300030932

Figure E-1

B-7 Water Quality

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: R.J. BURNSIDE & ASSOCIATES
17345 LESLIE STREET
Newmarket, ON L3Y0A4
(905) 953-8967

ATTENTION TO: Carmen Dinulescu

PROJECT NO: 030932

AGAT WORK ORDER: 12T622867

WATER ANALYSIS REVIEWED BY: Mike Muneswar, BSc (Chem), Senior Inorganic Analyst

DATE REPORTED: Jul 31, 2012

PAGES (INCLUDING COVER): 8

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

Certificate of Analysis

AGAT WORK ORDER: 12T622867
PROJECT NO: 030932

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: R.J. BURNSIDE & ASSOCIATES

ATTENTION TO: Carmen Dinulescu

Water Quality Assessment

DATE SAMPLED: Jul 20, 2012 DATE RECEIVED: Jul 23, 2012 DATE REPORTED: Jul 31, 2012 SAMPLE TYPE: Water

Parameter	Unit	G / S	RDL	MW1 3540062	RDL	MW2 3540065	MW4 3540071	MW7S 3540080	MW7D 3540086	MW8 3540094
Aluminum	mg/L	(0.1)	0.004	0.007	0.004	0.019	0.005	0.011	0.007	0.005
Arsenic	mg/L	0.025	0.003	<0.003	0.003	0.003	<0.003	<0.003	<0.003	<0.003
Barium	mg/L	1	0.002	0.265	0.002	0.072	0.097	0.125	0.151	0.105
Boron	mg/L	5	0.010	0.040	0.010	0.129	0.014	0.118	0.181	0.021
Cadmium	mg/L	0.005	0.002	<0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Calcium	mg/L		0.05	791	0.05	47.6	146	80.4	85.3	99.6
Chromium	mg/L	0.05	0.003	<0.003	0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Copper	mg/L	(1)	0.003	0.005	0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Iron	mg/L	(0.3)	0.010	0.030	0.010	0.010	<0.010	0.768	0.381	<0.010
Potassium	mg/L		0.05	10.2	0.05	3.99	1.41	4.34	5.69	1.35
Magnesium	mg/L		0.05	226	0.05	35.0	36.9	30.1	33.7	11.0
Mercury	mg/L	0.001	0.0001	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Manganese	mg/L	(0.05)	0.002	0.293	0.002	0.013	0.005	0.021	0.133	0.016
Molybdenum	mg/L		0.002	0.005	0.002	0.003	<0.002	<0.002	<0.002	<0.002
Sodium	mg/L	20 (200)	0.05	681	0.05	19.4	29.6	14.9	21.5	6.36
Nickel	mg/L		0.003	0.094	0.003	0.004	0.009	0.004	0.005	0.006
Total Phosphorus	mg/L		0.25	13.0	0.05	4.79	4.66	0.33	1.15	2.93
Lead	mg/L	0.01	0.002	<0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Selenium	mg/L	0.01	0.004	<0.004	0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Silver	mg/L		0.002	<0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Strontium	mg/L		0.005	2.70	0.005	3.63	0.341	3.50	5.34	0.294
Thallium	mg/L		0.006	<0.006	0.006	<0.006	<0.006	<0.006	<0.006	<0.006
Titanium	mg/L		0.002	0.005	0.002	<0.002	<0.002	<0.002	0.002	<0.002
Uranium	mg/L	0.02	0.002	0.006	0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Vanadium	mg/L		0.002	<0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Zinc	mg/L	(5)	0.005	0.014	0.005	<0.005	<0.005	0.016	0.053	<0.005
Fluoride	mg/L	1.5	0.50	<0.50	0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Chloride	mg/L	(250)	1.00	3270	0.10	25.2	172	27.9	37.0	8.93
Nitrite as N	mg/L	1.0	0.50	<0.50	0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Ortho phosphate as P	mg/L		1.00	<1.00	0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Bromide	mg/L		0.50	<0.50	0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Nitrate as N	mg/L	10.0	0.50	<0.50	0.05	<0.05	14.0	<0.05	<0.05	7.12
Sulphate	mg/L	(500)	1.00	68.5	0.10	38.0	58.3	64.6	83.4	23.2

Certified By:

AGAT Laboratories

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
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Certificate of Analysis

AGAT WORK ORDER: 12T622867
PROJECT NO: 030932

CLIENT NAME: R.J. BURNSIDE & ASSOCIATES

ATTENTION TO: Carmen Dinulescu

Water Quality Assessment

DATE SAMPLED: Jul 20, 2012 DATE RECEIVED: Jul 23, 2012 DATE REPORTED: Jul 31, 2012 SAMPLE TYPE: Water

Parameter	Unit	G / S	RDL	MW1 3540062	RDL	MW2 3540065	MW4 3540071	MW7S 3540080	MW7D 3540086	MW8 3540094
pH	pH Units	(6.5-8.5)	NA	7.88	NA	8.32	7.88	8.20	8.29	7.85
Ammonia as N	mg/L		0.02	0.76	0.02	0.23	0.20	0.20	0.37	<0.02
Total Organic Carbon	mg/L		0.5	4.6	0.5	5.0	1.9	8.3	5.3	2.4
Electrical Conductivity	uS/cm		2	7840	2	602	1090	616	748	479
Total Dissolved Solids	mg/L	(500)	20	5900	20	518	928	440	530	388
Saturation pH				6.11		7.08	6.74	6.93	6.83	7.04
% Difference/ Ion Balance			0.1	5.3	0.1	1.7	3.9	0.5	6.4	3.9
Total Hardness (as CaCO3)	mg/L	(80-100)	10	2910	10	263	517	325	352	294
Langlier Index				1.77		1.24	1.14	1.27	1.46	0.81
Carbonate (as CaCO3)	mg/L		5	<5	5	5	<5	<5	<5	<5
Bicarbonate (as CaCO3)	mg/L		5	210	5	242	277	260	323	224
Turbidity	NTU	(5)	0.5	4.5	0.5	27.4	6.8	18.4	6.7	20.5
Alkalinity (as CaCO3)	mg/L	(30-500)	5	210	5	246	277	260	323	224
Hydroxide (as CaCO3)	mg/L		5	<5	5	<5	<5	<5	<5	<5
Reactive Silica	mg/L		0.05	14.7	0.05	23.1	17.7	18.2	15.3	10.3
Colour	TCU	(5)	5	<5	5	<5	<5	<5	<5	7

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to O.Reg.169/03

3540062 Samples required dilution prior to analysis for Total Phosphorus in order to keep the analyte within the calibration range of the instrument; the RDL was changed to reflect the dilution.

Certified By:

Guideline Violation

AGAT WORK ORDER: 12T622867

PROJECT NO: 030932

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: R.J. BURNSIDE & ASSOCIATES

ATTENTION TO: Carmen Dinulescu

SAMPLEID	SAMPLE TITLE	GUIDELINE	ANALYSIS PACKAGE	PARAMETER	GUIDEVALUE	RESULT
3540062	MW1	O.Reg.169/03	Water Quality Assessment	Sodium	20 (200)	681
3540062	MW1	O.Reg.169/03	Water Quality Assessment	Total Hardness (as CaCO3)	(80-100)	2910
3540065	MW2	O.Reg.169/03	Water Quality Assessment	Total Hardness (as CaCO3)	(80-100)	263
3540071	MW4	O.Reg.169/03	Water Quality Assessment	Nitrate as N	10.0	14.0
3540071	MW4	O.Reg.169/03	Water Quality Assessment	Sodium	20 (200)	29.6
3540071	MW4	O.Reg.169/03	Water Quality Assessment	Total Hardness (as CaCO3)	(80-100)	517
3540080	MW7S	O.Reg.169/03	Water Quality Assessment	Total Hardness (as CaCO3)	(80-100)	325
3540086	MW7D	O.Reg.169/03	Water Quality Assessment	Sodium	20 (200)	21.5
3540086	MW7D	O.Reg.169/03	Water Quality Assessment	Total Hardness (as CaCO3)	(80-100)	352
3540094	MW8	O.Reg.169/03	Water Quality Assessment	Total Hardness (as CaCO3)	(80-100)	294

Quality Assurance

CLIENT NAME: R.J. BURNSIDE & ASSOCIATES

AGAT WORK ORDER: 12T622867

PROJECT NO: 030932

ATTENTION TO: Carmen Dinulescu

Water Analysis

RPT Date: Jul 31, 2012			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Water Quality Assessment															
Aluminum	1		0.032	0.034	6.1%	< 0.004	104%	90%	110%	95%	90%	110%	95%	70%	130%
Arsenic	1		< 0.003	< 0.003	0.0%	< 0.003	98%	90%	110%	103%	90%	110%	94%	70%	130%
Barium	1		0.104	0.102	1.9%	< 0.002	95%	90%	110%	95%	90%	110%	95%	70%	130%
Boron	1		0.069	0.070	1.4%	< 0.010	104%	90%	110%	94%	90%	110%	99%	70%	130%
Cadmium	1		< 0.002	< 0.002	0.0%	< 0.002	95%	90%	110%	108%	80%	120%	101%	70%	130%
Calcium	1	3540094	61.0	62.9	3.1%	< 0.05	105%	90%	110%	96%	90%	110%	100%	70%	130%
Chromium	1		< 0.003	< 0.003	0.0%	< 0.003	100%	90%	110%	99%	80%	120%	96%	70%	130%
Copper	1		< 0.003	< 0.003	0.0%	< 0.003	100%	90%	110%	98%	90%	110%	99%	70%	130%
Iron	1		< 0.010	< 0.010	0.0%	< 0.010	108%	90%	110%	99%	80%	120%	101%	70%	130%
Potassium	1	3540094	1.35	1.31	3.0%	< 0.05	96%	90%	110%	96%	90%	110%	98%	70%	130%
Magnesium	1	3540094	11.0	10.8	1.8%	< 0.05	96%	90%	110%	97%	90%	110%	99%	70%	130%
Mercury	1		< 0.0001	< 0.0001	0.0%	< 0.0001	101%	90%	110%	99%	90%	110%	107%	70%	130%
Manganese	1		< 0.002	< 0.002	0.0%	< 0.002	101%	90%	110%	103%	90%	110%	101%	70%	130%
Molybdenum	1		< 0.002	< 0.002	0.0%	< 0.002	98%	90%	110%	102%	90%	110%	107%	70%	130%
Sodium	1	3540094	6.36	6.29	1.1%	< 0.05	96%	90%	110%	96%	90%	110%	99%	70%	130%
Nickel	1		0.004	0.004	0.0%	< 0.003	99%	90%	110%	97%	90%	110%	100%	70%	130%
Total Phosphorus	1		< 0.05	< 0.05	0.0%	< 0.05	105%	80%	120%	102%	90%	110%	105%	70%	130%
Lead	1		< 0.002	< 0.002	0.0%	< 0.002	97%	90%	110%	96%	90%	110%	95%	70%	130%
Selenium	1		< 0.004	< 0.004	0.0%	< 0.004	98%	90%	110%	98%	90%	110%	97%	70%	130%
Silver	1		< 0.002	< 0.002	0.0%	< 0.002	96%	90%	110%	103%	90%	110%	104%	70%	130%
Strontium	1		1.47	1.48	0.7%	< 0.005	98%	90%	110%	101%	90%	110%	82%	70%	130%
Thallium	1		< 0.006	< 0.006	0.0%	< 0.006	95%	90%	110%	95%	90%	110%	94%	70%	130%
Titanium	1		0.002	0.002	0.0%	< 0.002	99%	90%	110%	98%	90%	110%	100%	70%	130%
Uranium	1		< 0.002	< 0.002	0.0%	< 0.002	95%	90%	110%	98%	90%	110%	96%	70%	130%
Vanadium	1		< 0.002	< 0.002	0.0%	< 0.002	97%	90%	110%	98%	90%	110%	99%	70%	130%
Zinc	1		< 0.005	< 0.005	0.0%	< 0.005	99%	90%	110%	101%	90%	110%	106%	70%	130%
Fluoride	1		< 0.05	< 0.05	0.0%	< 0.05	98%	90%	110%	104%	90%	110%	97%	80%	120%
Chloride	1		72.7	75.0	3.1%	< 0.10	96%	90%	110%	100%	90%	110%	113%	80%	120%
Nitrite as N	1		< 0.05	< 0.05	0.0%	< 0.05	NA	90%	110%	104%	90%	110%	92%	80%	120%
Ortho phosphate as P	1		< 0.10	< 0.10	0.0%	< 0.10	105%	90%	110%	102%	90%	110%	105%	80%	120%
Bromide	1		< 0.05	< 0.05	0.0%	< 0.05	107%	90%	110%	106%	90%	110%	100%	80%	120%
Nitrate as N	1		0.46	0.47	2.2%	< 0.05	93%	90%	110%	102%	90%	110%	102%	80%	120%
Sulphate	1		9.21	9.48	2.9%	< 0.10	99%	90%	110%	105%	90%	110%	104%	80%	120%
pH	1	3540071	7.88	7.92	0.5%	NA	100%	90%	110%	NA			NA		
Ammonia as N	1		0.03	0.03	0.0%	< 0.02	106%	90%	110%	99%	90%	110%	108%	80%	120%
Total Organic Carbon	1		5.0	5.0	0.0%	< 0.5	98%	90%	110%	90%	90%	110%	105%	80%	120%
Electrical Conductivity	1	3540071	1090	1070	1.9%	< 2	100%	80%	120%	NA			NA		
Total Dissolved Solids	1		728	716	1.7%	< 20	100%	80%	120%	NA			NA		
Turbidity	1		1.5	1.5	0.0%	< 0.5	99%	90%	110%	NA			NA		

Quality Assurance

CLIENT NAME: R.J. BURNSIDE & ASSOCIATES

AGAT WORK ORDER: 12T622867

PROJECT NO: 030932

ATTENTION TO: Carmen Dinulescu

Water Analysis (Continued)

RPT Date: Jul 31, 2012			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Alkalinity (as CaCO3)	1	3540071	277	270	2.6%	< 5	100%	90%	110%	NA			NA		
Reactive Silica	1		22.0	21.7	1.4%	< 0.05	102%	90%	110%	100%	90%	110%	103%	80%	120%
Colour	1		488	485	0.6%	< 5	102%	90%	110%	NA			NA		

Comments: NA - Not Applicable.

Certified By:

Method Summary

CLIENT NAME: R.J. BURNSIDE & ASSOCIATES
AGAT WORK ORDER: 12T622867
PROJECT NO: 030932
ATTENTION TO: Carmen Dinulescu

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Water Analysis			
Aluminum	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Arsenic	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Barium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Boron	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Cadmium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Calcium	MET-93-6105	EPA SW-846 6010C & 200.7	ICP/OES
Chromium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Copper	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Iron	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Potassium	MET-93-6105	EPA SW-846 6010C & 200.7	ICP/OES
Magnesium	MET-93-6105	EPA SW-846 6010C & 200.7	ICP/OES
Mercury	MET-93-6100	EPA SW 846 7470 & 245.1	CVAAS
Manganese	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Molybdenum	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Sodium	MET-93-6105	EPA SW-846 6010C & 200.7	ICP/OES
Nickel	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Total Phosphorus	INOR-93-6057	QuikChem 10-115-01-3-A & SM 4500-P I	LACHAT FIA
Lead	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Selenium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Silver	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Strontium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Thallium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Titanium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Uranium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Vanadium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Zinc	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Fluoride	INOR-93-6004	SM 4110 B	ION CHROMATOGRAPH
Chloride	INOR-93-6004	SM 4110 B	ION CHROMATOGRAPH
Nitrite as N	INOR-93-6004	SM 4110 B	ION CHROMATOGRAPH
Ortho phosphate as P	INOR-93-6004	SM 4110 B	ION CHROMATOGRAPH
Bromide	INOR-93-6004	SM 4110 B	ION CHROMATOGRAPH
Nitrate as N	INOR-93-6004	SM 4110 B	ION CHROMATOGRAPH
Sulphate	INOR-93-6004	SM 4110 B	ION CHROMATOGRAPH
pH	INOR-93-6000	SM 4500-H+ B	PC TITRATE
Ammonia as N	INOR-93-6002	AQ2 EPA-103A & SM 4500 NH3-F	AQ-2 DISCRETE ANALYZER
Total Organic Carbon	INOR-93-6049	EPA 415.1 & SM 5310	SHIMADZU CARBON ANALYZER
Electrical Conductivity	INOR-93-6000	SM 2510 B	PC TITRATE
Total Dissolved Solids	INOR-93-6028	SM 2540 C	BALANCE
Saturation pH		SM 2320 B	CALCULATION
% Difference/ Ion Balance		SM 1030 E	CALCULATION
Total Hardness (as CaCO3)	MET-93-6105	EPA SW-846 6010C & 200.7 & SM 2340 B	ICP/OES
Langlier Index		SM 2330B	CALCULATION
Carbonate (as CaCO3)	INOR-93-6000	SM 2320 B	PC TITRATE
Bicarbonate (as CaCO3)	INOR-93-6000	SM 2320 B	PC TITRATE
Turbidity	INOR-93-6044	SM 2130 B	NEPHELOMETER
Alkalinity (as CaCO3)	INOR-93-6000	SM 2320 B	PC TITRATE
Hydroxide (as CaCO3)	INOR-93-6000	SM 2320 B	PC TITRATE

Method Summary

CLIENT NAME: R.J. BURNSIDE & ASSOCIATES
AGAT WORK ORDER: 12T622867
PROJECT NO: 030932
ATTENTION TO: Carmen Dinulescu

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Reactive Silica	INOR-93-6047	AQ2 EPA-122A & SM 4500 SiO2 D	AQ2 DISCRETE ANALYSER
Colour	INOR-93-6046	SM 2120 B	SPECTROPHOTOMETER

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: R.J. BURNSIDE & ASSOCIATES
17345 LESLIE STREET
Newmarket, ON L3Y0A4
(905) 953-8967

ATTENTION TO: Carmen Dinulescu

PROJECT NO: 030932

AGAT WORK ORDER: 12T622865

WATER ANALYSIS REVIEWED BY: Mike Muneswar, BSc (Chem), Senior Inorganic Analyst

DATE REPORTED: Jul 30, 2012

PAGES (INCLUDING COVER): 8

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

Certificate of Analysis

AGAT WORK ORDER: 12T622865
PROJECT NO: 030932

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: R.J. BURNSIDE & ASSOCIATES

ATTENTION TO: Carmen Dinulescu

Water Quality Assessment - (PWQO)

DATE SAMPLED: Jul 20, 2012 DATE RECEIVED: Jul 23, 2012 DATE REPORTED: Jul 30, 2012 SAMPLE TYPE: Water

Parameter	Unit	G / S	RDL	Mis5 3540116	QST1 3540127	CRT4 3540142	CRT2 3540151
Silver	mg/L	0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Aluminum-dissolved	mg/L	0.075	0.004	0.008	0.006	0.006	0.005
Arsenic	mg/L	0.1	0.003	<0.003	<0.003	<0.003	<0.003
Boron	mg/L	0.20	0.010	0.028	0.137	0.069	0.059
Barium	mg/L		0.002	0.079	0.103	0.104	0.120
Beryllium	mg/L	0.011	0.001	<0.001	<0.001	<0.001	<0.001
Calcium	mg/L		0.05	123	113	87.5	98.2
Cadmium	mg/L	0.0002	0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	mg/L		0.003	<0.003	<0.003	<0.003	<0.003
Cobalt	mg/L	0.0009	0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Copper	mg/L	0.005	0.002	<0.002	<0.002	<0.002	<0.002
Iron	mg/L	0.3	0.010	0.047	<0.010	<0.010	0.038
Potassium	mg/L		0.05	2.36	4.36	2.50	2.32
Mercury	mg/L		0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Magnesium	mg/L		0.05	21.5	22.6	18.2	16.7
Manganese	mg/L		0.002	0.067	0.014	<0.002	0.075
Molybdenum	mg/L	0.04	0.002	<0.002	<0.002	<0.002	<0.002
Sodium	mg/L		0.05	88.3	61.8	15.0	17.4
Nickel	mg/L	0.025	0.003	0.005	0.005	0.004	0.004
Total Phosphorus	mg/L	0.03	0.02	0.14	0.09	0.09	0.06
Lead	mg/L	0.005	0.001	<0.001	<0.001	<0.001	<0.001
Antimony	mg/L	0.020	0.006	<0.006	<0.006	<0.006	<0.006
Selenium	mg/L	0.1	0.004	<0.004	<0.004	<0.004	<0.004
Tin	mg/L		0.002	<0.002	<0.002	<0.002	<0.002
Strontium	mg/L		0.005	0.728	1.47	1.47	1.21
Thallium	mg/L	0.0003	0.0003	<0.0003	<0.0003	<0.0003	<0.0003
Titanium	mg/L		0.002	<0.002	0.004	0.002	0.003
Uranium	mg/L	0.005	0.002	<0.002	<0.002	<0.002	<0.002
Vanadium	mg/L	0.005	0.002	0.003	0.002	<0.002	<0.002
Zinc	mg/L	0.03	0.005	<0.005	<0.005	<0.005	<0.005
Fluoride	mg/L		0.05	<0.05	<0.05	<0.05	<0.05
Chloride	mg/L		0.10	183	139	34.8	41.5
Nitrite as N	mg/L		0.05	<0.05	<0.05	<0.05	<0.05

Certified By:

Certificate of Analysis

AGAT WORK ORDER: 12T622865
PROJECT NO: 030932

CLIENT NAME: R.J. BURNSIDE & ASSOCIATES

ATTENTION TO: Carmen Dinulescu

Water Quality Assessment - (PWQO)

DATE SAMPLED: Jul 20, 2012

DATE RECEIVED: Jul 23, 2012

DATE REPORTED: Jul 30, 2012

SAMPLE TYPE: Water

				Mis5	QST1	CRT4	CRT2
Parameter	Unit	G / S	RDL	3540116	3540127	3540142	3540151
Phosphate as P	mg/L		0.10	<0.10	<0.10	<0.10	<0.10
Bromide	mg/L		0.05	<0.05	<0.05	<0.05	<0.05
Nitrate as N	mg/L		0.05	2.47	0.42	5.07	3.98
Sulphate	mg/L		0.10	44.8	123	49.2	41.8
pH	pH Units	6.5-8.5	NA	8.26	8.32	8.36	8.30
Ammonia as N	mg/L		0.02	0.03	<0.02	<0.02	<0.02
Total Organic Carbon	mg/L		0.5	2.8	2.5	2.1	1.8
Electrical Conductivity	uS/cm		2	1090	963	598	636
Total Dissolved Solids	mg/L		20	728	634	372	404
Saturation pH				6.80	6.96	7.03	6.95
% Difference/ Ion Balance			0.1	2.9	3.3	2.7	2.4
Hardness (as CaCO3)	mg/L		10	396	375	293	314
Carbonate (as CaCO3)	mg/L		5	<5	6	8	<5
Bicarbonate (as CaCO3)	mg/L		5	312	220	220	253
Langlier Index				1.46	1.36	1.33	1.35
Turbidity	NTU		0.5	0.7	1.2	1.1	2.1
Alkalinity (as CaCO3)	mg/L		5	312	225	229	256
Hydroxide (as CaCO3)	mg/L		5	<5	<5	<5	<5
Reactive Silica	mg/L		0.05	19.2	10.0	7.58	7.93
Colour	TCU		5	8	8	6	<5

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to PWQO (mg/L)

Certified By:

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Guideline Violation

AGAT WORK ORDER: 12T622865

PROJECT NO: 030932

CLIENT NAME: R.J. BURNSIDE & ASSOCIATES

ATTENTION TO: Carmen Dinulescu

SAMPLEID	SAMPLE TITLE	GUIDELINE	ANALYSIS PACKAGE	PARAMETER	GUIDEVALUE	RESULT
3540116	Mis5	PWQO (mg/L)	Water Quality Assessment - (PWQO)	Total Phosphorus	0.03	0.14
3540127	QST1	PWQO (mg/L)	Water Quality Assessment - (PWQO)	Total Phosphorus	0.03	0.09
3540142	CRT4	PWQO (mg/L)	Water Quality Assessment - (PWQO)	Total Phosphorus	0.03	0.09
3540151	CRT2	PWQO (mg/L)	Water Quality Assessment - (PWQO)	Total Phosphorus	0.03	0.06

Quality Assurance

CLIENT NAME: R.J. BURNSIDE & ASSOCIATES

AGAT WORK ORDER: 12T622865

PROJECT NO: 030932

ATTENTION TO: Carmen Dinulescu

Water Analysis

RPT Date: Jul 30, 2012			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Water Quality Assessment - (PWQO)															
Silver	1	3540142	< 0.0001	< 0.0001	0.0%	< 0.0001	96%	90%	110%	103%	90%	110%	104%	70%	130%
Aluminum-dissolved	1	3540116	0.008	0.007	13.3%	< 0.004	94%	90%	110%	95%	90%	110%	90%	70%	130%
Arsenic	1	3540142	< 0.003	< 0.003	0.0%	< 0.003	98%	90%	110%	103%	90%	110%	94%	70%	130%
Boron	1	3540142	0.069	0.070	1.4%	< 0.010	104%	90%	110%	94%	90%	110%	99%	70%	130%
Barium	1	3540142	0.104	0.102	1.9%	< 0.002	95%	90%	110%	95%	90%	110%	95%	70%	130%
Beryllium	1	3540142	< 0.001	< 0.001	0.0%	< 0.001	104%	90%	110%	99%	90%	110%	101%	70%	130%
Calcium	1	3540142	61.0	62.9	3.1%	< 0.05	105%	90%	110%	96%	90%	110%	100%	70%	130%
Cadmium	1	3540142	< 0.0001	< 0.0001	0.0%	< 0.0001	95%	90%	110%	108%	90%	110%	101%	70%	130%
Chromium	1	3540142	< 0.003	< 0.003	0.0%	< 0.003	100%	90%	110%	99%	90%	110%	96%	70%	130%
Cobalt	1	3540142	< 0.0005	< 0.0005	0.0%	< 0.0005	98%	90%	110%	100%	90%	110%	100%	70%	130%
Copper	1	3540142	< 0.002	< 0.002	0.0%	< 0.002	100%	90%	110%	98%	90%	110%	99%	70%	130%
Iron	1	3540142	< 0.010	< 0.010	0.0%	< 0.010	108%	90%	110%	99%	90%	110%	101%	70%	130%
Potassium	1		2.31	2.27	1.7%	< 0.05	96%	90%	110%	96%	90%	110%	98%	70%	130%
Mercury	1		< 0.0001	< 0.0001	0.0%	< 0.0001	99%	90%	110%	98%	90%	110%	97%	80%	120%
Magnesium	1		5.77	5.60	3.0%	< 0.05	96%	90%	110%	97%	90%	110%	99%	70%	130%
Manganese	1	3540142	< 0.002	< 0.002	0.0%	< 0.002	101%	90%	110%	103%	90%	110%	101%	70%	130%
Molybdenum	1	3540142	< 0.002	< 0.002	0.0%	< 0.002	98%	90%	110%	102%	90%	110%	107%	70%	130%
Sodium	1		5.78	5.61	3.0%	< 0.05	96%	90%	110%	96%	90%	110%	99%	70%	130%
Nickel	1	3540142	0.004	0.004	0.0%	< 0.003	99%	90%	110%	97%	90%	110%	100%	70%	130%
Total Phosphorus	1		0.14	0.13	7.4%	< 0.02	95%	90%	110%	103%	90%	110%	93%	80%	120%
Lead	1	3540142	< 0.001	< 0.001	0.0%	< 0.001	97%	90%	110%	96%	90%	110%	95%	70%	130%
Antimony	1	3540142	< 0.006	< 0.006	0.0%	< 0.006	103%	90%	110%	94%	90%	110%	101%	70%	130%
Selenium	1	3540142	< 0.004	< 0.004	0.0%	< 0.004	98%	90%	110%	98%	90%	110%	97%	70%	130%
Tin	1	3540142	< 0.002	< 0.002	0.0%	< 0.002	101%	90%	110%	100%	90%	110%	107%	70%	130%
Strontium	1	3540142	1.47	1.48	0.7%	< 0.005	98%	90%	110%	101%	90%	110%	82%	70%	130%
Thallium	1	3540142	< 0.0003	< 0.0003	0.0%	< 0.0003	95%	90%	110%	95%	90%	110%	94%	70%	130%
Titanium	1	3540142	0.002	0.002	0.0%	< 0.002	99%	90%	110%	98%	90%	110%	100%	70%	130%
Uranium	1	3540142	< 0.002	< 0.002	0.0%	< 0.002	95%	90%	110%	98%	90%	110%	96%	70%	130%
Vanadium	1	3540142	< 0.002	< 0.002	0.0%	< 0.002	97%	90%	110%	98%	90%	110%	99%	70%	130%
Zinc	1	3540142	< 0.005	< 0.005	0.0%	< 0.005	99%	90%	110%	101%	90%	110%	106%	70%	130%
Fluoride	1	3540116	< 0.05	< 0.05	0.0%	< 0.05	98%	90%	110%	104%	90%	110%	87%	80%	120%
Chloride	1	3540116	183	183	0.0%	< 0.10	96%	90%	110%	100%	80%	120%	86%	80%	120%
Nitrite as N	1	3540116	< 0.05	< 0.05	0.0%	< 0.05	NA	90%	110%	104%	80%	120%	105%	80%	120%
Phosphate as P	1	3540116	< 0.10	< 0.10	0.0%	< 0.10	105%	90%	110%	102%	90%	110%	109%	80%	120%
Bromide	1	3540116	< 0.05	< 0.05	0.0%	< 0.05	107%	90%	110%	106%	90%	110%	98%	80%	120%
Nitrate as N	1	3540116	2.47	2.42	2.0%	< 0.05	93%	90%	110%	102%	90%	110%	94%	80%	120%
Sulphate	1	3540116	44.8	43.6	2.7%	< 0.10	99%	90%	110%	105%	90%	110%	90%	80%	120%
pH	1		7.93	7.92	0.1%	NA	100%	90%	110%	NA			NA		
Ammonia as N	1	3540116	0.03	0.03	0.0%	< 0.02	106%	90%	110%	99%	90%	110%	108%	80%	120%

Quality Assurance

CLIENT NAME: R.J. BURNSIDE & ASSOCIATES
AGAT WORK ORDER: 12T622865
PROJECT NO: 030932
ATTENTION TO: Carmen Dinulescu

Water Analysis (Continued)

RPT Date: Jul 30, 2012			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Total Organic Carbon	1		5.0	5.0	0.0%	< 0.5	98%	90%	110%	90%	90%	110%	105%	80%	120%
Electrical Conductivity	1		277	278	0.4%	< 2	100%	80%	120%	NA			NA		
Total Dissolved Solids	1	3540116	728	716	1.7%	< 20	100%	80%	120%	NA			NA		
Turbidity	1		1.5	1.5	0.0%	< 0.5	99%	90%	110%	NA			NA		
Alkalinity (as CaCO3)	1		96	96	0.0%	< 10	100%	80%	120%	NA			NA		
Reactive Silica	1		22.0	21.7	1.4%	< 0.05	102%	90%	110%	100%	90%	110%	103%	80%	120%
Colour	1		488	485	0.6%	< 5	102%	90%	110%	NA			NA		

Comments: NA - Not Applicable.

Certified By:

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Method Summary

CLIENT NAME: R.J. BURNSIDE & ASSOCIATES
AGAT WORK ORDER: 12T622865
PROJECT NO: 030932
ATTENTION TO: Carmen Dinulescu

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Water Analysis			
Silver	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Aluminum-dissolved	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Arsenic	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Boron	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Barium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Beryllium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Calcium	MET-93-6105	EPA SW-846 6010C & 200.7	ICP/OES
Cadmium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Chromium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Cobalt	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Copper	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Iron	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Potassium	MET-93-6105	EPA SW-846 6010C & 200.7	ICP/OES
Mercury	MET-93-6100	EPA SW-846 7470 & 245.1	CVAAS
Magnesium	MET-93-6105	EPA SW-846 6010C & 200.7	ICP/OES
Manganese	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Molybdenum	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Sodium	MET-93-6105	EPA SW-846 6010C & 200.7	ICP/OES
Nickel	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Total Phosphorus	INOR-93-6022	SM 4500-P B&E	SPECTROPHOTOMETER
Lead	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Antimony	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Selenium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Tin	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Strontium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Thallium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Titanium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Uranium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Vanadium	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Zinc	MET-93-6103	EPA SW-846 6020A & 200.8	ICP-MS
Fluoride	INOR-93-6004	SM 4110 B	ION CHROMATOGRAPH
Chloride	INOR-93-6004	SM 4110 B	ION CHROMATOGRAPH
Nitrite as N	INOR-93-6004	SM 4110 B	ION CHROMATOGRAPH
Phosphate as P	INOR-93-6004	SM 4110 B	ION CHROMATOGRAPH
Bromide	INOR-93-6004	SM 4110 B	ION CHROMATOGRAPH
Nitrate as N	INOR-93-6004	SM 4110 B	ION CHROMATOGRAPH
Sulphate	INOR-93-6004	SM 4110 B	ION CHROMATOGRAPH
pH	INOR-93-6000	SM 4500-H+ B	PC TITRATE
Ammonia as N	INOR-93-6002	AQ2 EPA-103A & SM 4500 NH3-F	AQ-2 DISCRETE ANALYZER
Total Organic Carbon	INOR-93-6049	EPA 415.1 & SM 5310 B	SHIMADZU CARBON ANALYSER
Electrical Conductivity	INOR-93-6000	SM 2510 B	PC TITRATE
Total Dissolved Solids	INOR-93-6028	SM 2540 C	BALANCE
Saturation pH		SM 2320 B	CALCULATION
% Difference/ Ion Balance		SM 1030 E	CALCULATION
Hardness (as CaCO3)	MET-93-6105	EPA SW-846 6010C & 200.7 & SM 2340 B	CALCULATION
Carbonate (as CaCO3)	INOR-93-6000	SM 2320 B	PC TITRATE
Bicarbonate (as CaCO3)	INOR-93-6000	SM 2320 B	PC TITRATE
Langlier Index			CALCULATION

Method Summary

CLIENT NAME: R.J. BURNSIDE & ASSOCIATES

AGAT WORK ORDER: 12T622865

PROJECT NO: 030932

ATTENTION TO: Carmen Dinulescu

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Turbidity	INOR-93-6044	SM 2130 B	NEPHELOMETER
Alkalinity (as CaCO3)	INOR-93-6000	SM 2320 B	PC TITRATE
Hydroxide (as CaCO3)	INOR-93-6000	SM 2320 B	PC TITRATE
Reactive Silica	INOR-93-6047	AQ2 EPA-122A & SM 4500 SiO2 D	AQ2 DISCRETE ANALYSER
Colour	INOR-93-6046	SM 2120 B	SPECTROPHOTOMETER

Table F-1
Field Chemistry
Heritage Heights

Surface Water Station	Salinity (mg/L)	Temperature (°C)	Dissolved Oxygen (mg/L)	pH	Conductivity (µS/cm)	Total Dissolved Solids (g/L)	Total Suspended Solids (mg/L)
MAY1							
March 22, 2011	2.39	6.4	11.5	7.83	4486	2.914	-
March 7, 2012	1.85	6.0	15.6	8.22	3566	2.318	-
November 6, 2012	0.95	4.3	14.4	9.07	1876	1.220	-
November 8, 2017	0.88	8.3	7.7	9.33	1170	1.114	12
November 29, 2017	1.38	4.2	na	8.83	2490	1.800	0
MAY2							
March 22, 2011	2.01	5.8	13.3	7.90	3817	2.481	-
March 7, 2012	1.21	7.0	15.3	8.51	2354	1.530	-
MAY3							
March 22, 2011	0.84	2.3	11.2	7.37	1686	1.097	-
MIS1							
March 22, 2011	1.27	4.2	14.2	7.51	2489	1.615	-
March 7, 2012	1.53	1.3	18.4	9.06	2960	1.920	-
November 19, 2013	1.30	2.3	16.6	7.10	1447	1.66	2.00
MIS2							
August 6, 2014	Approx. 2-3cm standing water infront of culvert on east side, dry on west side						
MIS3							
March 22, 2011	0.90	3.0	12.6	7.81	1396	0.823	-
MIS4							
December 1, 2014	no flow						
MIS5							
July 27, 2010	0.51	18.9	9.3	7.95	1024	0.665	-
August 31, 2010	0.62	19.5	5.0	7.92	1248	0.811	-
November 1, 2010	0.61	4.8	13.1	8.28	1217	0.791	-
November 19, 2010	0.51	3.7	16.1	8.33	1040	0.676	-
December 20, 2010	0.61	1.2	14.6	8.49	1245	0.809	-
March 22, 2011	0.50	3.3	12.5	7.59	1018	0.662	-
April 13, 2011	0.63	6.9	14.5	7.90	1255	0.815	-
May 10, 2011	0.54	11.1	16.8	7.24	800	0.708	-
July 26, 2011	0.61	17.7	5.1	8.17	1214	0.789	-
September 12, 2011	0.62	17.6	7.6	8.05	1246	0.810	-
November 8, 2011	0.29	9.3	11.3	8.41	595	0.386	-
March 7, 2012	0.54	2.2	21.3	8.89	1091	0.709	-
June 8, 2012	0.45	13.4	6.9	8.50	967	0.629	-
September 12, 2012	0.56	14.8	7.5	8.65	1122	0.729	-
November 6, 2012	0.52	3.3	12.0	9.44	1065	0.693	-
July 15, 2013	0.56	17.8	6.3	8.73	1130	0.734	3
October 1, 2013	0.61	15.6	2.4	8.58	1213	0.788	2
November 19, 2013	0.47	4.3	12.3	7.25	574	0.618	32
August 6, 2014	0.53	16.66	6.20	7.71	902	0.70	11
December 1, 2014	0.54	3.58	10.96	8.65	650	0.72	7
July 19, 2017	0.64	18.00	11.09	8.27	1143	0.80	3
August 30, 2017	0.58	20.21	9.41	8.70	1067	0.76	23
October 5, 2017	0.54	14.16	7.87	8.32	862	0.71	0
November 8, 2017	0.60	5.32	6.39	8.92	747	0.78	1
November 29, 2017	0.68	5.60	na	8.46	1269	0.89	0

Note: Field chemistry was only measured when flow was measured or when <0.1L/s flow was noted
"-' denotes data which is not available

Table F-1
Field Chemistry
Heritage Heights

Surface Water Station	Salinity (mg/L)	Temperature (°C)	Dissolved Oxygen (mg/L)	pH	Conductivity (µS/cm)	Total Dissolved Solids (g/L)	Total Suspended Solids (mg/L)
MIS6							
March 22, 2011	0.26	2.2	10.8	7.25	533	0.346	-
March 7, 2012	0.32	2.5	19.0	8.73	656	0.427	-
June 8, 2012	0.26	13.6	12.3	8.39	540	0.351	-
November 6, 2012	0.40	8.4	12.9	9.26	816	0.530	-
November 19, 2013	0.38	7.0	11.0	7.35	506	0.501	7
December 1, 2014	0.23	5.63	11.02	8.47	294	0.30	2
November 29, 2017	1.30	8.70	na	8.05	233	1.64	44
MIS7							
July 27, 2010	0.47	20.1	11.7	8.30	947	0.615	-
August 31, 2010	0.55	21.7	11.8	8.37	1111	0.722	-
September 20, 2010	0.54	11.6	13.4	8.50	1083	0.704	-
November 1, 2010	0.53	5.8	18.4	8.69	1068	0.694	-
November 19, 2010	0.46	4.0	17.0	8.53	942	0.613	-
March 22, 2011	0.42	3.2	11.8	7.59	860	0.559	-
April 13, 2011	0.55	6.5	15.3	8.08	1115	0.725	-
May 10, 2011	0.44	12.2	18.1	7.84	665	0.572	-
July 26, 2011	0.58	19.6	9.1	8.33	1154	0.750	-
September 12, 2011	0.55	18.5	11.4	8.16	1113	0.724	-
November 8, 2011	0.51	9.0	14.6	8.62	1023	0.665	-
March 7, 2012	0.46	2.5	22.1	8.98	946	0.615	-
June 8, 2012	0.48	14.2	11.2	8.49	972	0.622	-
September 12, 2012	0.33	14.7	12.6	8.93	668	0.434	-
November 6, 2012	0.40	2.7	14.7	9.35	818	0.531	-
July 15, 2013	0.24	22.8	9.6	8.61	495	0.322	47
October 1, 2013	0.59	16.8	5.1	8.68	1189	0.773	6
November 19, 2013	0.47	3.7	15.5	7.65	572	0.627	30
April 28, 2014	0.75	10.2	29.8	8.64	1063	0.960	0
August 6, 2014	0.54	21.3	7.5	8.33	1035	0.720	31
December 1, 2014	0.50	3.3	12.5	8.51	691	0.657	11
July 19, 2017	0.37	18.8	10.3	8.70	663	0.471	8
August 30, 2017	0.31	22.6	12.1	9.18	598	0.410	3
October 5, 2017	0.35	16.7	13.3	8.49	609	0.470	20
November 8, 2017	0.31	6.0	8.5	9.10	408	0.415	5
November 29, 2017	0.54	5.6	na	8.66	1019	0.722	12
MIS8							
July 27, 2010	0.16	20.9	11.3	8.32	331	0.215	-
March 22, 2011	0.22	3.7	12.3	7.75	463	0.300	-
March 7, 2012	0.61	6.1	25.4	8.86	1227	0.798	-
MIS9							
July 27, 2010	0.55	22.1	6.9	7.95	1098	0.714	-
November 19, 2010	0.69	4.4	15.8	8.63	1378	0.896	-
December 20, 2010	0.77	0.5	15.2	8.59	1553	1.009	-
March 22, 2011	0.54	4.3	9.6	7.66	1099	0.714	-
April 13, 2011	0.66	6.5	13.0	8.47	1313	0.853	-
May 10, 2011	0.58	15.3	17.0	7.84	943	0.752	-
November 8, 2011	0.90	9.7	13.4	8.57	1769	1.150	-
March 7, 2012	0.54	5.2	18.7	8.52	1086	0.706	-
November 6, 2012	0.43	4.4	13.1	9.40	882	0.574	-
July 15, 2013	0.52	23.0	9.4	8.41	1047	0.681	9
October 1, 2013	0.58	15.7	3.2	8.63	1165	0.758	16
November 19, 2013	0.45	3.8	13.7	7.43	549	0.599	0
April 28, 2014	0.43	14.0	18.7	8.13	685	0.564	0
August 6, 2014	0.54	16.8	5.3	7.50	917	0.706	9
December 1, 2014	0.52	2.9	12.1	8.49	612	0.689	0
November 29, 2017	0.42	4.7	na	8.90	815	0.571	17

Note: Field chemistry was only measured when flow was measured or when <0.1L/s flow was noted
"-' denotes data which is not available

Table F-1
Field Chemistry
Heritage Heights

Surface Water Station	Salinity (mg/L)	Temperature (°C)	Dissolved Oxygen (mg/L)	pH	Conductivity (µS/cm)	Total Dissolved Solids (g/L)	Total Suspended Solids (mg/L)
WAN1							
March 22, 2011	0.57	2.1	12.0	7.50	1155	0.751	-
WAN2							
March 22, 2011	0.60	2.2	11.7	7.57	1224	0.795	-
May 10, 2011	0.48	13.8	13.4	7.45	763	0.630	-
March 7, 2012	0.63	7.9	15.9	8.71	1252	0.814	-
November 6, 2012	0.57	2.8	11.6	9.38	1160	0.75	-
November 19, 2013	0.58	4.0	14.4	7.51	698	0.76	11
WAN3							
March 22, 2011	0.47	2.9	12.0	7.34	956	0.621	-
March 7, 2012	0.70	10.7	15.1	8.54	1384	0.900	-
November 19, 2013	0.27	4.2	11.8	7.31	340	0.37	22
BOV1							
December 1, 2014	trickle through grass; not measurable						
BOV2							
March 22, 2011	0.32	5.5	11.2	7.79	660	0.429	-
November 8, 2011	0.48	9.9	12.9	8.69	971	0.631	-
March 7, 2012	0.38	7.5	17.0	8.88	782	0.509	-
November 19, 2013	0.47	4.0	4.1	7.38	576	0.625	18
BOV3							
July 27, 2010	1.47	16.7	-	7.22	2839	1.849	-
March 22, 2011	0.75	5.3	12.5	7.71	1493	0.971	-
November 8, 2011	1.01	9.7	9.3	8.32	1980	1.287	-
March 7, 2012	0.94	1.9	16.8	8.57	1877	1.219	-
November 6, 2012	0.87	4.4	7.7	9.32	1720	1.118	-
November 19, 2013	0.84	4.4	9.1	7.02	1013	1.087	28
December 1, 2014	1.16	1.42	9.43	8.65	1263	1.49	6
BOV4							
March 22, 2011	0.50	2.4	10.2	7.31	1032	0.677	-
November 8, 2011	0.55	9.5	12.5	8.30	1110	0.721	-
March 7, 2012	0.66	2.9	16.1	8.51	1321	0.859	-
November 6, 2012	0.54	7.8	12.3	9.22	1089	0.708	-
November 19, 2013	0.55	7.4	10.8	7.09	737	0.722	41
December 1, 2014	0.62	3.71	10.40	8.80	739	0.81	16
HER1							
July 27, 2010	0.36	21.7	7.2	7.80	746	0.485	-
March 22, 2011	0.42	4.7	10.8	7.62	860	0.559	-
May 10, 2011	0.37	14.0	11.5	7.31	592	0.487	-
November 8, 2011	0.18	8.9	9.4	8.58	372	0.242	-
March 7, 2012	0.35	4.4	16.6	8.65	-	-	-
November 6, 2012	0.34	3.8	8.3	9.50	709	0.46	-

Note: Field chemistry was only measured when flow was measured or when <0.1L/s flow was noted
"-' denotes data which is not available

Table F-1
Field Chemistry
Heritage Heights

Surface Water Station	Salinity (mg/L)	Temperature (^{o}C)	Dissolved Oxygen (mg/L)	pH	Conductivity (µS/cm)	Total Dissolved Solids (g/L)	Total Suspended Solids (mg/L)
QST1							
July 27, 2010	0.40	22.3	10.1	8.65	809	0.526	-
August 31, 2010	0.40	19.6	10.9	8.40	819	0.532	-
September 20, 2010	0.40	11.3	12.9	8.56	812	0.528	-
November 1, 2010	0.51	6.0	18.2	9.11	1034	0.672	-
November 19, 2010	0.42	4.1	17.8	9.02	866	0.563	-
February 23, 2011	0.42	0.3	-	8.57	864	0.562	-
March 22, 2011	0.44	3.9	12.8	8.04	890	0.579	-
April 13, 2011	0.54	6.8	13.2	8.41	1089	0.708	-
May 10, 2011	0.48	14.1	13.6	8.02	768	0.631	-
July 26, 2011	0.35	19.7	10.7	8.49	721	0.469	-
September 12, 2011	0.44	18.0	11.1	8.21	892	0.580	-
November 8, 2011	0.52	9.1	14.5	8.81	1043	0.678	-
March 7, 2012	0.55	3.0	20.3	9.15	1116	0.725	-
June 8, 2012	0.65	15.0	12.4	8.75	1300	0.845	-
September 12, 2012	0.35	16.9	13.5	9.08	714	0.464	-
November 6, 2012	0.43	3.3	13.1	9.56	871	0.566	-
July 15, 2013	0.30	23.6	11.0	8.62	619	0.403	14
October 1, 2013	0.56	17.6	4.5	8.91	1117	0.726	2
November 19, 2013	0.45	4.3	15.4	7.96	557	0.599	13
April 28, 2014	0.72	11.8	19.0	8.10	1067	0.926	0
August 6, 2014	0.59	20.2	7.9	8.28	1068	0.765	22
December 1, 2014	0.53	3.6	12.9	8.57	636	0.698	4
July 19, 2017	0.52	18.3	10.3	8.96	937	0.667	9
August 30, 2017	0.49	21.3	13.2	9.26	917	0.641	11
October 5, 2017	0.44	11.6	17.2	8.41	660	0.576	1
November 8, 2017	0.34	8.7	9.7	9.49	481	0.454	7
November 29, 2017	0.53	4.9	2.9	9.30	1000	0.710	0
RL1							
July 27, 2010	0.31	20.1	7.6	7.78	656	0.448	-
November 1, 2010	0.53	5.5	13.7	8.09	1071	0.696	-
November 19, 2010	0.48	3.5	15.1	8.30	983	0.639	-
December 20, 2010	0.43	1.5	12.5	8.25	881	0.571	-
March 22, 2011	0.57	3.2	12.6	7.48	1122	0.699	-
April 13, 2011	0.62	7.1	13.3	7.79	1236	0.804	-
May 10, 2011	0.54	11.2	17.5	7.19	791	0.699	-
July 26, 2011	0.61	18.0	7.6	8.46	1217	0.791	-
September 12, 2011	0.56	17.2	8.0	8.03	981	0.688	-
March 7, 2012	0.54	2.1	18.9	8.96	1098	0.714	-
June 8, 2012	0.44	12.9	8.4	8.81	886	0.576	-
September 12, 2012	0.59	13.4	7.6	8.67	1185	0.770	-
November 6, 2012	0.49	3.3	13.0	9.64	1006	0.653	-
July 15, 2013	0.47	17.7	6.3	8.52	946	0.616	16
October 1, 2013	0.55	14.2	1.9	8.67	1107	0.721	-
November 19, 2013	0.45	4.3	12.1	7.25	557	0.600	34
April 28, 2014	0.61	10.2	29.4	7.65	875	0.793	0
August 6, 2014	0.47	13.3	6.0	7.33	740	0.619	0
December 1, 2014	0.53	3.8	10.3	8.81	639	0.698	8
July 19, 2017	0.51	15.4	10.2	8.07	935	0.661	26
October 5, 2017	0.44	16.6	11.5	8.37	755	0.584	11
November 8, 2017	0.47	7.3	6.6	8.86	623	0.612	2
November 29, 2017	0.53	6.3	na	8.32	975	0.694	4

Note: Field chemistry was only measured when flow was measured or when <0.1L/s flow was noted
"-' denotes data which is not available

B-8 FEFLOW Model Memorandum

AquaResource
A Division of Matrix Solutions Inc.

- MEMORANDUM -

To: Bill Blackport, Blackport & Associates

From: Paul Chin and David Van Vliet, AquaResource

Date: August 31, 2012

Re: Groundwater Flow Model - Phase 1
NORTH WEST BRAMPTON – HERITAGE HEIGHTS
LANDSCAPE SCALE ANALYSIS UPDATE & SUBWATERSHED STUDY

1.0 Introduction

The purpose of this memorandum is to report on the modelling effort undertaken for Phase 1 of the Heritage Heights Subwatershed Study. We use new field data and historical data gathered during Phase 1 to verify the calibration of the Credit Valley Conservation's (CVC) watershed-scale FEFLOW groundwater model and to assess the suitability of it, and the underlying conceptual model, for use as the foundation of a new MIKE SHE model being constructed for Phase 2. The MIKE SHE model will be a subwatershed-scale, integrated surface water/ groundwater model of sufficient resolution to evaluate groundwater influences on wetlands at the subwatershed scale and the hydro-period of typical wetlands in the study area.

1.1 OBJECTIVES

The objective of the modelling effort for Phase 1 of this Heritage Heights Subwatershed Study is to confirm that the current version of the CVC watershed-scale FEFLOW groundwater model, and the conceptual model it represents, reflects observed groundwater flow within the Heritage Heights study area. The Phase 2 modelling program will utilize the conceptual three-dimensional groundwater flow model within the MIKE SHE integrated model to study groundwater and surface water interactions.

The watershed-scale FEFLOW groundwater model was developed by CVC and reported in the CVC Tier Two Integrated Water Budget Report (AquaResource, 2009a). It was updated and used as the groundwater model for the North West Brampton (West Huttonville, Fletcher's) Subwatershed Study (AMEC, 2011). That study and the associated surface water and groundwater models provide a general conceptual understanding or framework characterizing the hydrogeology of the Heritage Heights study area. This understanding helps to focus efforts in the current study, where the main objective is to assess the existing local function of groundwater as it relates to watercourses and wetland features, and to evaluate the efficacy of alternative management scenarios under future conditions.

The MIKE SHE model will be developed in Phase 2 to study shallow groundwater conditions and provide further insight on:

- The transient nature of the groundwater flow system, including the seasonal variation in depth to the water table, and interactions with streams and wetlands;
- The water balance for typical wetland areas including an evaluation of their function and hydro-period to aid in setting targets for subwatershed-scale management;
- The range of potential recharge rates that is consistent with the available water level and groundwater discharge observation data; and
- The impact of various land use scenarios on surface water and groundwater and the performance of mitigation measures.

1.2 CVC WATERSHED-SCALE FEFLOW MODEL UPDATE

CVC’s three-dimensional regional groundwater flow model, developed using the finite-element code FEFLOW (WASY, 2007), encompasses the Credit River watershed and parts of the surrounding areas (Figure 1). The Heritage Heights study area lies within the watershed and covers portions of subwatersheds 9 (Norval to Port Credit) and 7 (Huttonville Creek). The model integrates the available information of the hydrogeologic system of the Credit River watershed and has been shown by the CVC to be a valuable tool for understanding existing three-dimensional groundwater flow and discharge, and evaluating potential impacts of future development or climate change. This model has been used by CVC and its member municipalities for over 12 years to understand and manage the groundwater function in the watershed ecosystem, and as the basis for wellhead protection and future land use development studies.

AquaResource recently updated the FEFLOW model to reflect model application studies completed since 2006, including incorporating the updates done for the North West Brampton (West Huttonville, Fletcher's) Subwatershed Study (AquaResource, 2009b). The recent update incorporated local-scale refinements from numerous subwatershed-scale studies including: the bedrock topography and the delineation of buried bedrock valleys; the distribution of unconsolidated materials (sand, gravel and tills); the characteristics of bedrock units; and the incorporation of additional water levels and spot flow measurements for local calibration. Although these updates are important for representing local conditions, they did not fundamentally change the simulated regional flow, groundwater discharge, and water budget for the CVC subwatersheds (AquaResource, 2011).

1.3 METHODOLOGY

The updated CVC groundwater flow model was examined to confirm its consistency with new field data collected as part of the Heritage Heights Subwatershed Study. As part of Phase 1 of this study, nine groundwater monitoring wells and 18 drive-point piezometers were installed across the subject lands to investigate the subsurface and groundwater conditions. Available data from these monitoring locations were used to update the conceptual hydrogeologic model for this study (described in the Hydrogeology section of the main body of the Phase 1 report) and to check the hydraulic head prediction of the existing CVC groundwater model against the new data. Of the 18 drive-point piezometers, eight were recently installed and thus only 10 have sufficient monitoring data that can be used for this verification exercise at this time. Additionally, 43 groundwater monitoring points reported in a number of previous studies were added to the observation dataset and used to verify the model's level of calibration. The average water level was calculated for wells having multiple readings. The locations of hydraulic head calibration points are shown on Figure 2 with multi-level wells shown as one point. Data gathered for the current study have the prefix "Burnside".

Surface water spot flow measurements have also been collected at 26 locations within the study area along the tributaries of the Credit River and West Huttonville Creek. These measurements were compared against the groundwater discharge predicted by the current CVC FEFLOW model to help confirm the ability of the groundwater flow model to represent the subwatershed-scale hydrogeologic conditions.

2.0 Calibration Results

2.1 HYDRAULIC HEAD CALIBRATION RESULTS

The groundwater level (head) calibration targets used to verify the calibration of the updated CVC FEFLOW model within the study area are shown on Figure 2 and listed in Appendix A along with the simulated and observed water levels and the calibration residual for each point. A calibration residual is calculated as the difference between the simulated and observed water level for each point.

2.1.1 Calibration Residuals Scatter Plot

Figure 3 shows a scatter plot of the calibration residuals. Scatter plots are used to visualize the goodness-of-fit for hydraulic head targets with model-simulated heads plotted on the vertical axis and observed hydraulic heads plotted on the horizontal axis. The line corresponding to an exact match is the 45-degree solid line going through the origin of the plot (the 1:1 line). Deviations of ±5 m are shown on the plot as parallel dashed lines offset from the 1:1 line. Points falling outside of the ±5 m deviation lines represent observation locations where the simulated hydraulic head differs from the observed value by more than 5 m. This difference may be due to model error, assumptions in the conceptual model, or may also be due to errors associated with the field-observed data itself.

Overall, the scatter plot for the various subsets of calibration targets illustrate that the water level calibration error is well-distributed on either side of the solid diagonal line of perfect fit with a majority of points falling between the outer dashed lines indicating ±5 m residual error (simulated head minus observed head). There is a slight bias towards under-estimating groundwater levels that appears to be consistent throughout the target groups. The new monitoring wells and piezometers have many points that lie very close to the 1:1 line of perfect fit demonstrating the goodness of fit between the simulated and observed data. The model under-estimates the water levels of some of the deep points with lower observed water levels (around 225 to 230 masl) as shown by the points below the -5 m deviation line.

2.1.2 Calibration Statistics

Table 1 summarizes the calibration statistics for various groupings within the observation data.

Table 1: Summary of Calibration Statistics (Water Levels)

	Number of Points	Mean Error (m)	Mean Absolute Error (m)	Root Mean Squared Error (m)	Normalized Root Mean Squared Error	Range of Observed Data (m)
1. New Monitoring Wells	9	-1.3	1.5	2.6	4.7%	55.73
2. New Drive Point Piezometers	10	-1.3	1.3	2.1	8.3%	25.24
3. All Observation Points	62	-2.1	3.0	4.3	7.7%	55.73

The results suggest that on average, the model reasonably represents observed water level conditions within standardized and accepted statistical measures of calibration. These standard statistical measures of calibration are summarized below:

Mean Error (ME)

The Mean Error (ME) is the arithmetic mean of all calibration residuals and is a measure of whether, on average, simulated water levels are higher or lower than those observed. Ideally, the ME should be as close as possible to zero. This statistic indicates that on average, for all the observation points, the simulated water levels are lower than the observed values by 2.1 m. For the new wells and piezometers, the simulated water levels are on average 1.3 m lower than the observed values.

Mean Absolute Error (MAE)

The Mean Absolute Error (MAE) is calculated by taking the mean of the absolute value of all calibration residuals and is a measure of the average deviation between simulated and observed water levels. During model calibration, this statistic should be minimized as much as possible. The CVC model produces simulated heads for all the targets that have a MAE of 3.0 m with about half that amount for just the new wells (1.5 m) and piezometers (1.3 m).

Root Mean Squared Error (RMSE)

The Root Mean Squared Error (RMSE) is similar to standard deviation and provides a measure of the degree of scatter about the 1:1 line. The RMSE is calculated by averaging the squares of each residual error and then taking the square root of that average. In squaring the residual errors, the RMSE gives higher weighting to larger residuals. When compared to the Mean Absolute Error (MAE), the greater the difference between the MAE and the RMSE (which will always be equal or greater than the MAE), the greater the variance in the individual residuals. Lower values of RMSE are typically desired for high-quality data, and the statistics achieved may be a reflection of several factors including: the complexity and suitability of the conceptual model, seasonal water level and pumping fluctuations, and model error.

For the complete target dataset, the model has a RMSE of 4.3 m meaning that the majority of predicted water levels fall within 4.3 m of the observed value. For the newer data collected for this study, the model has an RMSE of 2.6 m and 2.1 m for the well and piezometers, respectively. We consider these calibration error statistics to be acceptable for a model of this scale.

Normalized Root Mean Squared Error (NRMSE)

The Normalized Root Mean Squared Error (NRMSE) is calculated by dividing the Root Mean Squared Error (RMSE) by the range in observed water level elevations. This percentage value allows the goodness-of-fit in one model to be compared to another model regardless of the scale of the model.

The NRMSE for the current model considering all calibration targets is 7.7% which is reasonable based on professional experience with other nearby modelling studies and considering the relatively small range in observed data (limited local scale topography) and limited number of observation points. The NRMSE for the new wells is 4.7% and for the piezometers is 8.3% which is also reasonable.

2.1.3 Spatial Distribution of Residuals

Figure 2 illustrates the spatial distribution of calibration residuals in the Heritage Heights study area. This map compares the model-simulated head and the field-observed head for each calibration target. The residuals are calculated by subtracting the observed head from the model-simulated head, and then visualized on the maps as blue or orange dots. Blue dots are targets where the simulated head is lower than the observed and orange dots are targets where the simulated head is greater than the observed. The size of the dots reflects the magnitude of the residual.

It is desirable to minimize the occurrence of spatial trends in residuals, and this has generally been achieved in the study area. The model-simulated heads are slightly lower than the observed water levels in the study area and this can be seen in the northwest and through the central portion of the study area which are the middle reaches and headwaters area of the Credit River Tributaries.

The poorest match of simulated and observed water levels is in the deeper overburden and bedrock wells drilled for the Norval Quarry Study (Golder, 2010). This is an area above the steep slope of the main Credit River channel where the water table drops off dramatically towards the Credit River. In this area and in others along the Credit River, uncertainty related to the depth of the bedrock surface and the configuration of the buried bedrock valley, lower reliability of bedrock well water levels, and sharp hydraulic gradients all contribute to the poorer match.

2.1.4 Simulated Water Levels

Figure 4 illustrates the model-simulated water table contours and Figure 5 shows the observed shallow water levels (equipotential surface) interpolated from water levels in wells up to 15 m depth. Both maps show that groundwater flow direction is strongly influenced by topography, the Main Credit River, and bedrock topography. Both the simulated water table and the observed shallow water level maps show that groundwater flow in the study area is to the south and south east towards the main Credit River following topography. The simulated water table shows contours converging on streams throughout the study area outside of the headwater areas in the north west. This is not as evident in the observed water level map as the interpolation did not include surface water points to control the water table elevation, and it was not constrained by the ground surface. As such, this map represents the equipotential surface of wells up to 15 m depth and not the water table. Regardless, there is general agreement between the simulated and observed water levels as to the elevation and direction of groundwater flow.

2.2 BASEFLOW CALIBRATION RESULTS

The ability of the CVC groundwater model to accurately simulate groundwater discharge is of critical importance to evaluate groundwater function within Heritage Heights. Baseflow calibration targets derived from spot baseflow measurements were taken throughout the study area. Table 2 summarizes the minimum, maximum and median observed spot flows along with the FEFLOW model-simulated groundwater discharge.

Table 2: Summary of Spot Flow Monitoring in Heritage Heights

Monitoring Station	Min. Observed Spot Flow (L/s)	Max. Observed Spot Flow (L/s)	Median of Observed Spot Flow (L/s)	CVC Model-simulated Discharge (L/s)
BOV1	0	0	0	0
BOV2	0	20	0	0.3
BOV3	0	4	0	0.0
BOV4	0	2	0	0.0
HER1	0	110	0	4.0
MAY1	0	0	0	0.0
MAY2	0	0	0	0.0
MAY3	0	0	0	0.0
MIS1	0	4	0	0.0
MIS2	0	0	0	0.0
MIS3	0	3	0	0.0
MIS4	0	0	0	0.0
MIS5	0	125	2	3.4
MIS6	0	18	0	0.0
MIS7	0	254	3	6.7

Monitoring Station	Min. Observed Spot Flow (L/s)	Max. Observed Spot Flow (L/s)	Median of Observed Spot Flow (L/s)	CVC Model-simulated Discharge (L/s)
MIS8	0	30	0	0.0
MIS9	0	9.4	0	0.0
QST1	0	378	21	13.0
RL1	0	90	1	2.2
RL2	0	7	0	0.0
RL3	0	24	0	0.5
WAN1	0	4	0	0.0
WAN2	0	57	0	0.0
WAN3	0	46	0	0.0
WIN1	0	2	0	0.0
WIN2	0	32	0	3.0

These results show the calibrated groundwater discharge rates are generally consistent with the range of observed values and close to the median observation for each monitoring station. The median of spot flow measurements gives a better representation of what the majority of the measurements are and does not bias a few high readings in the way an average mean may. Many of the tributaries that are observed as dry during the summer periods are simulated as being dry in the steady-state calibrated model providing further confidence in the representation of groundwater discharge.

3.0 Conclusions

3.1 SUMMARY

The CVC watershed-scale FEFLOW groundwater flow model updated and calibrated for the North West Brampton (West Huttonville, Fletcher's) Subwatershed Study (AMEC, 2011; and AquaResource, 2009b) has been recently updated to reflect all CVC model application studies completed since 2006. The watershed-wide updates included information on the local distribution of hydrostratigraphic units, bedrock topography, hydraulic conductivity values, surface water boundaries, and static water levels used as calibration targets.

Data gathered during Phase 1 of the Heritage Heights study, along with historical data, was used to verify the calibration of the CVC FEFLOW model to assess the suitability of it, and the underlying conceptual model, for use as the foundation of a new, integrated surface water/groundwater model being constructed for the Heritage Heights Subwatershed Study.

Overall the regional CVC model is consistent with the observed data for both hydraulic head and spot baseflow estimates. Although the average water levels are slightly under-predicted by the model, they are within seasonal variations. The FEFLOW model has been calibrated to steady-state, annual-average conditions and thus does not capture the transient seasonal variations. The model-predicted groundwater discharge also matches the observed spot baseflow data under average, steady-state conditions.

Based on the agreement between field data and simulated results, it is concluded that the existing FEFLOW model acceptably represents the groundwater flow system in the study area and can be used within the MIKE SHE integrate model in Phase 2. This new model will be used to further study the transient, near-surface groundwater flow conditions that influence wetland function on the Halton Till within the study area.

The forthcoming subwatershed-scale MIKE SHE model includes sufficient resolution to evaluate the function of the wetlands at the subwatershed scale and the hydro-period of typical wetlands in the study area. Only an integrated simulation including both surface and groundwater processes can be used to provide appropriate insight into the role of surface water and groundwater in a wetland's water balance.

4.0 References

AMEC, 2011. Mount Pleasant Community Sustainable Natural Heritage System Planning - Huttonville and Fletcher's Creeks Subwatershed Study. Prepared for the City of Brampton, June 2011.

AquaResource, Inc., 2009a. Integrated Water Budget Report - Tier Two (SPC Accepted Draft) Credit Valley Source Protection Area. Prepared for CVC, July 2009.

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AquaResource, Inc., 2011. Updates to Credit Valley Conservation Groundwater Flow Model. Technical Memo to CVC, Dec. 2011.

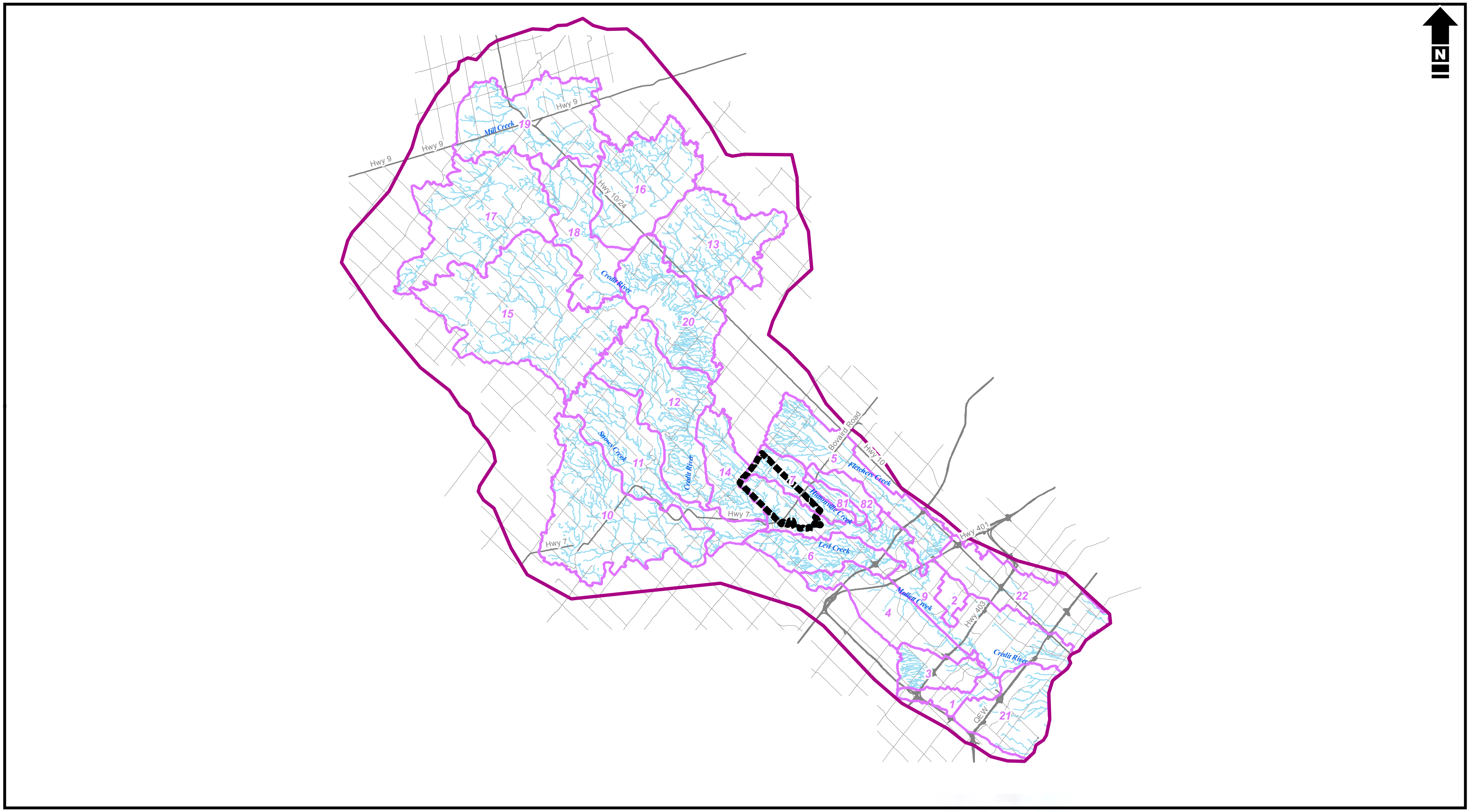
Golder Associates Ltd., 2010. Level 1 / 2 Hydrogeological Technical Report Norval Quarry. Prepared for Brampton Brick Ltd., Brampton, Ontario, July 2010.

WASY Institute for Water Resources Planning and Systems Research Ltd., 2007. FEFLOW 5.4. Finite Element Subsurface Flow and Transport Simulation System.

Appendix A: Water Level Calibration Data

Observation Name	Simlulated Head (masl)	Observed Head (masl)	Simulated Head-Observed Head (m)
Burnside_MW1	256.56	263.72	-7.16
Burnside_MW2	249.64	249.95	-0.31
Burnside_MW3	242.09	243.35	-1.26
Burnside_MW4	242.77	242.75	0.03
Burnside_MW5	233.42	234.49	-1.07
Burnside_MW6	227.49	229.91	-2.42
Burnside_MW7_D	238.46	238.52	-0.05
Burnside_MW7_S	238.47	238.64	-0.17
Burnside_MW8	208.71	207.99	0.72
Burnside_PZ1_D	249.49	251.74	-2.25
Burnside_PZ10	238.94	239.80	-0.86
Burnside_PZ2	249.49	249.66	-0.17
Burnside_PZ3	242.68	243.41	-0.73
Burnside_PZ4	236.88	241.72	-4.85
Burnside_PZ5	241.13	241.10	0.03
Burnside_PZ6	227.87	231.50	-3.62
Burnside_PZ7	226.23	226.50	-0.27
Burnside_PZ8_S	244.41	244.60	-0.19
Burnside_PZ9	246.74	246.98	-0.24
Coffey_BH08-1	236.15	235.90	0.25
Coffey_BH08-11	249.44	250.40	-0.96
Coffey_BH08-14	255.61	262.40	-6.79
Coffey_BH08-3	237.41	237.50	-0.09
Coffey_BH08-4	237.51	237.30	0.21
Coffey_BH08-5	239.49	241.60	-2.11
Coffey_BH08-8	239.84	241.90	-2.06
Coffey_BH9	251.68	254.67	-2.99
Golder_MW07-01-2	234.87	233.72	1.15
Golder_MW07-01-3	235.14	234.00	1.14
Golder_MW07-01-4	235.32	236.21	-0.89
Golder_MW07-02-2	232.79	240.94	-8.16
Golder_MW07-02-3	233.06	240.79	-7.74
Golder_MW07-02-4	233.23	240.92	-7.69
Golder_MW07-03-1	222.99	220.92	2.06
Golder_MW07-03-2	223.23	218.78	4.45

Observation Name	Simlulated Head (masl)	Observed Head (masl)	Simulated Head-Observed Head (m)
Golder_MW07-03-3	223.44	225.47	-2.04
Golder_MW07-03-4	223.58	228.23	-4.65
Golder_MW07-04-1	226.88	226.02	0.86
Golder_MW07-04-2	226.98	226.78	0.2
Golder_MW07-04-3	227.06	227.27	-0.21
Golder_MW07-05-2	228.35	233.41	-5.07
Golder_MW07-05-3	228.38	233.97	-5.6
Golder_MW08-06-1	217.78	225.90	-8.12
Golder_MW08-06-2	217.33	226.16	-8.83
Golder_MW08-06-3	217.15	229.23	-12.08
Golder_MW08-06-4	217.08	229.21	-12.13
Golder_MW08-07-1	230.20	230.53	-0.32
Golder_MW08-07-2	230.40	235.19	-4.79
Golder_MW08-07-3	230.49	236.19	-5.69
Golder_MW08-07-4	230.51	236.34	-5.83
Golder_MW08-08-1	235.68	230.89	4.79
Golder_MW08-08-2	236.11	240.89	-4.78
Golder_MW08-08-3	236.29	241.50	-5.22
Golder_MW08-08-4	236.30	240.94	-4.64
Golder_SV08-01-1	224.83	224.14	0.69
Golder_SV08-01-2	224.93	225.05	-0.12
Golder_SV08-01-3	224.96	227.05	-2.09
Golder_SV08-02-1	227.71	227.15	0.56
Golder_SV08-02-2	227.75	226.58	1.17
Shad_N5_P	247.91	242.00	5.91
Shad_S2_P	243.07	239.70	3.37
Shad_S3_P	243.64	242.30	1.34



Legend

- 🟪 Model Domain
- 🟪 Subwatershed Boundaries with Number
- — Highway / Expressway
- — Road
- ■■■ Heritage Heights Study Area
- — Drainage

1:425,000

5 0 5

Kilometres

NAD 1983 UTM ZONE 17N

Reference: Ontario Ministry of Natural Resources (2010), Credit Valley Conservation Authority (2010)

amec MatrixSolutions Inc. SAVANTA BURNSIDE **Blackport & Associates** STONYBROOK

North West Brampton Heritage Heights Subwatershed Study

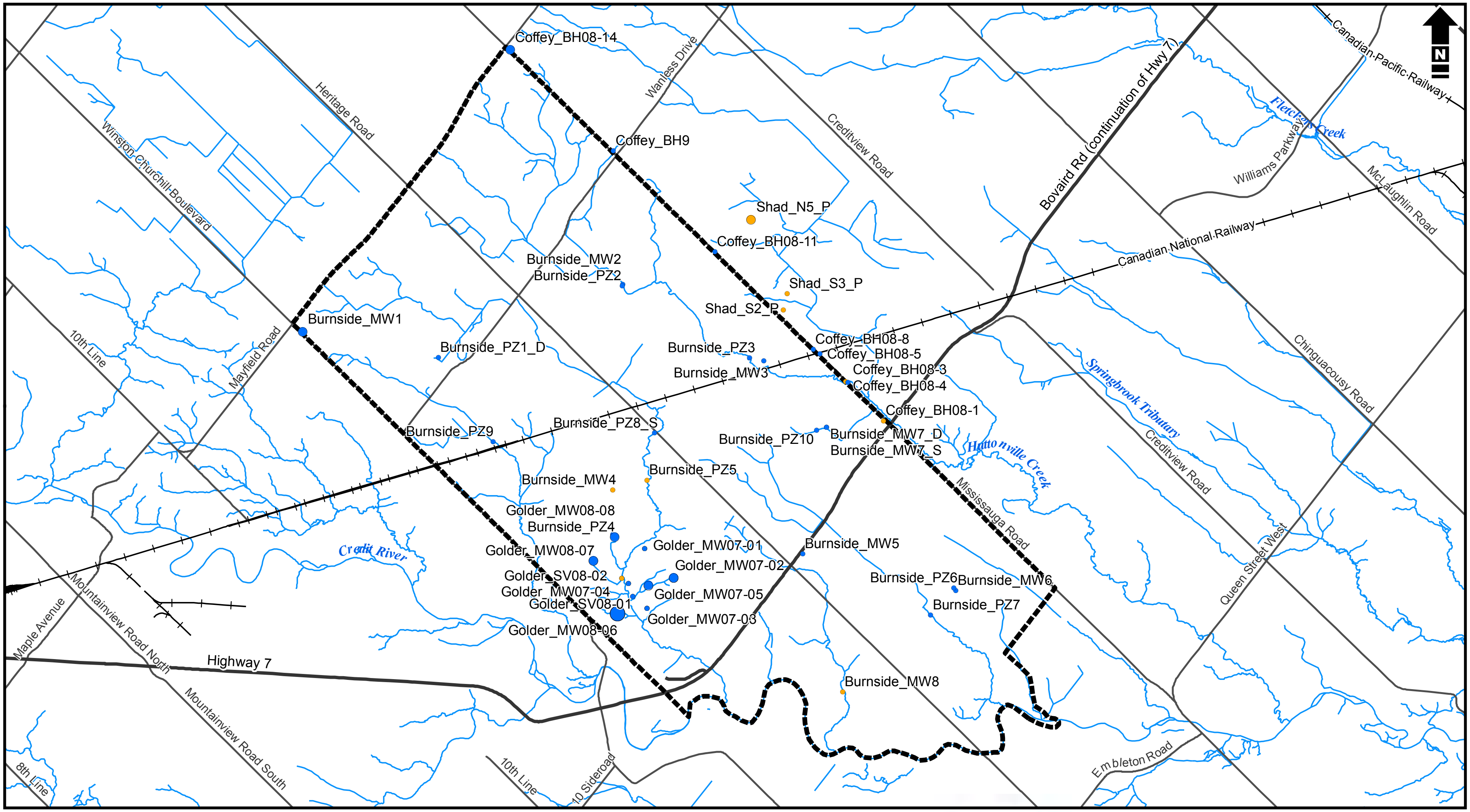
CVC Model Domain

Date: 15 Nov 2012	Project: 15519-528	Technical: P. Chin	Reviewer: D. Van Vliet	Drawn: C. Curry

Disclaimer: Prepared solely for the use of the City of Brampton as specified in the accompanying report. No representation of any kind is made to other parties with which the City of Brampton has not entered into contract.

Figure 1

T:\2011013_HeritageHeightsSWS\GIS\ArcGIS\MXDs\2011022_FIGURE-1_CVC_Model_Domain.mxd



Legend

Simulated Head - Observed Head (m)

- ● < -10 (Simulated Head Lower than Observed)
- ● -10 to -5
- ● -5 to 0
- ● 0 to 5
- ● 5 to 10
- ● > 10 (Simulated Head Higher than Observed)
- — Drainage

- ┼ Railroad
- ▬ Highway / Expressway
- — Road
- ▪▪▪ Heritage Heights Study Area

1:45,000

500 0 500

Metres

NAD 1983 UTM ZONE 17N

Reference: Ontario Ministry of Natural Resources (2010), Credit Valley Conservation Authority (2010)

T:\2011013 HeritageHeightsSWS\GIS\ArcGIS\MXDs\2011022 FIGURE-2 Calibration Residual Spatial Distribution.mxd

Blackport & Associates

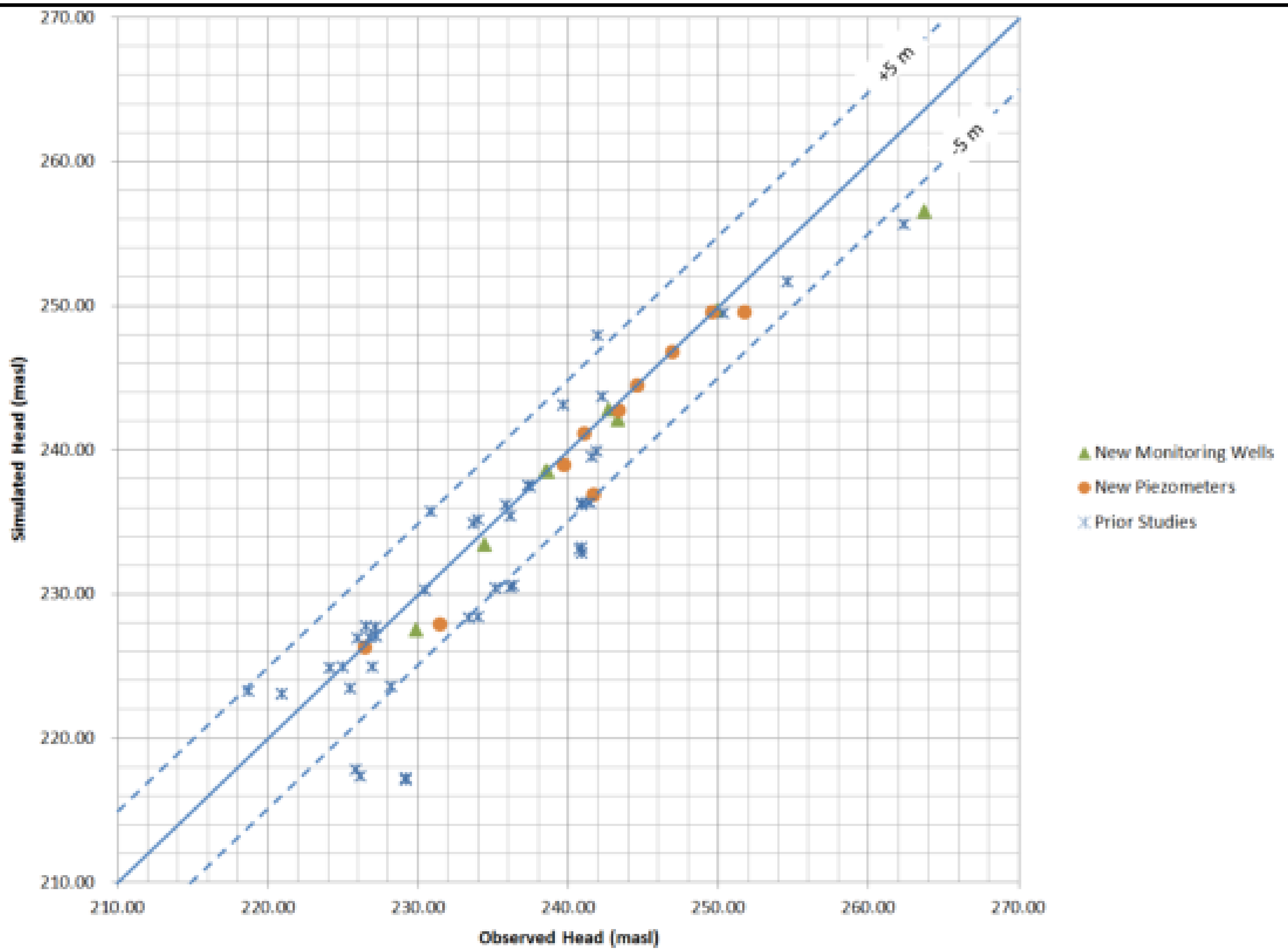
North West Brampton Heritage Heights Subwatershed Study

Calibration Residual Spatial Distribution

Date: 15 Nov 2012	Project: 15519-528	Technical: P. Chin	Reviewer: D. Van Vliet	Drawn: C. Curry

Disclaimer: Prepared solely for the use of the City of Brampton as specified in the accompanying report. No representation of any kind is made to other parties with which the City of Brampton has not entered into contract.

Figure 2



amec Savanta Matrix Solutions Inc. Burnside Blackport & Associates Stonybrook

North West Brampton Heritage Heights Subwatershed Study

Calibration Residual Scatter Plot

Date: 07 Sep 2012	Project: 15519-528	Technical: P. Chin	Reviewer: P. Chin	Drawn: P. Chin

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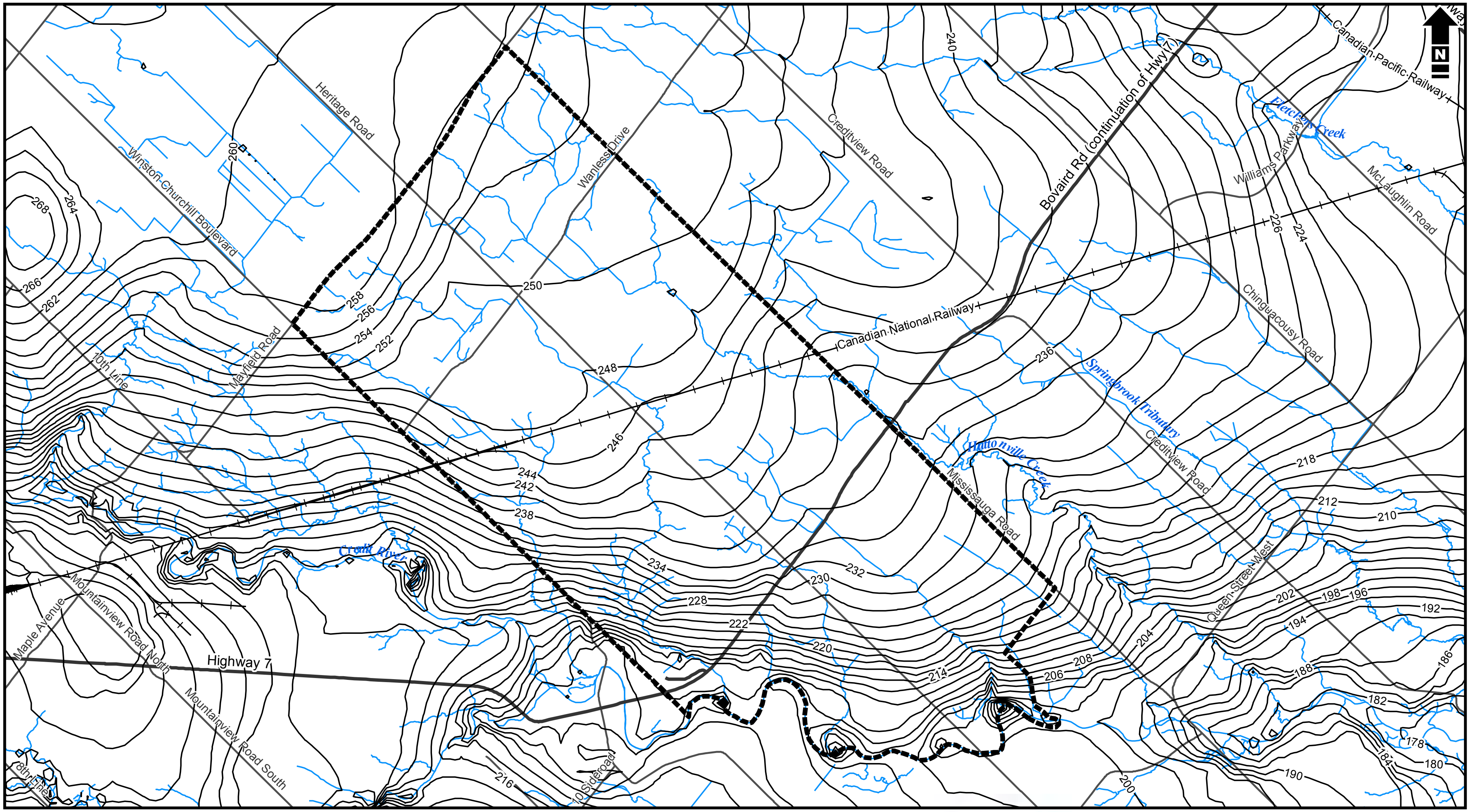
Figure 3

T:\2011013_HeritageHeightsSWS\GIS\ArcGIS\MXDs\



Legend

- Simulated Water Level Contours Interval 2m
- Railroad
- Highway / Expressway
- Road
- Heritage Heights Study Area
- Drainage

1:45,000

500 0 500

Metres

NAD 1983 UTM ZONE 17N

Reference: Ontario Ministry of Natural Resources (2010), Credit Valley Conservation Authority (2010)

T:\2011013_HeritageHeights\SWS\GIS\ArcGIS\MXDs\2011022_FIGURE-4_Model_Simulated_Water_Table.mxd

amec

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SAVANTA

Matrix Solutions Inc.

Blackport & Associates

STONYBROOK

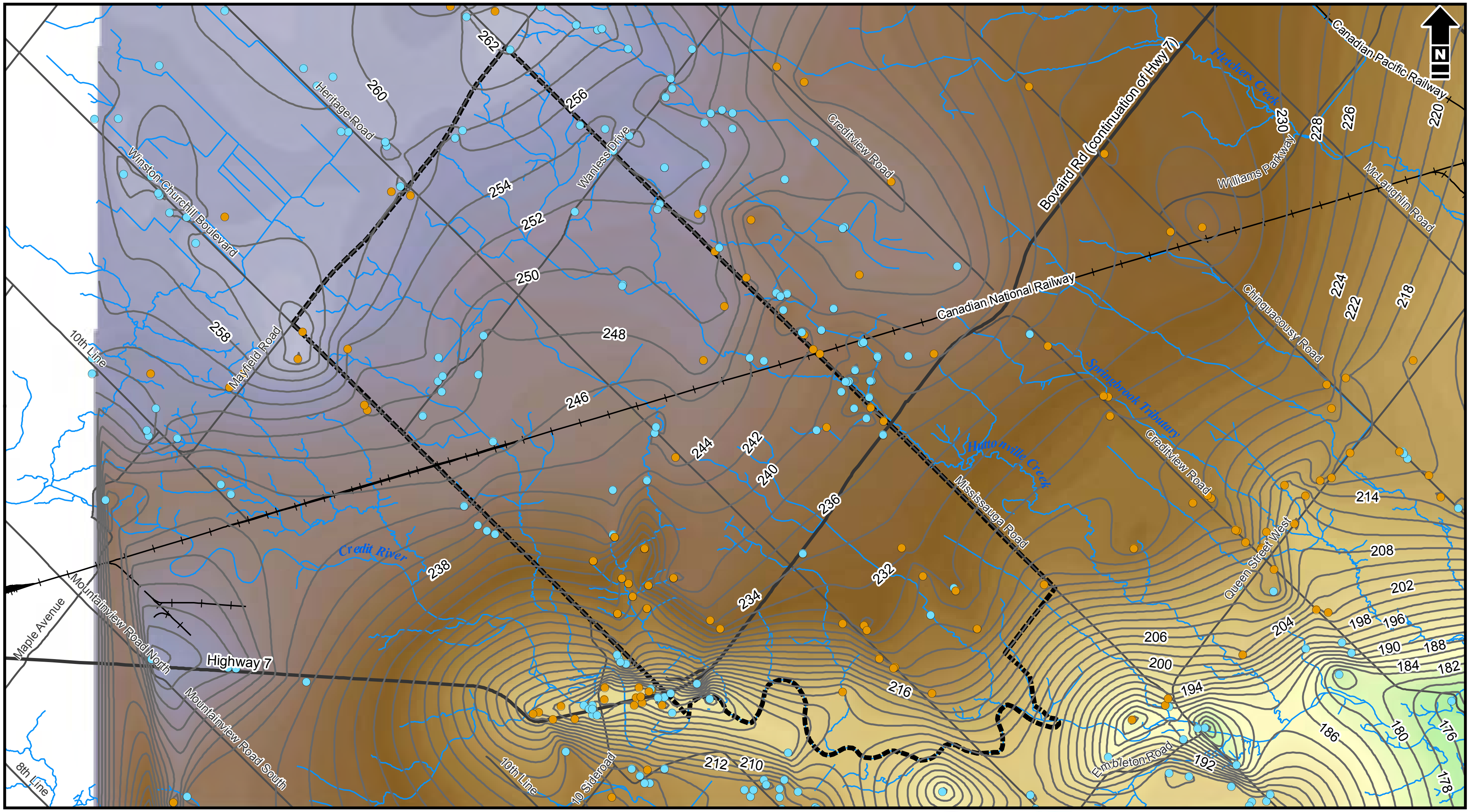
North West Brampton Heritage Heights Subwatershed Study

Model Simulated Water Table

Date: 15 Nov 2012	Project: 15519-528	Technical: P. Chin	Reviewer: D. Van Vliet	Drawn: C. Curry

Disclaimer: Prepared solely for the use of the City of Brampton as specified in the accompanying report. No representation of any kind is made to other parties with which the City of Brampton has not entered into contract.

Figure 4



Legend

- ● Overburden Wells
- ● Bedrock Wells
- — Contours - Interval 2m
- —+— Railroad
- ━ Highway / Expressway
- — Road
- ▬ ▬ Heritage Heights Study Area
- — Drainage

Shallow Water Level - Well Depth < 15m (m)

High : 278

Low : 155

1:45,000

500 0 500

Metres

NAD 1983 UTM ZONE 17N

Reference: Ontario Ministry of Natural Resources (2010), Credit Valley Conservation Authority (2010)

Blackport & Associates

North West Brampton Heritage Heights Subwatershed Study

Observed Shallow Water Levels

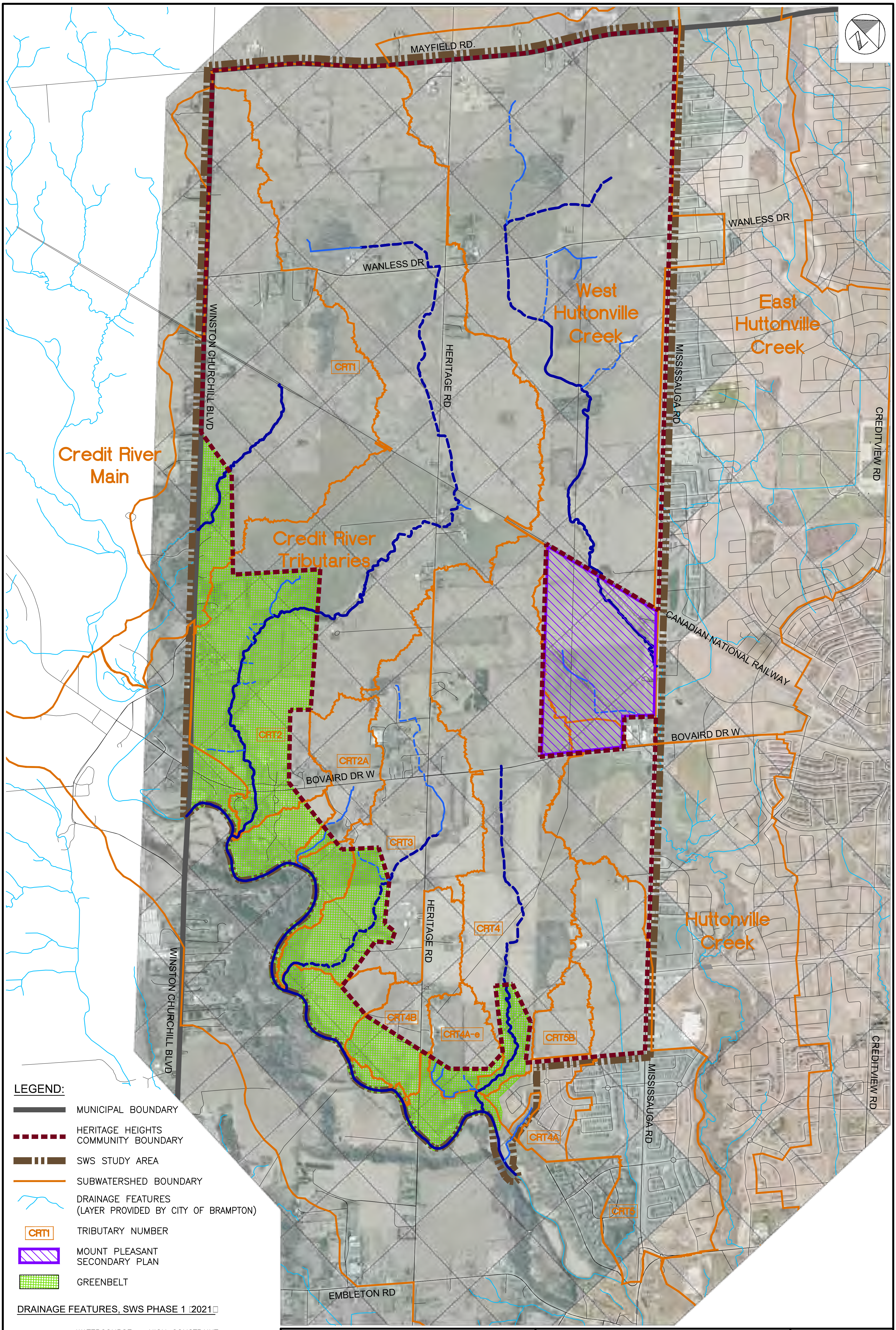
Date: 15 Nov 2012	Project: 15519-528	Technical: P. Chin	Reviewer: D. Van Vliet	Drawn: C. Curry

Figure
5

T:\2011013 HeritageHeightsSWS\GIS\ArcGIS\MXDs\2011022 FIGURE-5 Observed Shallow Water Levels.mxd

Appendix C

Hydrology and Hydraulics



LEGEND:

▬	MUNICIPAL BOUNDARY
▪▪▪▪	HERITAGE HEIGHTS COMMUNITY BOUNDARY
▬▮▮▬	SWS STUDY AREA
—	SUBWATERSHED BOUNDARY
～	DRAINAGE FEATURES (LAYER PROVIDED BY CITY OF BRAMPTON)
CRT1	TRIBUTARY NUMBER
▨	MOUNT PLEASANT SECONDARY PLAN
🟩	GREENBELT

DRAINAGE FEATURES, SWS PHASE 1 (2021)

▬	WATERCOURSE – HIGH CONSTRAINT
‒ ‒ ‒	WATERCOURSE – MEDIUM CONSTRAINT
—	HEADWATER DRAINAGE FEATURE – PROTECTION
- - -	HEADWATER DRAINAGE FEATURE – CONSERVATION

NORTH WEST BRAMPTON
HERITAGE HEIGHTS
SUBWATERSHED STUDY
CITY OF BRAMPTON

STUDY AREA
PLAN

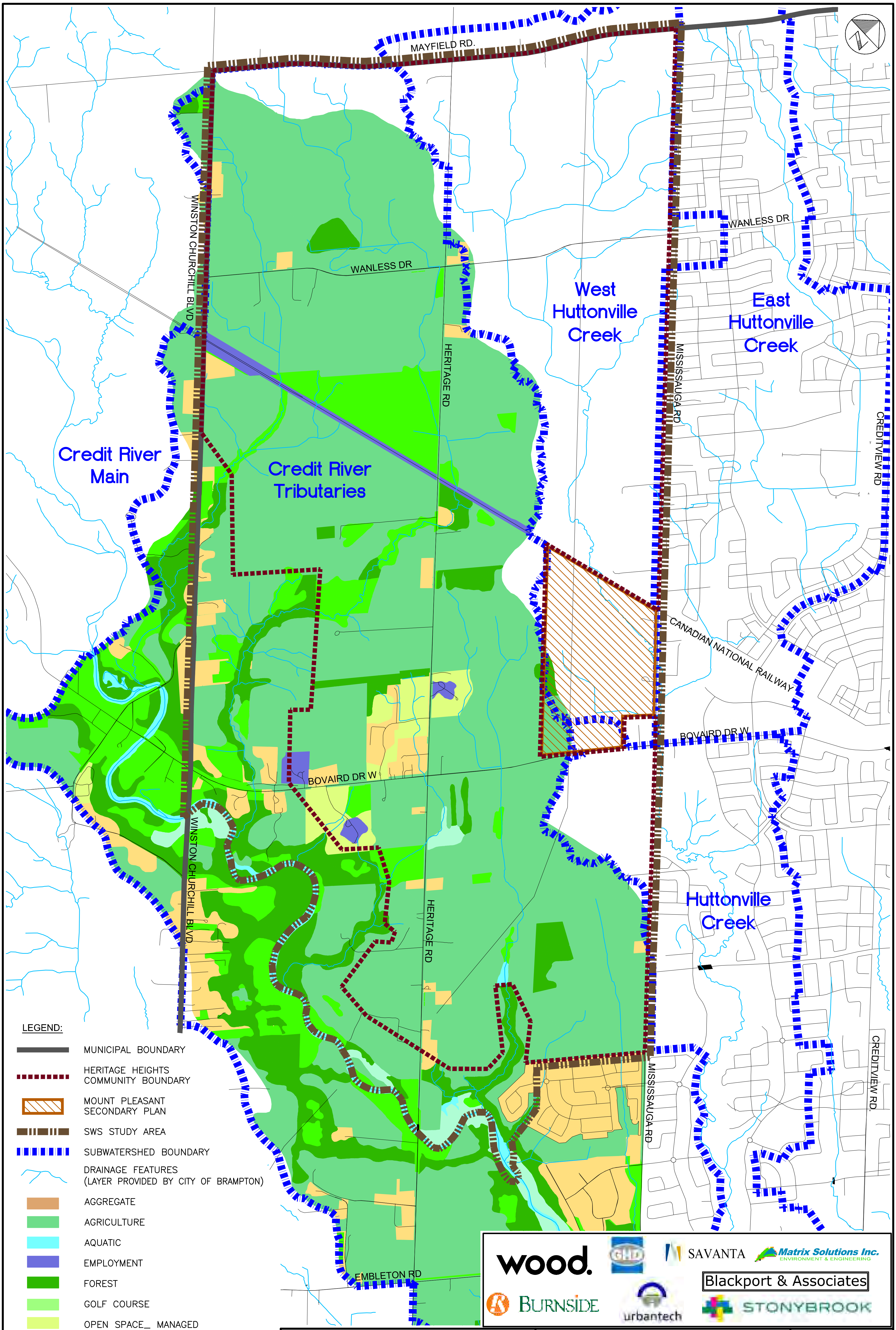
Scale 1:10,000
0 100m 500m

Consultant File No.
111117

Drawing No.
STUDY AREA

Jun 08/21 – richard.bartolo

I:\Misc\HeritageHeights\CAD\01-Dwg-1 Study Area.dwg



wood.

SAVANTA

Matrix Solutions Inc.
ENVIRONMENT & ENGINEERING

BURNSIDE

urbantech

Blackport & Associates

STONYBROOK

NORTH WEST BRAMPTON
HERITAGE HEIGHTS
SUBWATERSHED STUDY
CITY OF BRAMPTON

CREDIT RIVER TRIBUTARIES
EXISTING LAND USE
Source CVC

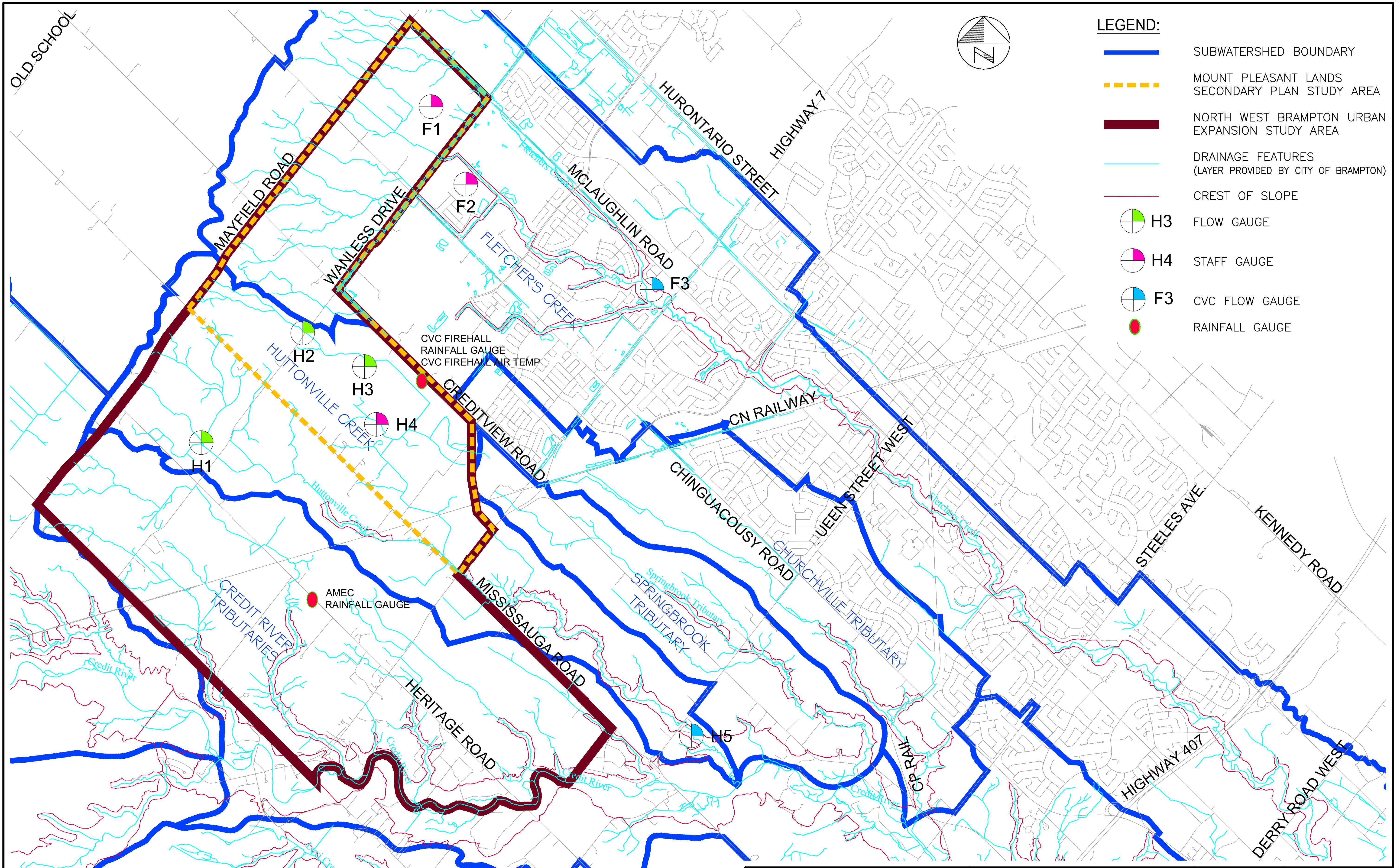
Scale 1:10,000
0 100m 500m

Consultant File No.
111117

Drawing No.
CRT LU 1

Jun 07/21 – richard.bartolo

I:\Misc\HeritageHeights\CAD\02-CRT Land Use 1-cvc.dwg



NOTE: ALL WATER QUALITY SITES ALSO FIELD MEASURED FOR DO, pH, TEMPERATURE, CONDUCTIVITY

2006-2007 FIELD PROGRAM NWB
HUTTONVILLE FLETCHERS CREEK
CITY OF BRAMPTON

STREAM FLOW
MONITORING LOCATIONS

wood.

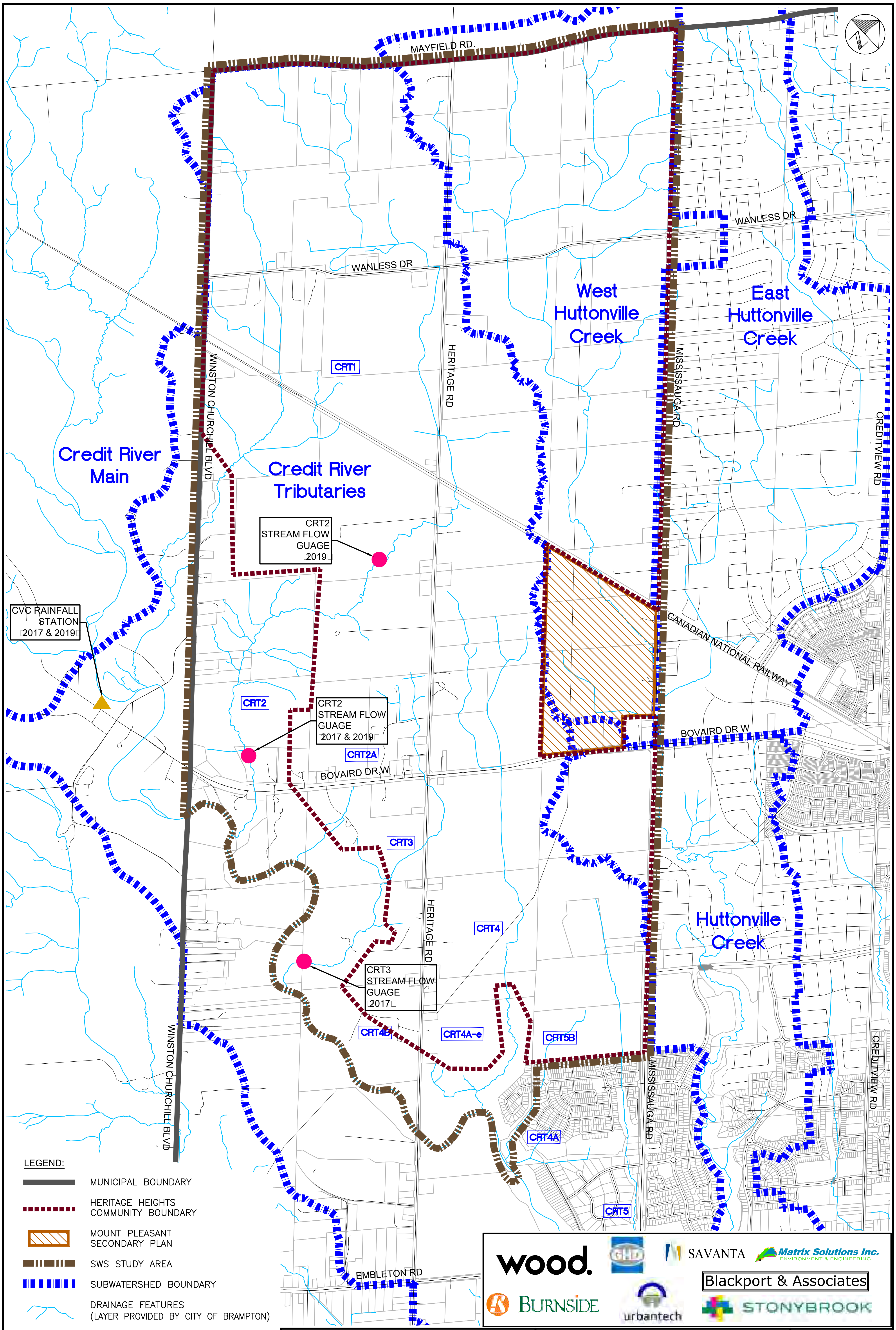
Scale
1:40,000

Consultant File No.
106123

Figure
HYDROLOGY 1

Jun 03/21 – richard.bartol

I:\Misc\HeritageHeights\CAD\03–char–fighydro1.dwg



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Blackport & Associates
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urbantech
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NORTH WEST BRAMPTON
HERITAGE HEIGHTS
SUBWATERSHED STUDY
CITY OF BRAMPTON

STREAM FLOW
MONITORING LOCATIONS
(2017-2019)

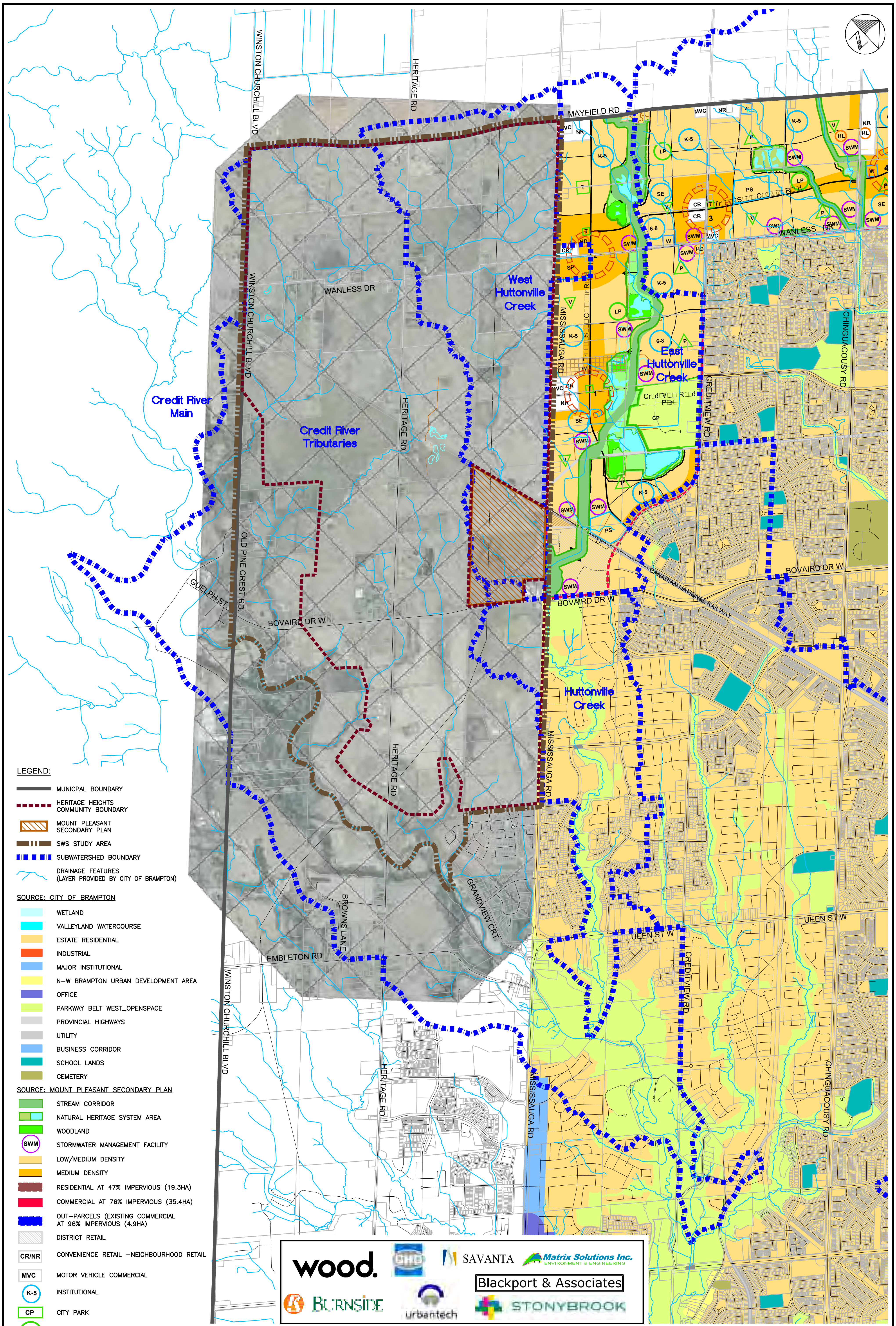
Scale 1:10,000
0 100m 500m

Consultant File No.
111117

Drawing No.
HYDROLOGY 2

Jun 07/21 – richard.bartolo

I:\Misc\HeritageHeights\CAD\04-Monitoring2017-2019.dwg



LEGEND:

▬	MUNICPAL BOUNDARY
▪▪▪	HERITAGE HEIGHTS COMMUNITY BOUNDARY
▨	MOUNT PLEASANT SECONDARY PLAN
▬▮▬	SWS STUDY AREA
▪▪▪	SUBWATERSHED BOUNDARY
∼	DRAINAGE FEATURES (LAYER PROVIDED BY CITY OF BRAMPTON)

SOURCE: CITY OF BRAMPTON

■	WETLAND
■	VALLEYLAND WATERCOURSE
■	ESTATE RESIDENTIAL
■	INDUSTRIAL
■	MAJOR INSTITUTIONAL
■	N-W BRAMPTON URBAN DEVELOPMENT AREA
■	OFFICE
■	PARKWAY BELT WEST_OPENSPACE
■	PROVINCIAL HIGHWAYS
■	UTILITY
■	BUSINESS CORRIDOR
■	SCHOOL LANDS
■	CEMETERY

SOURCE: MOUNT PLEASANT SECONDARY PLAN

■	STREAM CORRIDOR
■■	NATURAL HERITAGE SYSTEM AREA
■	WOODLAND
SWM	STORMWATER MANAGEMENT FACILITY
■	LOW/MEDIUM DENSITY
■	MEDIUM DENSITY
■	RESIDENTIAL AT 47% IMPERVIOUS (19.3HA)
■	COMMERCIAL AT 76% IMPERVIOUS (35.4HA)
■	OUT-PARCELS (EXISTING COMMERCIAL AT 96% IMPERVIOUS (4.9HA)
▨	DISTRICT RETAIL
CR/NR	CONVENIENCE RETAIL -NEIGHBOURHOOD RETAIL
MVC	MOTOR VEHICLE COMMERCIAL
K-5	INSTITUTIONAL
CP	CITY PARK
LP	LOCAL PARK
P/V	PARKETTE -VEST POCKET
T	TOWN SQUARE

I:\Misc\HeritageHeights\CAD\05-Hutto Land Use 2.dwg

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Blackport & Associates
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NORTH WEST BRAMPTON
HERITAGE HEIGHTS
SUBWATERSHED STUDY
CITY OF BRAMPTON

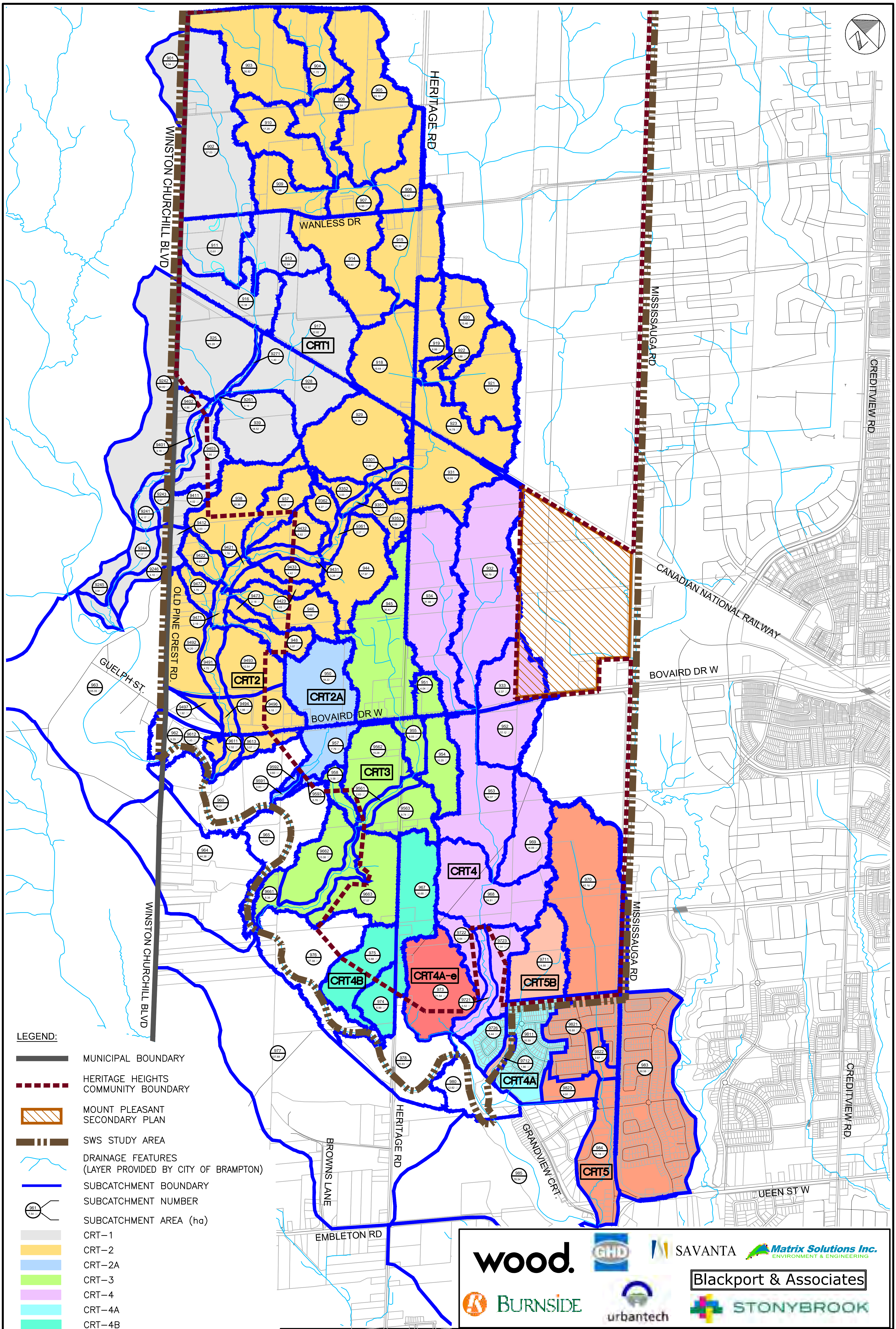
EXISTING LAND USE
WEST HUTTONVILLE CREEK

Scale 1:15,000
0 100m 500m

Consultant File No.
111117

Drawing No.
HUTT LU 2

Jun 07/21 — richard.bartolo



LEGEND:

- MUNICIPAL BOUNDARY
- HERITAGE HEIGHTS COMMUNITY BOUNDARY
- ▨ MOUNT PLEASANT SECONDARY PLAN
- SWS STUDY AREA
- DRAINAGE FEATURES (LAYER PROVIDED BY CITY OF BRAMPTON)
- SUBCATCHMENT BOUNDARY
- 961 / 7.54 SUBCATCHMENT NUMBER / SUBCATCHMENT AREA (ha)
- ▨ CRT−1
- ▨ CRT−2
- ▨ CRT−2A
- ▨ CRT−3
- ▨ CRT−4
- ▨ CRT−4A
- ▨ CRT−4B
- ▨ CRT−4E
- ▨ CRT−5
- ▨ CRT−5B
- ☐ CREDIT RIVER MAIN

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NORTH WEST BRAMPTON
HERITAGE HEIGHTS
SUBWATERSHED STUDY
CITY OF BRAMPTON

EXISTING LAND USE
DRAINAGE AREA PLAN
HUTTONVILLE CREEK &
CREDIT RIVER TRIBUTARIES

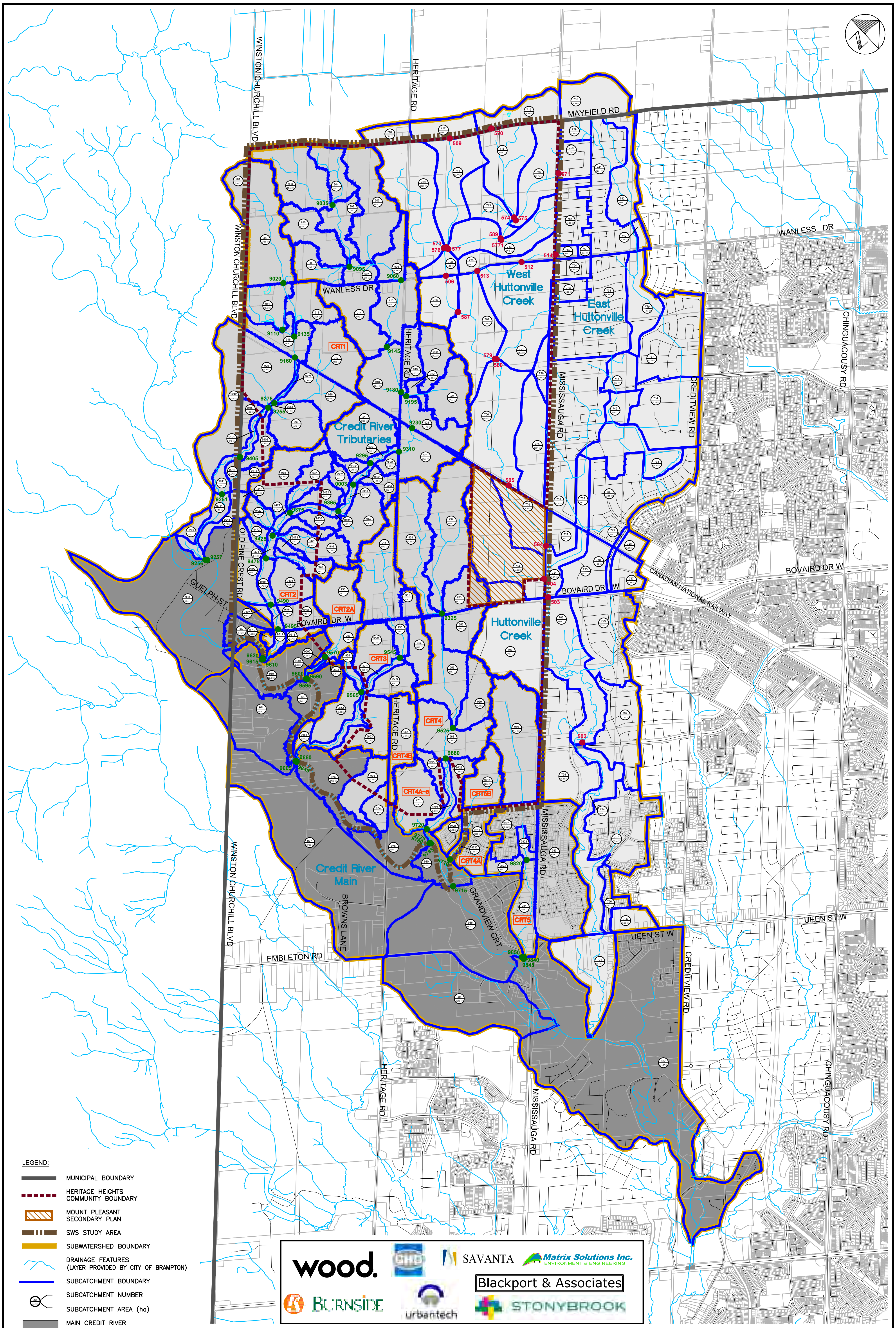
Scale 1:10,000
0 100m 500m

Consultant File No.
111117

Drawing No.
HYDRO-1

Jun 07/21 – richard.bartolo

I:\Misc\HeritageHeights\CAD\06−Hydro−1 Subcatch−credit.dwg



wood.

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NORTH WEST BRAMPTON
HERITAGE HEIGHTS
SUBWATERSHED STUDY
CITY OF BRAMPTON

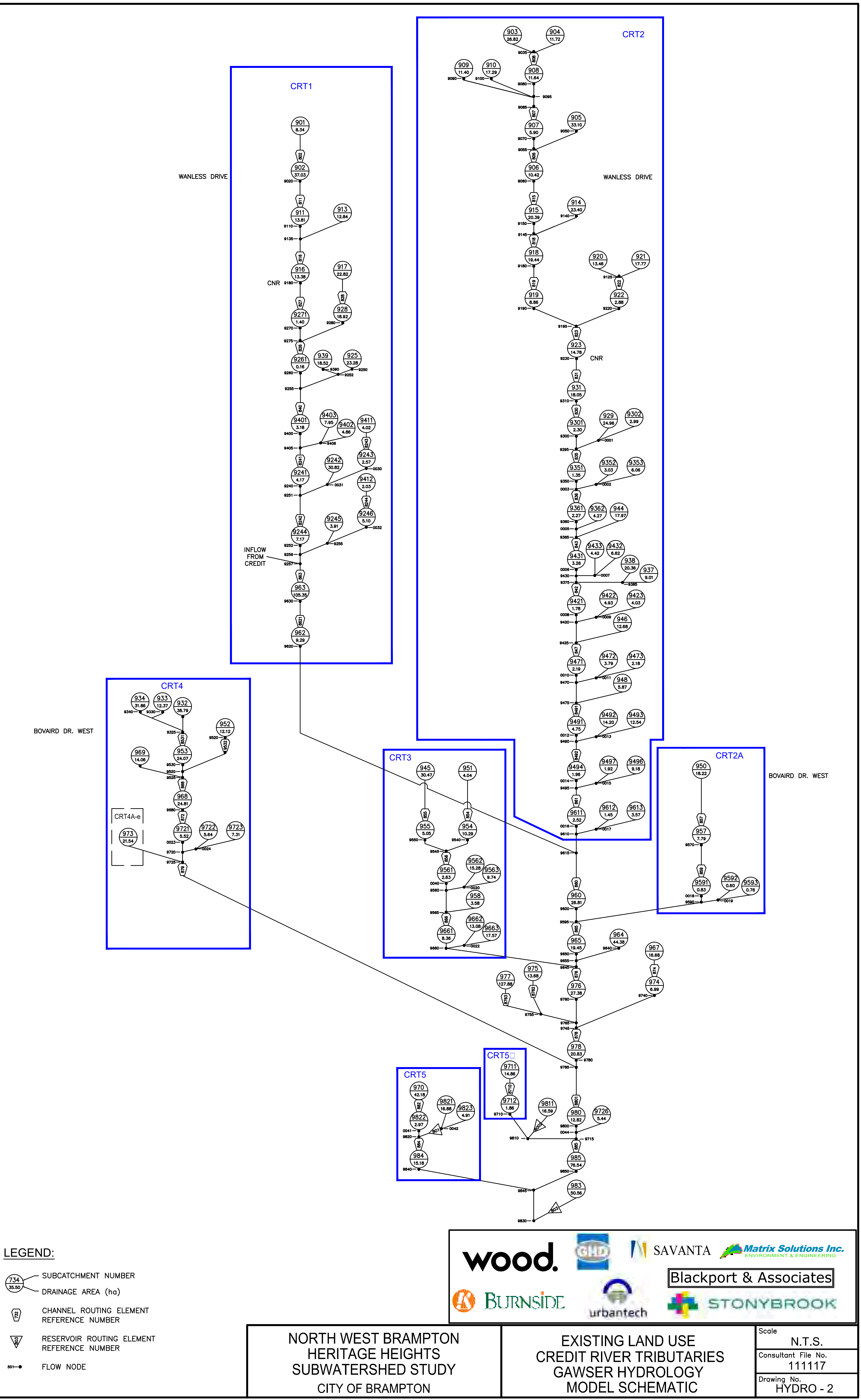
EXISTING LAND USE
DRAINAGE AREA PLAN
HUTTONVILLE CREEK &
CREDIT RIVER TRIBUTARIES

Scale 1:15,000
0 100m 500m

Consultant File No.
111117

Drawing No.
HYDRO-1

Jun 07/21 – richard.bartolo



wood. GHD SAVANTA Matrix Solutions Inc. ENVIRONMENT & ENGINEERING
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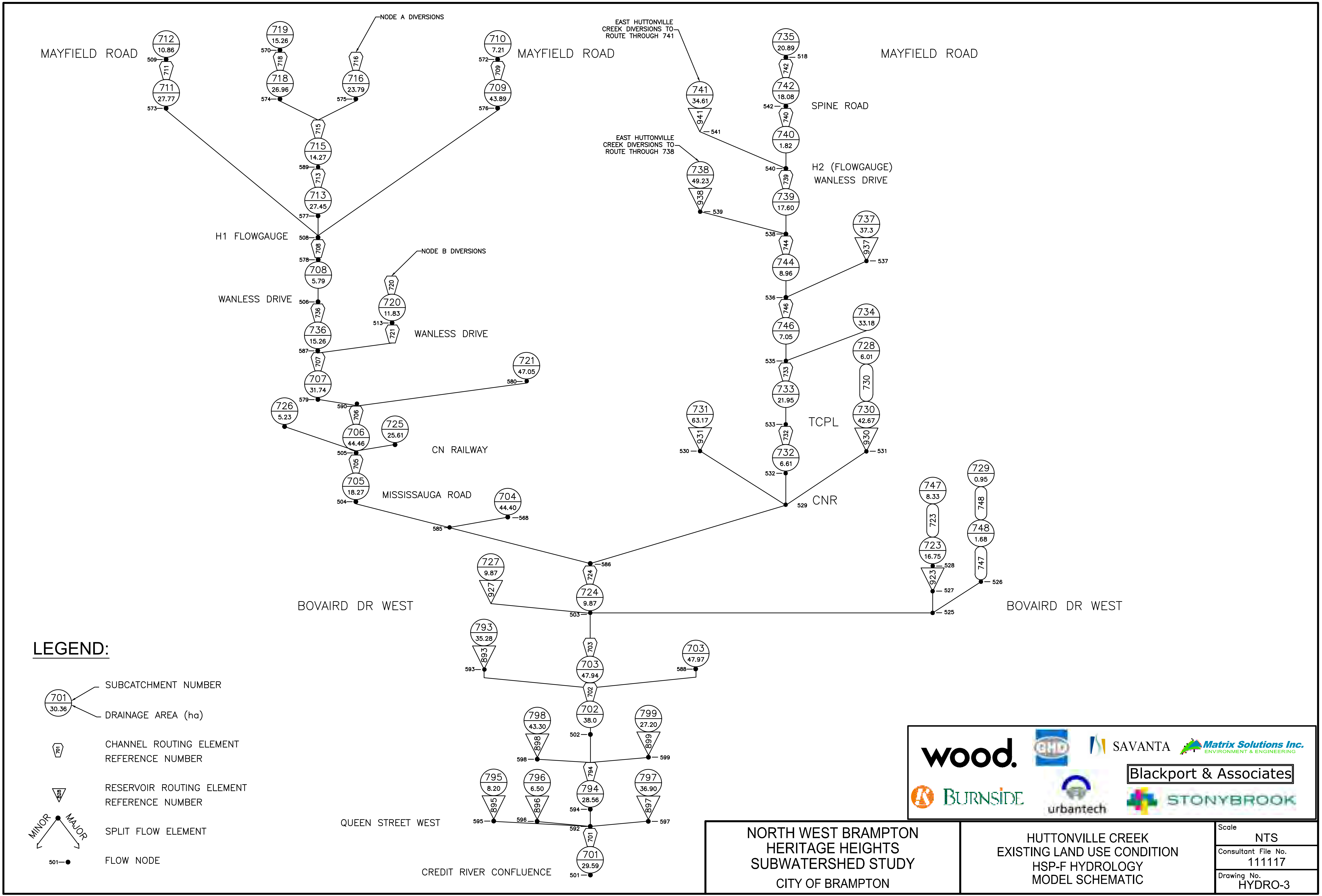
NORTH WEST BRAMPTON
HERITAGE HEIGHTS
SUBWATERSHED STUDY
CITY OF BRAMPTON

EXISTING LAND USE
CREDIT RIVER TRIBUTARIES
GAWSER HYDROLOGY
MODEL SCHEMATIC

Scale
N.T.S.
Consultant File No.
111117
Drawing No.
HYDRO - 2

I:\Misc\HeritageHeights\CAD\08-Hydro-2 Schematic.dwg

Jun 03/21 – richard.bartolo



wood. GHD SAVANTA Matrix Solutions Inc. ENVIRONMENT & ENGINEERING
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NORTH WEST BRAMPTON
HERITAGE HEIGHTS
SUBWATERSHED STUDY

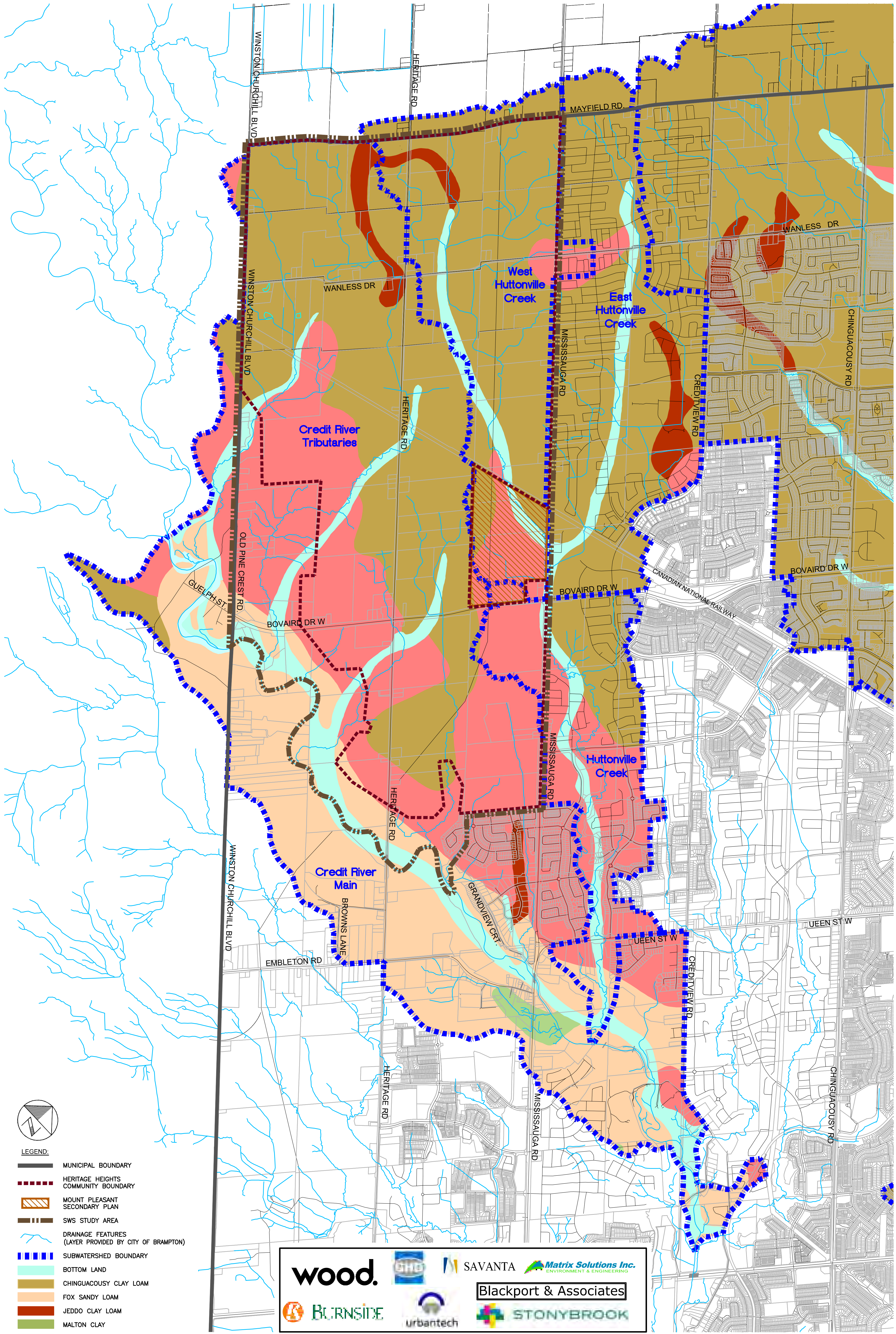
CITY OF BRAMPTON

HUTTONVILLE CREEK
EXISTING LAND USE CONDITION
HSP-F HYDROLOGY
MODEL SCHEMATIC

Scale	NTS
Consultant File No.	111117
Drawing No.	HYDRO-3

Jun 03/21 – richard.bartolo

I:\Misc\HeritageHeights\CAD\09-Hydro-3 Schematic-ExHuttonville.dwg



LEGEND:

- ▬ MUNICIPAL BOUNDARY
- ┅ HERITAGE HEIGHTS COMMUNITY BOUNDARY
- ▨ MOUNT PLEASANT SECONDARY PLAN
- ▬ SWS STUDY AREA
- ～ DRAINAGE FEATURES (LAYER PROVIDED BY CITY OF BRAMPTON)
- ┅ SUBWATERSHED BOUNDARY
- ■ BOTTOM LAND
- ■ CHINGUACOUSY CLAY LOAM
- ■ FOX SANDY LOAM
- ■ JEDDO CLAY LOAM
- ■ MALTON CLAY
- ■ MUCK
- ■ ONEIDA CLAY LOAM
- ■ PEEL CLAY
- ■ WATER

SOURCE: OMAFRA

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STONYBROOK

NORTH WEST BRAMPTON
HERITAGE HEIGHTS
SUBWATERSHED STUDY
CITY OF BRAMPTON

SOILS OF
HUTTONVILLE CREEK &
CREDIT RIVER TRIBUTARIES

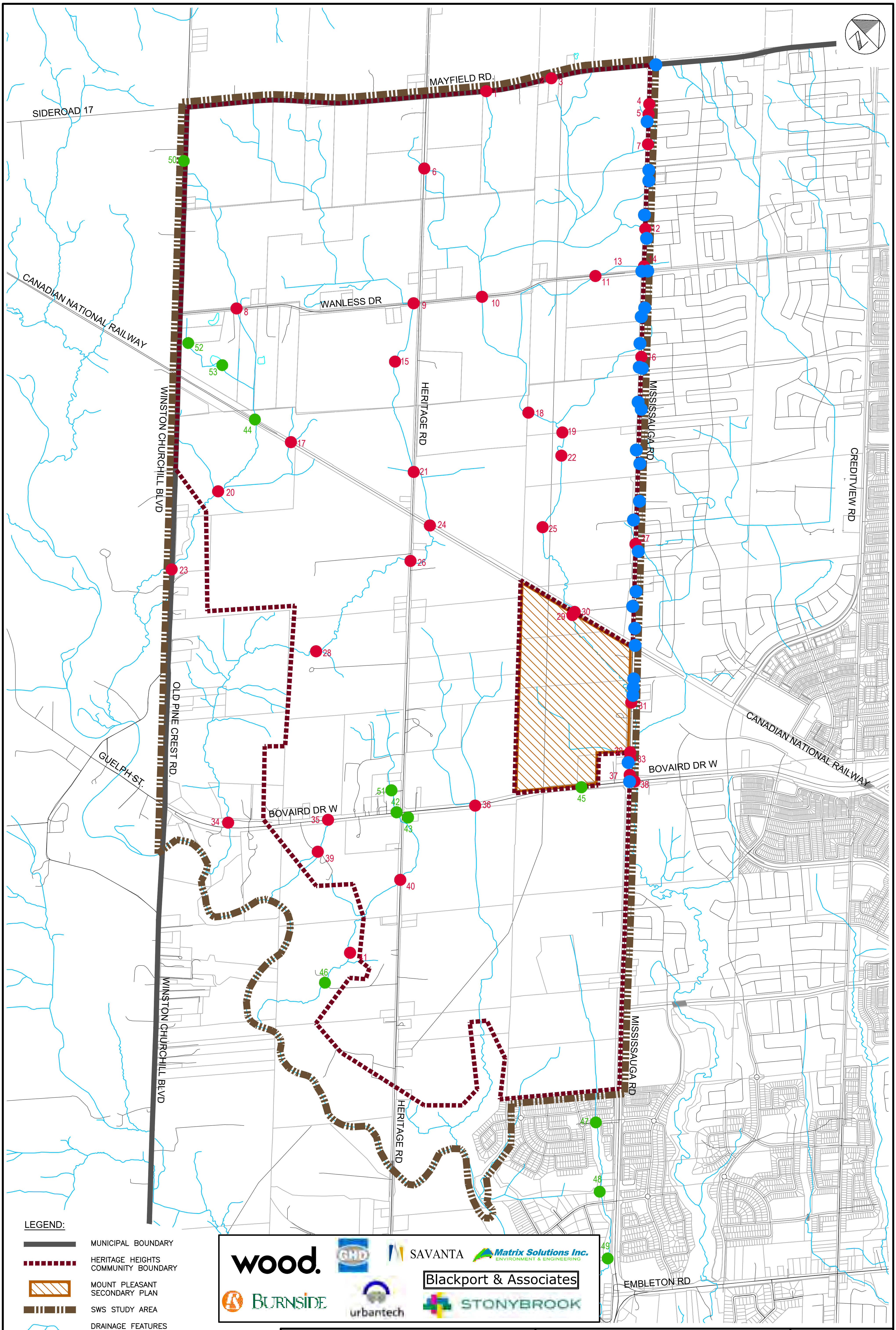
Scale 1:15,000

Consultant File No.
111117

Drawing No.
HYDRO 4

Jun 07/21 – richard.bartolo

i:\Misc\HeritageHeights\CAD\10-Hydro-4 soil map.dwg



LEGEND:

▬	MUNICIPAL BOUNDARY
▪▪▪	HERITAGE HEIGHTS COMMUNITY BOUNDARY
▨	MOUNT PLEASANT SECONDARY PLAN
▬	SWS STUDY AREA
〰	DRAINAGE FEATURES (LAYER PROVIDED BY CITY OF BRAMPTON)
● 1	CULVERT LOCATION (SURVEYED)
● 47	CULVERT LOCATION (NOT SURVEYED)
●	ROADSIDE CULVERT LOCATION

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Matrix Solutions Inc.
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Blackport & Associates
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NORTH WEST BRAMPTON
HERITAGE HEIGHTS
SUBWATERSHED STUDY
CITY OF BRAMPTON

CULVERT INVENTORY

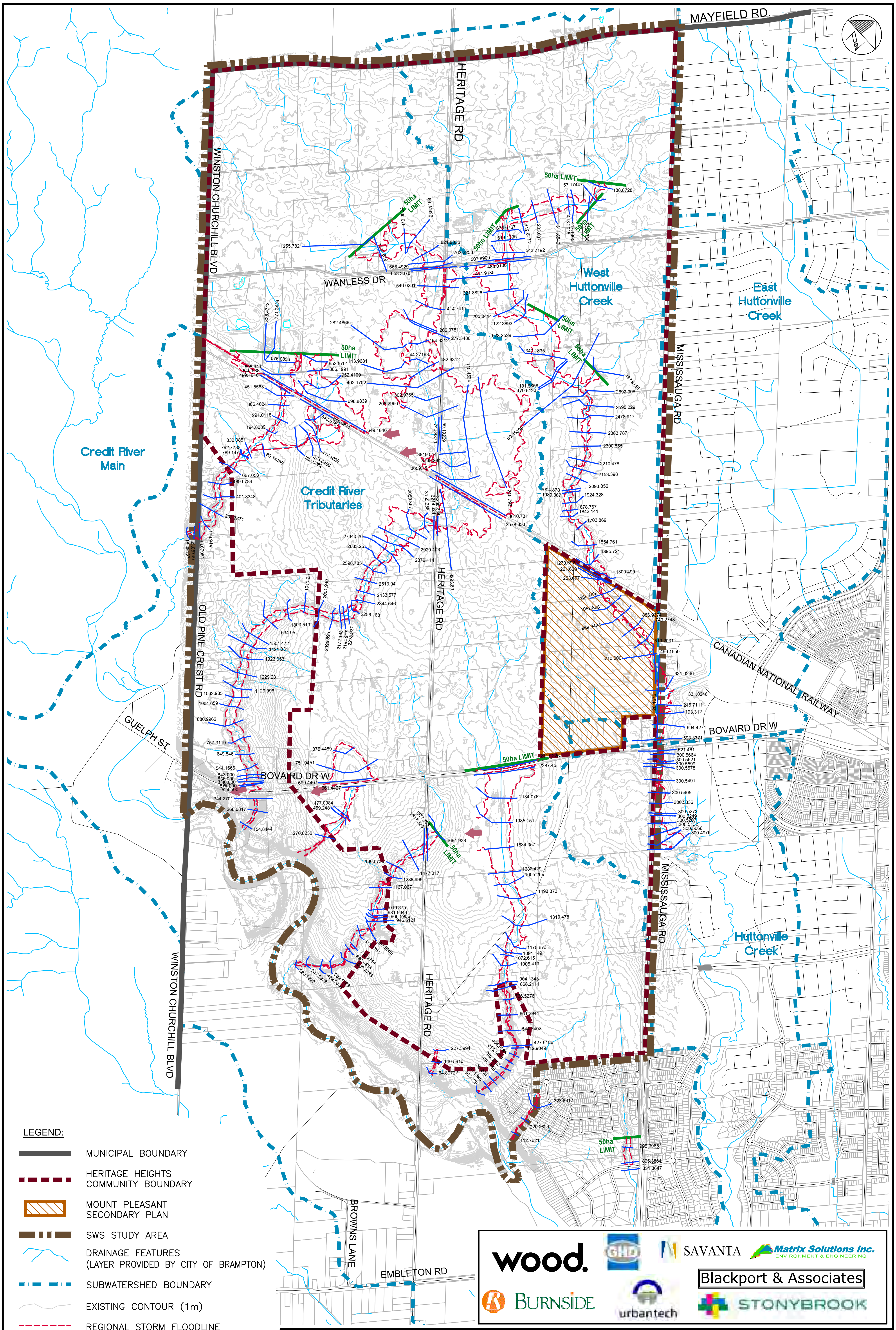
Scale 1:10,000
0 100m 500m

Consultant File No.
111117

Drawing No.
HYDRA 1

I:\Misc\HeritageHeights\CAD\11-Hydra-1 Culvert Inv.dwg

Jun 07/21 – richard.bartolo



LEGEND:

▬	MUNICIPAL BOUNDARY
▬ ▬ ▬	HERITAGE HEIGHTS COMMUNITY BOUNDARY
▨	MOUNT PLEASANT SECONDARY PLAN
▬ ▪ ▪ ▬	SWS STUDY AREA
〰	DRAINAGE FEATURES (LAYER PROVIDED BY CITY OF BRAMPTON)
— · —	SUBWATERSHED BOUNDARY
—	EXISTING CONTOUR (1m)
- - -	REGIONAL STORM FLOODLINE
⬅	SPILL
— 2628.147	HEC-RAS CROSS-SECTION AND ID NUMBER

wood.

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STONYBROOK

NORTH WEST BRAMPTON
HERITAGE HEIGHTS
SUBWATERSHED STUDY
CITY OF BRAMPTON

REGIONAL FLOODLINE AND
HEC-RAS SECTION LOCATIONS
HUTTONVILLE CREEK &
CREDIT RIVER TRIBUTARIES

Scale 1:10,000
0 100m 500m

Consultant File No.
111117

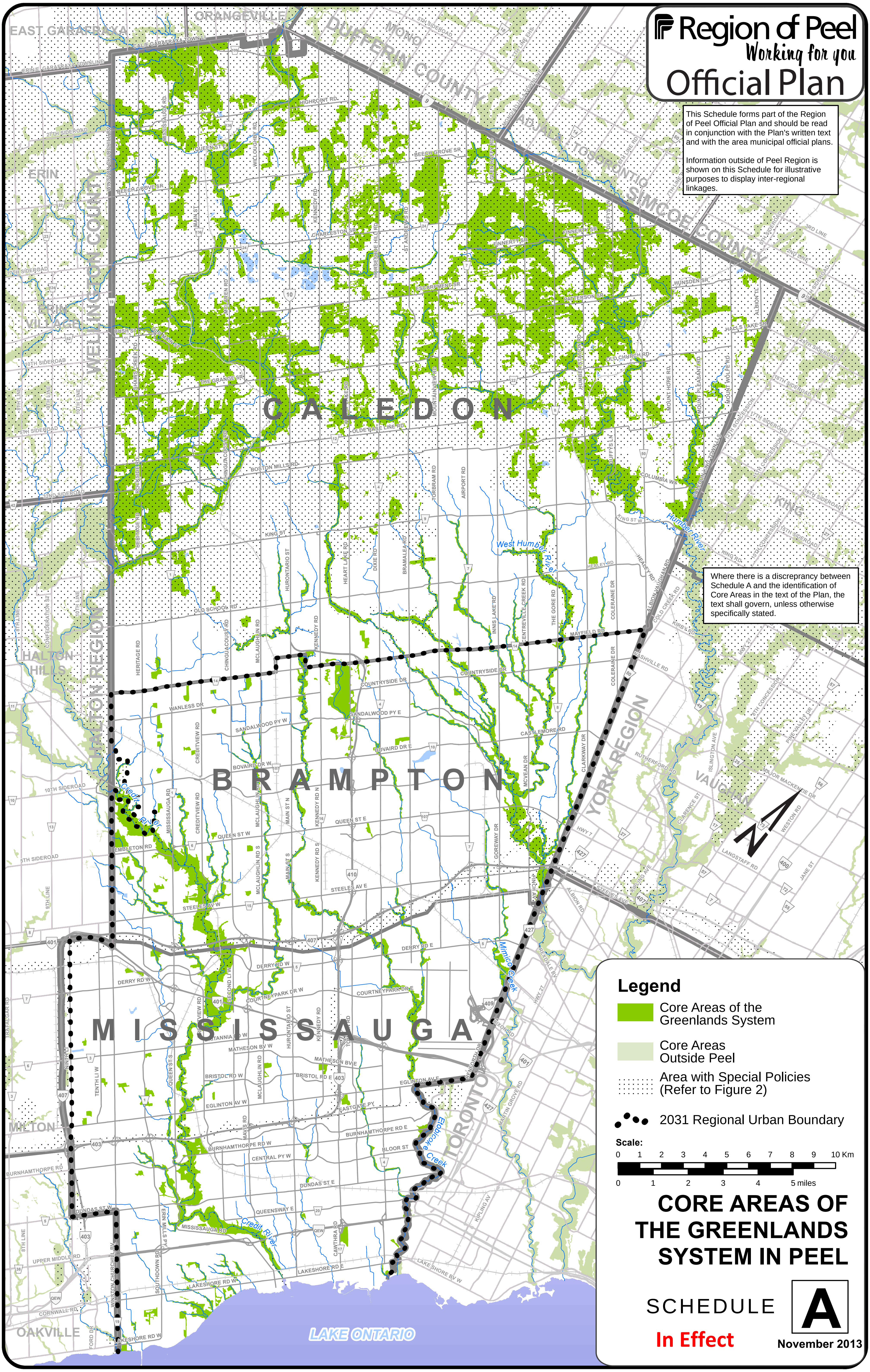
Drawing No.
HYDRA-3

I:\Misc\HeritageHeights\CAD\13-Hydra-3 Floodplain.dwg

Appendix D

Terrestrial Resources

Region of Peel
Working for you
Official Plan



This Schedule forms part of the Region of Peel Official Plan and should be read in conjunction with the Plan's written text and with the area municipal official plans.

Information outside of Peel Region is shown on this Schedule for illustrative purposes to display inter-regional linkages.

Where there is a discrepancy between Schedule A and the identification of Core Areas in the text of the Plan, the text shall govern, unless otherwise specifically stated.

Legend

🟩 Core Areas of the Greenlands System

▨ Core Areas Outside Peel

⁘ Area with Special Policies (Refer to Figure 2)

●●● 2031 Regional Urban Boundary

Scale:

0 1 2 3 4 5 6 7 8 9 10 Km

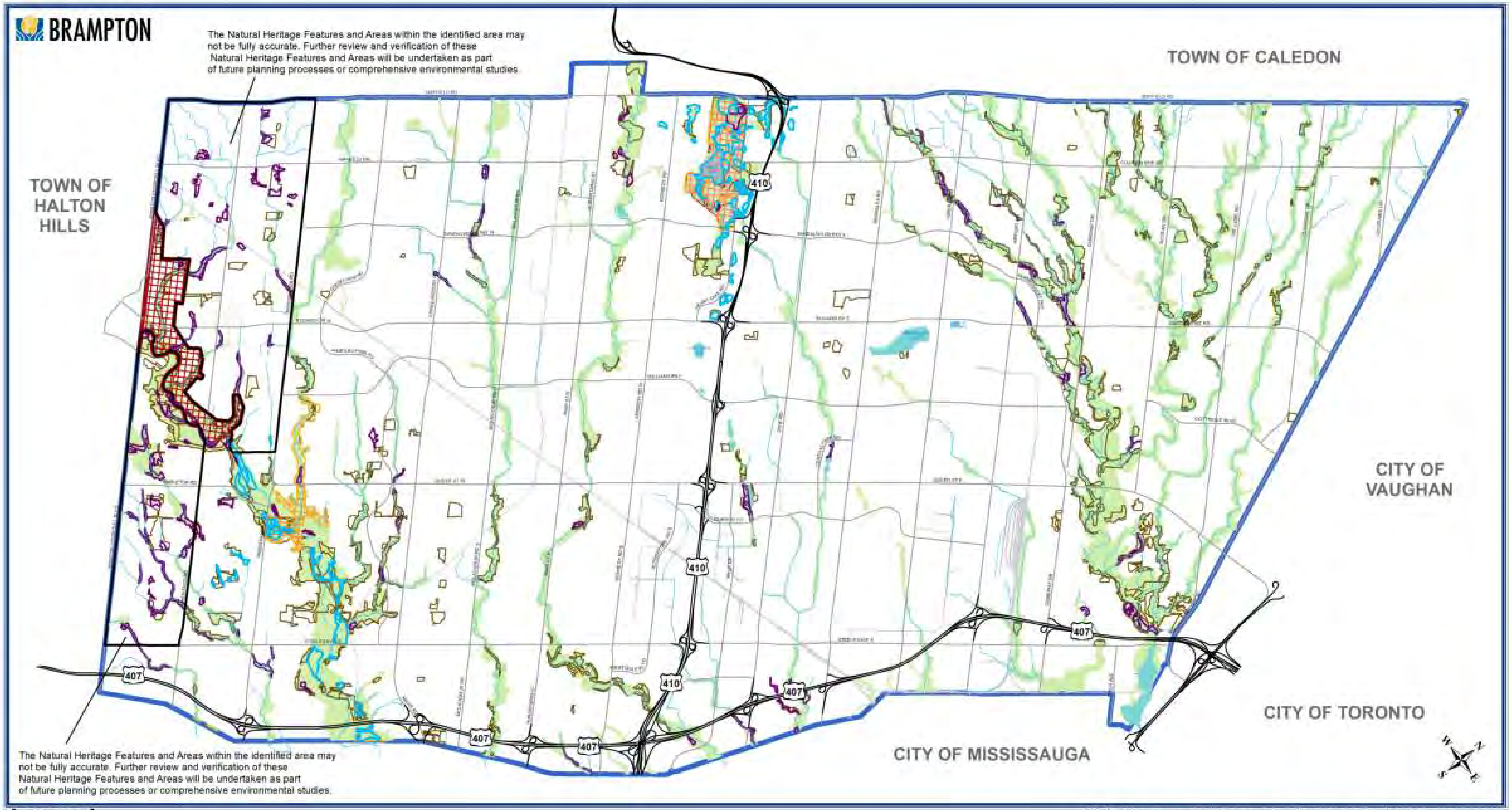
0 1 2 3 4 5 miles

CORE AREAS OF THE GREENLANDS SYSTEM IN PEEL

SCHEDULE A

In Effect

November 2013



The Natural Heritage Features and Areas within the identified area may not be fully accurate. Further review and verification of these Natural Heritage Features and Areas will be undertaken as part of future planning processes or comprehensive environmental studies.

The Natural Heritage Features and Areas within the identified area may not be fully accurate. Further review and verification of these Natural Heritage Features and Areas will be undertaken as part of future planning processes or comprehensive environmental studies.

Legend

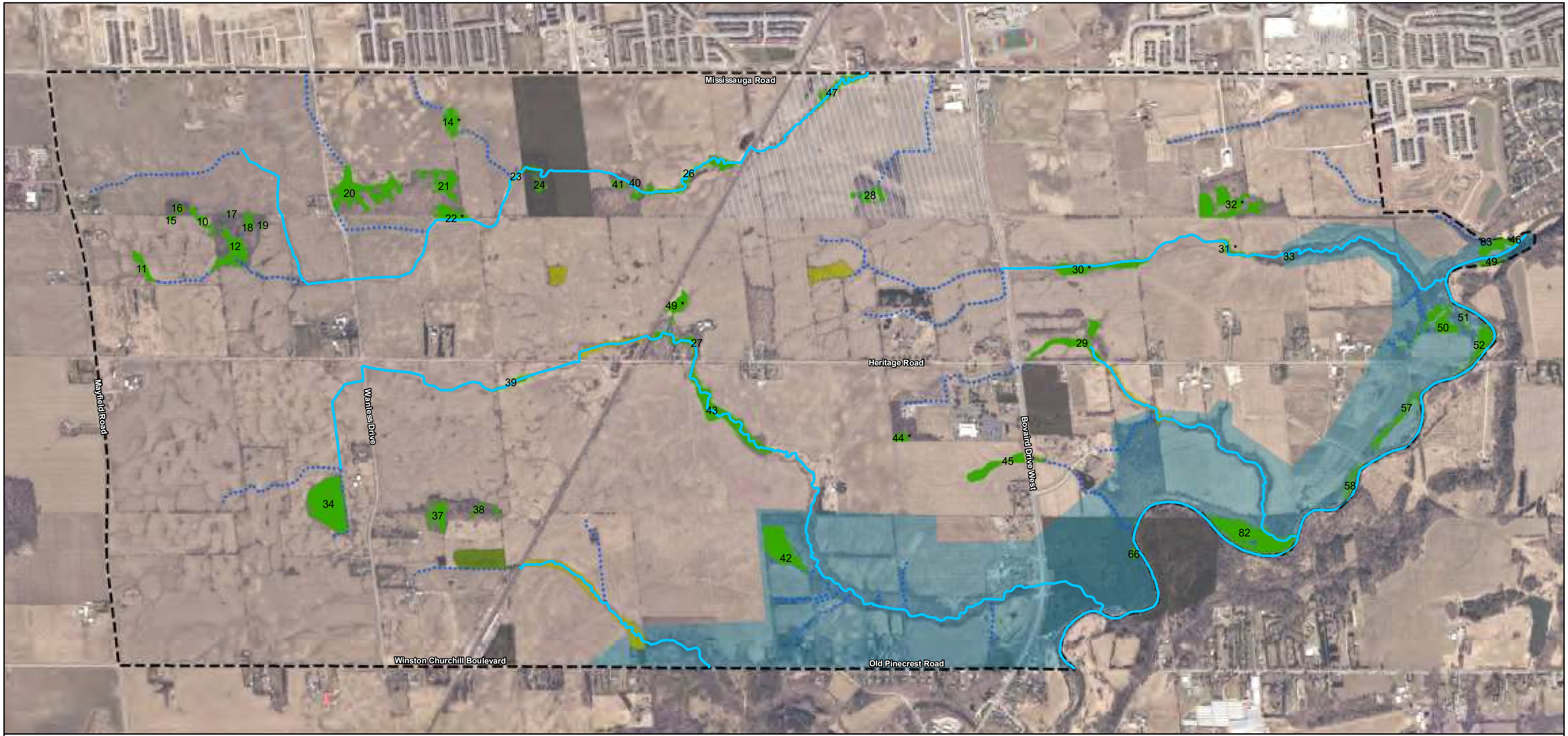
- 🟩 VALLEYLAND/WATERCOURSE CORRIDOR
- ☐ WOODLAND
- 🟥 SPECIAL POLICY AREA
- ☐ OTHER WETLAND
- ☐ PROVINCIALLY SIGNIFICANT WETLAND
- 🟦 LAKES
- ▨ AREAS OF NATURAL AND SCIENTIFIC INTEREST - EARTH SCIENCE
- ▨ AREAS OF NATURAL AND SCIENTIFIC INTEREST - LIFE SCIENCE
- ☐ ENVIRONMENTALLY SENSITIVE / SIGNIFICANT AREA
- ▨ PROVINCIAL GREENBELT/PROTECTED COUNTRYSIDE

NOTES: WATERCOURSES AND TRIBUTARIES ARE SHOWN FOR CONTEXT PURPOSES

The boundaries and alignments of designations on this Schedule are approximate and are not to be scaled. This map forms part of the Official Plan of the City of Brampton and must be read in conjunction with the text, other Schedules, and Secondary Plans. Mapping to support the implementation of the "Development, Interference with Wetlands and Alterations to Shorelines and Watercourses Regulation" is not specifically reflected by this Regulation. The Toronto and Region Conservation Authority and Credit Valley Conservation should be contacted for details regarding their respective requirements for the areas regulated under the said Regulation.

SCHEDULE D NATURAL HERITAGE FEATURES AND AREAS

Date: 2020/11/23
Last Amended Date - Aug 10th,2020
Planning, Building and Economic Development
City of Brampton 2006 Official Plan September 2020 Office Consolidation.



NOTES:
1. Coordinate System: NAD 1983 UTM Zone 17N.
2. Base features produced under license with the Ontario Ministry of Natural Resources and Forestry © Queen's Printer for Ontario, 2021.
3. Orthoimagery © First Base Solutions, 2021. Imagery taken in 2019.

Legend

- – – Study Area
- ▨ Mount Pleasant Heights Lands
- ■ Land Access Unavailable
- ■ Greenbelt Plan Area
- — Watercourse
- ···· Headwater Drainage Feature
- ■ Provincially Significant Wetlands (MNRF 2021)

Wetlands not Significant Wetlands

- ■ Locally Significant Wetland (0.5 - 2 ha)
- ■ Locally Significant Wetland (> 2 ha)

* These wetlands are part of an active review process

Lands within the Provincial Greenbelt Area are located within the SWS Study Area but are not part of the City of Brampton Urban Area.

Project 1901516

Heritage Heights Subwatershed Study

Figure T1
Significant Wetlands

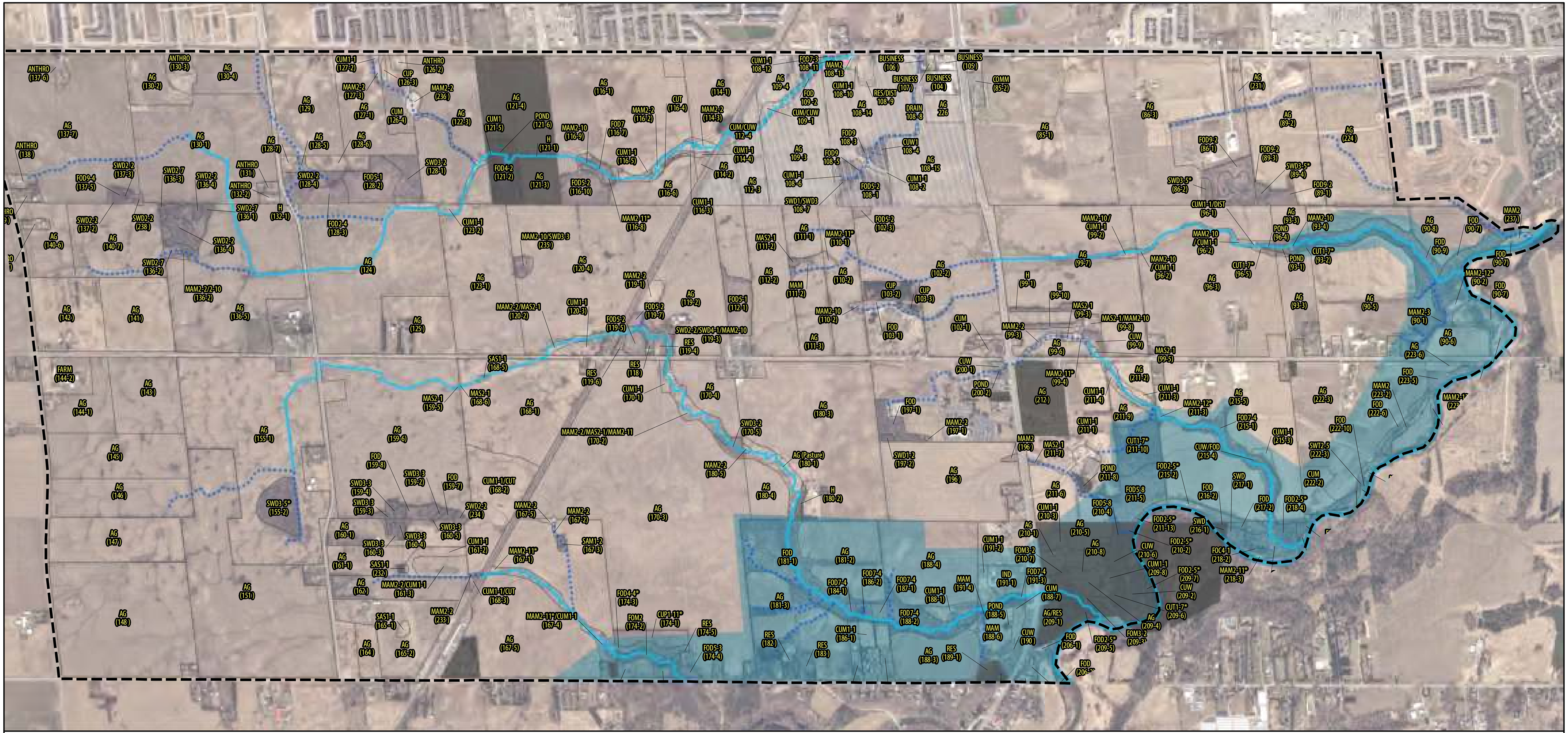
0 300 m

1:18,000

N

GEI Consultants
Savanta Division

Path: C:\SAVANTA\1901516 - Heritage Heights\figures\report_figures\2021 06 03 Phase1FigureUpdates\1901516_rpt_figT1_SignificantWetlands.mxd Date Saved: Monday, June 7, 2021



NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
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Legend

- Study Area
- Land Access Unavailable
- Greenbelt Plan Area
- Mount Pleasant Heights Lands
- Watercourse
- Headwater Drainage Feature
- ELC Communities (Savanta Inc.)

ELC Code

ELC Polygon Unique Identifier

ELC Legend

Coniferous Forest (FOC)

FOC4-1 Fresh-Moist White Cedar Coniferous Forest

Mixed Forest (FOM)

FOM2 Dry-Fresh Mixed Forest

FOM3-2 Dry-Fresh Sugar Maple-Hemlock Mixed Forest

Deciduous Forest (FOD)

FOD2-5* Dry-Fresh Oak-Maple-Hardwood Deciduous Forest

FOD4-2 Dry-Fresh White Ash Deciduous Forest

FOD4-4* Dry-Fresh Black Walnut Deciduous Forest

FOD5-1 Dry-Fresh Sugar Maple Deciduous Forest

FOD5-2 Dry-Fresh Sugar Maple-Beech Deciduous Forest

FOD5-3 Dry-Fresh Sugar Maple-Oak Deciduous Forest

FOD5-8 Dry-Fresh Sugar Maple-White Ash Deciduous Forest

FOD7 Fresh-Moist Lowland Deciduous Forest

FOD7-2 Fresh-Moist Ash Lowland Deciduous Forest

FOD7-3 Fresh-Moist Willow Lowland Deciduous Forest

FOD7-4 Fresh-Moist Black Walnut Lowland Deciduous Forest

FOD9 Fresh-Moist Oak-Maple-Hickory Deciduous Forest

FOD9-2 Fresh-Moist Oak-Maple Deciduous Forest

Deciduous Swamp (SWD)

SWD1 Oak Mineral Deciduous Swamp Ecosite

SWD2-2 Green Ash Mineral Deciduous Swamp

SWD2-5 Red-osier Dogwood Mineral Thicket Swamp

SWD3 Maple Mineral Deciduous Swamp Ecosite

SWD3-2 Silver Maple Mineral Deciduous Swamp

SWD3-3 Swamp Maple Mineral Deciduous Swamp

SWD3-5* Swamp Maple-Green Ash Mineral Deciduous Swamp

SWD4-1 Willow Mineral Deciduous Swamp

Marsh (MA)

MAM Mineral Meadow Marsh

MAM2 Mineral Marsh Ecosite

MAM2-1 Bluejoint Mineral Meadow Marsh

MAM2-2 Reed-canary Grass Mineral Meadow Marsh

MAM2-3 Red-top Mineral Meadow Marsh

MAM2-10 Forb Mineral Meadow Marsh

MAM2-11* Mixed Mineral Meadow Marsh

MAM2-12* Reed Mannagrass Mixed Mineral Meadow Marsh

MAS2-1 Cattail Mineral Shallow Marsh

Cultural (CU)

CUM Cultural Meadow

CUM1 Mineral Cultural Meadow Ecosite

CUM1-1 Dry-Moist Old Field Meadow

CUP Cultural Plantation

CUT Cultural Thicket

CUT1-7* Hawthorn-Buckthorn Cultural Thicket

CUW Cultural Woodland

CUW1 Cultural Woodland Ecosite

CUP1-11* Deciduous (White Ash) Cultural Plantation

Submerged Shallow Aquatic (SAS)

SAS1-1 Pondweed Submerged Shallow Aquatic

*not listed in Southern Ontario ELC

AG Agricultural

ANTHRO Anthropogenic

BUSINESS Business

COMM Commercial

DRAIN Drainage

DIST Disturbed

FARM Farm

H Hedgerow

IND Industrial

POND Pond

RES Residence

Project 1901516

Heritage Heights Subwatershed Study

Figure T2
ELC Vegetation Communities

0 300 m

1:17,000

N

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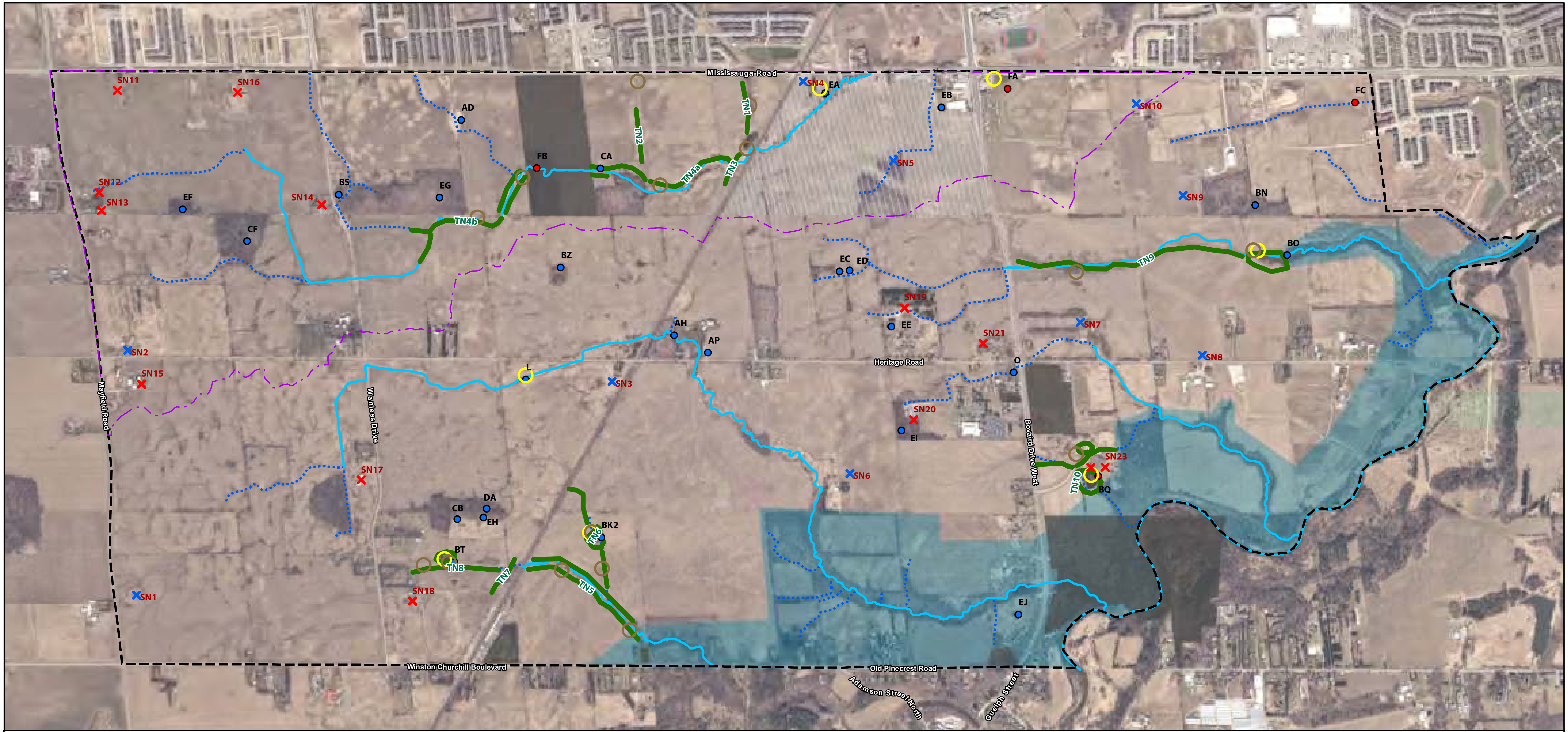
Savanta Division

Lands within the Provincial Greenbelt Area are located within the SWS Study Area but are not part of the City of Brampton Urban Area.

Path: C:\SAVANTA\1901516 - Heritage Heights\figures\report_figures\2021 06 03 Phase1FigureUpdates\1901516_rpt_figT2_ELC_VegetationCommunities.mxd Date Saved: Monday, June 7, 2021



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Legend

- - - Study Area
▨ Mount Pleasant Heights Lands
🟦 Greenbelt Plan Area
⬛ Land Access Unavailable
-·- West Huttonville Creek Sub-watershed: breeding bird area searches performed by Dougan and Associates (2005-2006) and MNR (2006)
— Watercourse
······ HDF Management Area
✕ 2017 Snake Hibernacula Survey Areas
✕ 2018 Snake Hibernacula Proposed Survey Areas
● 2017 AMC Station Locations
● 2018 AMC Station Locations
▬ 2018 Turtle Nesting Transects
○ 2017-2018 Turtle BaskingSurvey Locations
○ 2017-2018 Turtle Nesting Survey Locations

Lands within the Provincial Greenbelt Area are located within the SWS Study Area but are not part of the City of Brampton Urban Area.

Project 1901516

Heritage Heights Subwatershed Study

Figure T3
Breeding Amphibian Call - Count Stations & Turtle Survey Locations

0 300 m
1:18,000

N

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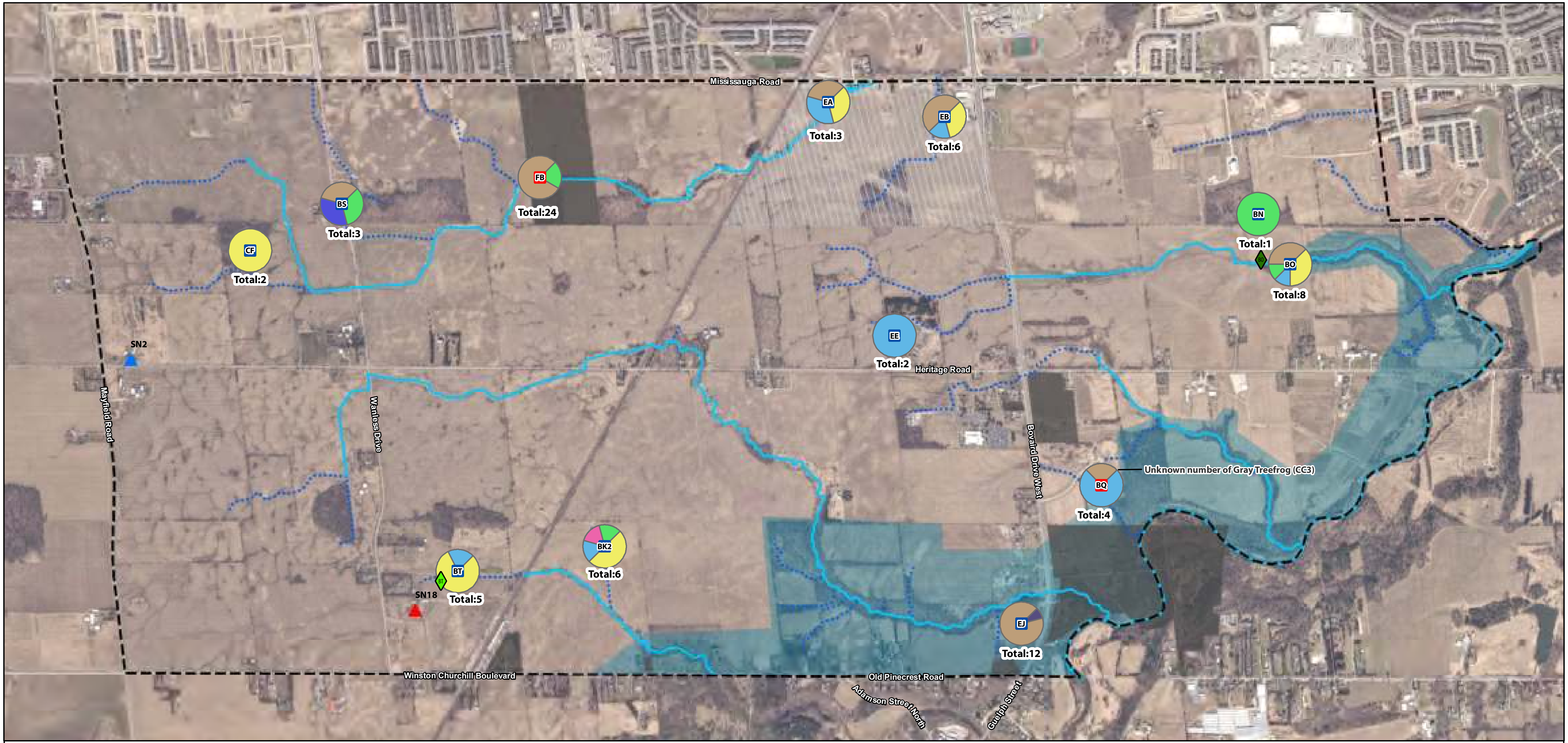

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Legend

- ▬ ▬ Study Area
- ▨ Mount Pleasant Heights Lands
- 🟦 Greenbelt Plan Area
- ⬛ Land Access Unavailable
- ▪▪▪▪ HDF Management Area
- ── Watercourse
- ☐ 2018 Anuran Monitoring Stations with Amphibians Observed
- ☐ 2017 Anuran Monitoring Stations with Amphibians Observed
- ▲ Eastern Garter Snake Sighting 2018
- ▲ Eastern Garter Snake Sighting 2017

Anuran Calls Identified (no. of individuals)

- 🟫 American Toad
- 🟦 Spring Peeper
- 🟩 Wood Frog
- 🟪 Northern Leopard Frog
- 🟦 Green Frog
- 🟨 Gray Treefrog
- 🟪 Bullfrog

2017 Basking Turtle Observations

- ◆ Midland Painted Turtle (18 ind)
- ◆ Snapping Turtle (2 ind)

Project 1901516

Heritage Heights Subwatershed Study

Figure T4
Breeding Amphibian Calls and Reptile Observations

0 300 m

1:18,000

N

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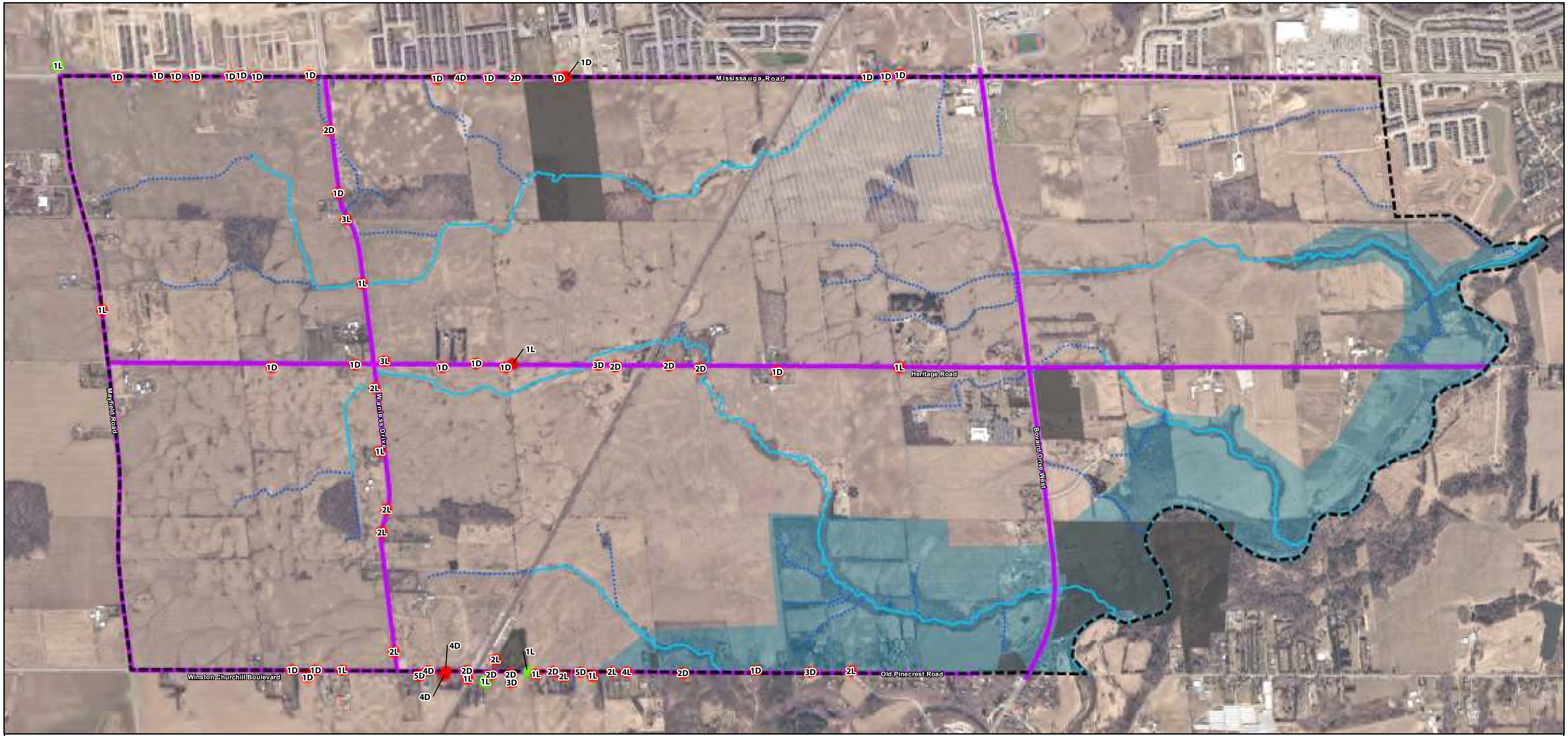
Savanta Division

Lands within the Provincial Greenbelt Area are located within the SWS Study Area but are not part of the City of Brampton Urban Area.

**Counts of calling individuals have been summarized across surveys by year and by station.*

Path: C:\SAVANTA\1901516 - Heritage Heights\figures\report_figures\2021 06 03 Phase1FigureUpdates\1901516_rpt_figT4_ BreedingAmphibianCallsandReptileObs.mxd Date Saved: Monday, June 7, 2021



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Legend

- ▬ ▬ Study Area
- ▨ Mount Pleasant Heights Lands
- 🟦 Greenbelt Plan Area
- ■ Land Access Unavailable
- ▬ Roads Surveyed
- ····· HDF Management Area
- ▬ Watercourse

Amphibian Road Crossing Survey Results

- 🔴 American Toad
- 🟢 Green Frog

L = Live D = Dead
# = Number of individuals observed

Lands within the Provincial Greenbelt Area are located within the SWS Study Area but are not part of the City of Brampton Urban Area.

Heritage Heights Subwatershed Study

Project 1901516

Figure T5
Amphibian Road Crossing Survey 2008-2009

0 300 m

1:18,000

N

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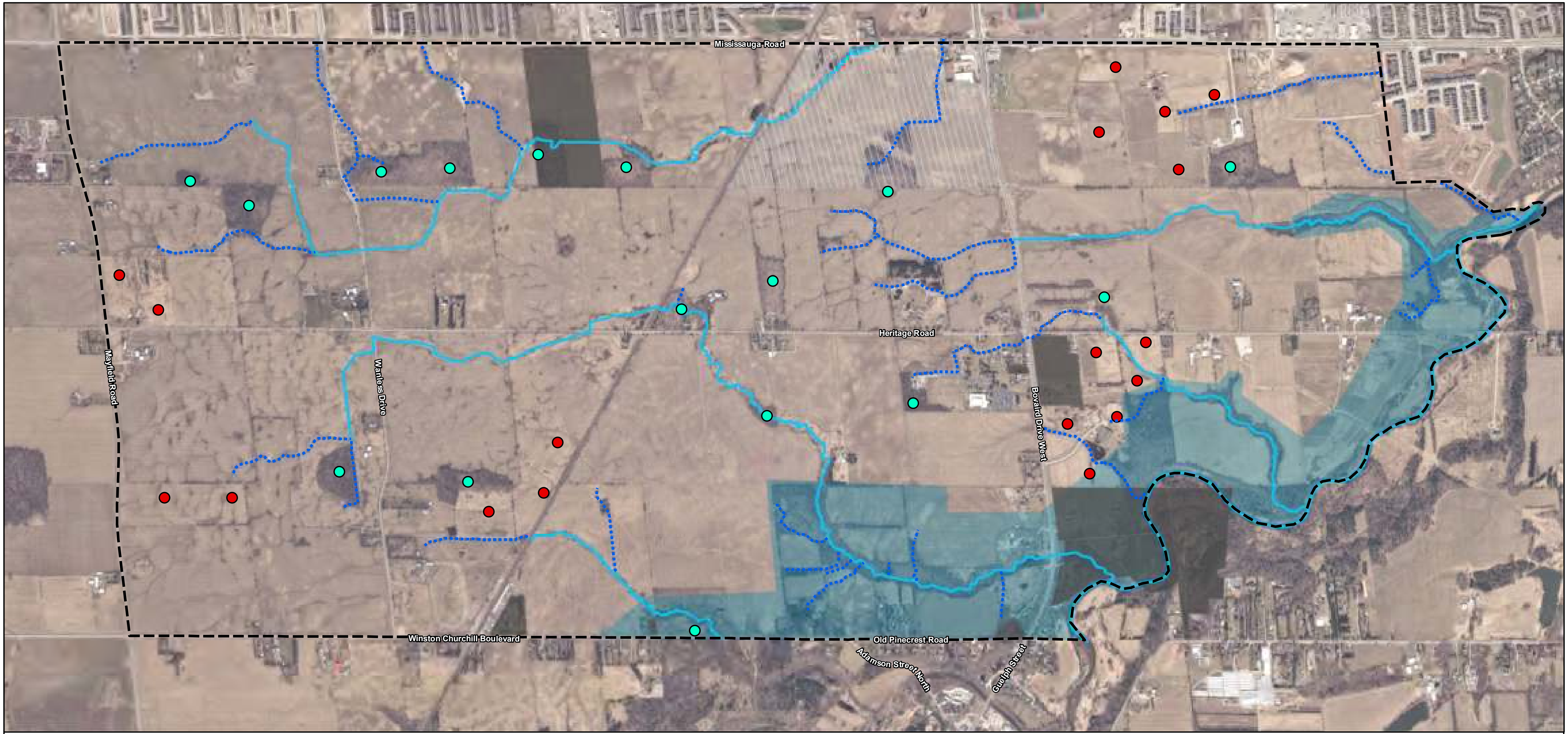
Savanta Division



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Legend

▬ ▬ Study Area
▨ Mount Pleasant Heights Lands
■ Land Access Unavailable
■ Greenbelt Plan Area
━ Watercourse
▪▪▪▪▪ HDF Management Area

2017 Bird Survey Stations

● Grassland Species At Risk Survey
● Woodland Species At Risk Survey

Lands within the Provincial Greenbelt Area are located within the SWS Study Area but are not part of the City of Brampton Urban Area.

Project 1901516

Heritage Heights Subwatershed Study

Figure T6
Breeding Bird Survey - Point Count

0 300 m
1:18,000

N

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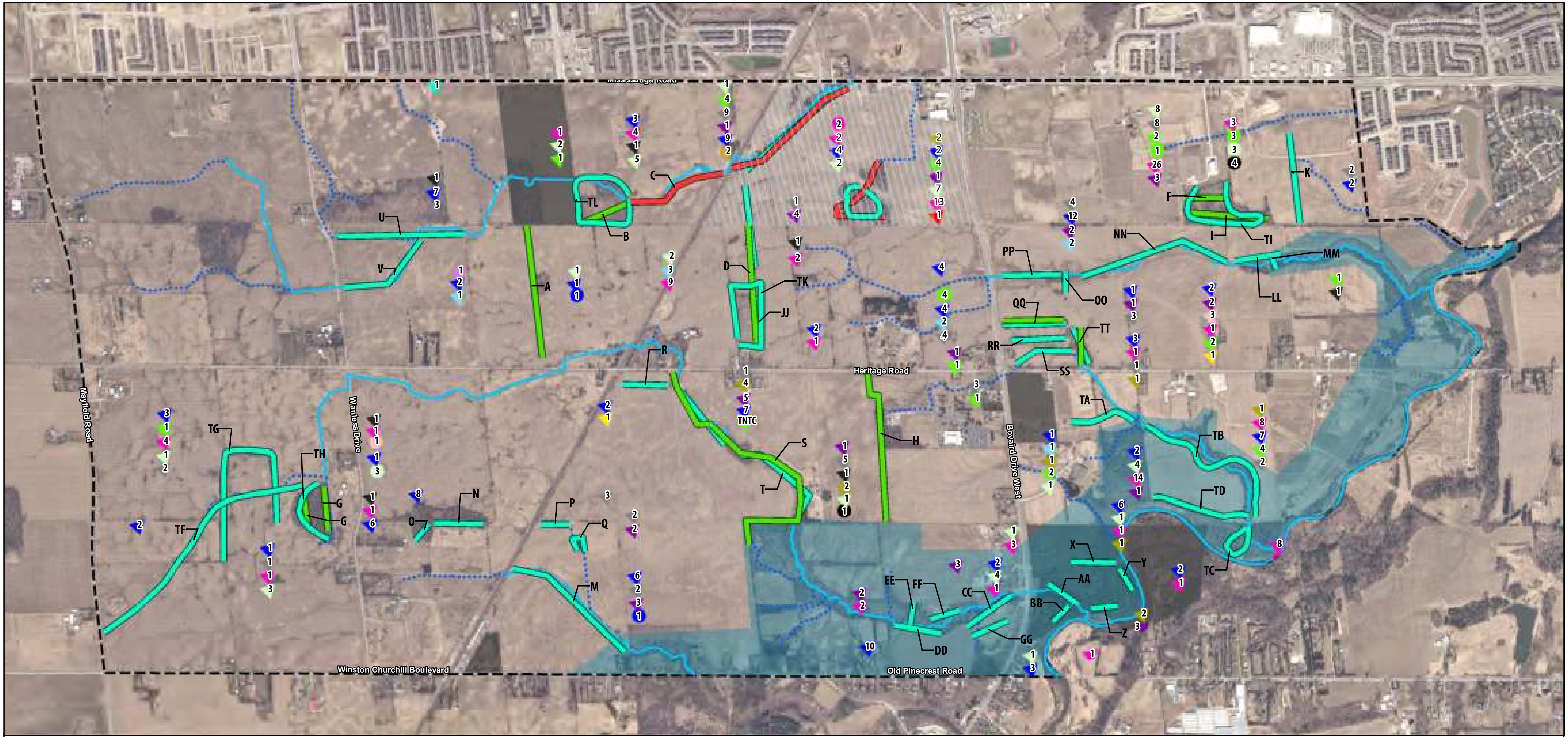

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Legend

- ▬ ▬ Study Area
- ▨ Mount Pleasant Heights Lands
- 🟦 Greenbelt Plan Area
- ⬛ Land Access Unavailable
- ⋯ HDF Management Area
- ▬ Watercourse

Tracks

- ▲ Beaver
- ▲ Canada Geese
- ▲ Chipmunk
- ▲ Coyote
- ▲ Domestic Dog
- ▲ Eastern Cottontail
- ▲ Eastern Gray Squirrel
- ▲ Ermine
- ▲ Mink
- ▲ Otter
- ▲ Peromyscus Species
- ▲ Raccoon
- ▲ Striped Skunk
- ▲ Unknown Small Mammal Species
- ▲ Vole Species
- ▲ Weasel Species
- ▲ White-tailed Deer
- ▲ Wild Canidae Species

Species
2
Number of Occurences

Trails

- ● Coyote
- ● Domestic Dog
- ● Eastern Cottontail
- ● Eastern Gray Squirrel
- ● Unknown Mouse Species
- ● Unknown Small Mammal Species
- ● White-tailed Deer

Winter Wildlife Transects

- 🟩 2008
- 🟥 2009
- 🟦 2011

Project 1901516

Heritage Heights Subwatershed Study

Figure T7
WW Transect

0 300 m
1:18,000

N

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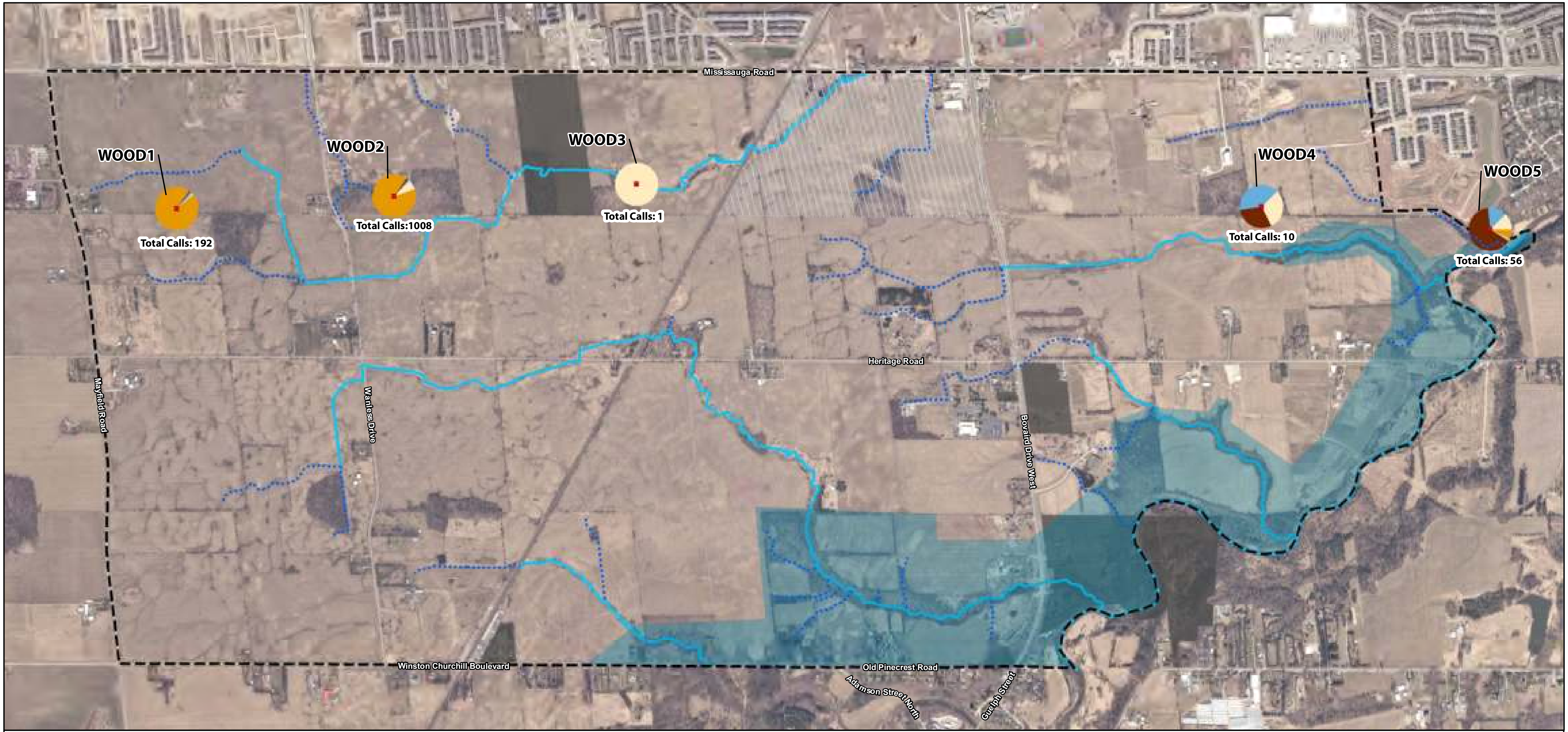
Project 1901516

Heritage Heights Subwatershed Study

Figure T8
Bat Accoustic Survey Results



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Legend

- ▬ ▬ Study Area
- ▨ Mount Pleasant Heights Lands
- ■ Land Access Unavailable
- ■ Greenbelt Plan Area
- ▬ Watercourse
- ▪▪▪▪▪ HDF Management Area
- ■ Bat Accoutic Survey Locations

Bat Accoustic Survey Results

- 🟦 Hoary bat
- 🟫 Big brown bat
- ⬜ Silver-haired bat
- 🟥 Eastern red bat
- 🟧 Eastern small-footed myotis
- 🟨 Unknown

0 300 m

1:18,000

N

Lands within the Provincial Greenbelt Area are located within the SWS Study Area but are not part of the City of Brampton Urban Area.

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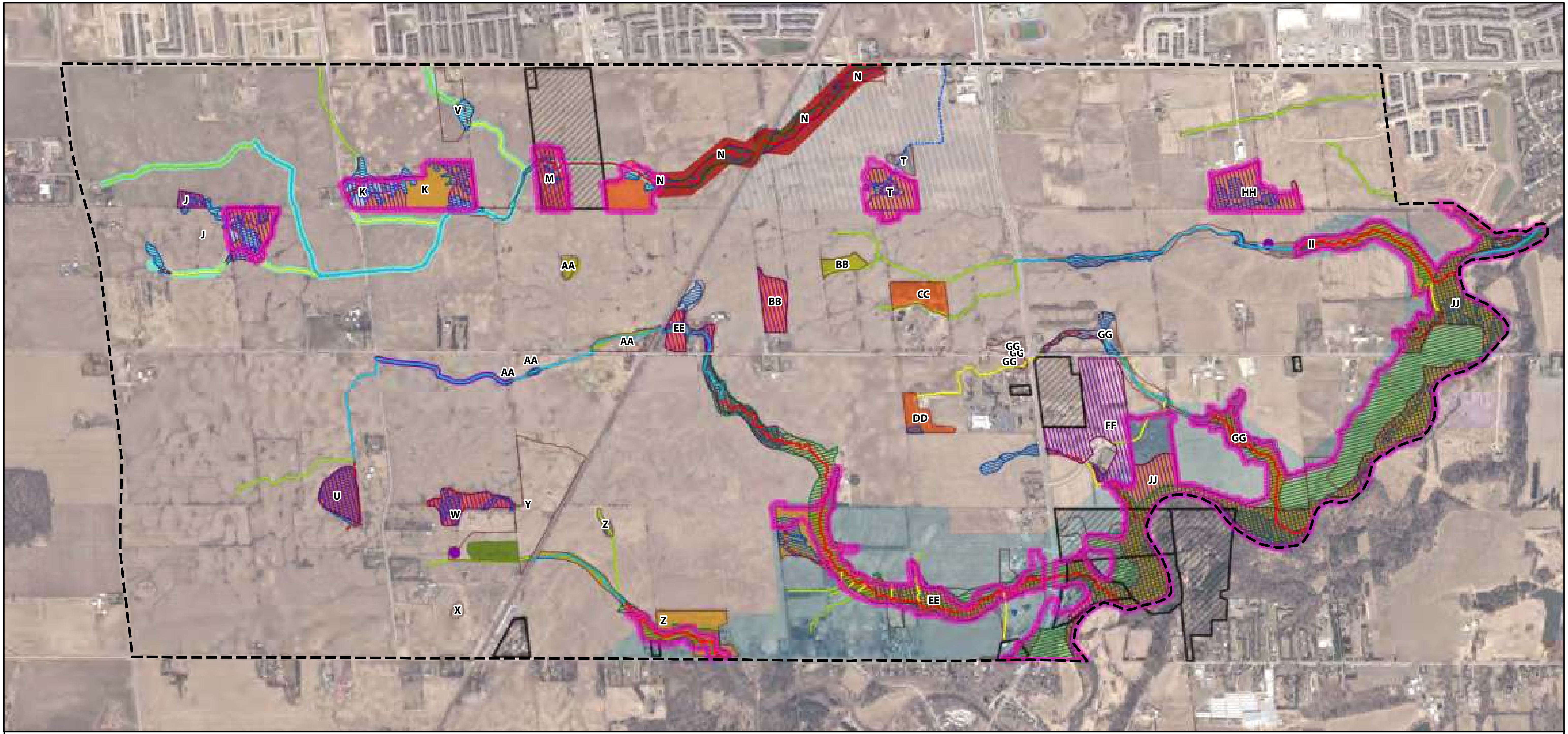

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Legend

- Study Area
- Mount Pleasant Heights Lands
- Core Greenland (Peel ROP 2013)
- Land Access Unavailable
- Greenbelt Plan Area
- Natural System Integration Unit (NSIU)
- Locally Significant Wetland (0.5 - 2 ha)
- Locally Significant Wetland (> 2 ha)
- Significant Wetlands
- ROPA 21B Core Valleyland and Stream Corridors
- Significant Wildlife Habitat Area
- Significant Wildlife Habitat Water Course
- Candidate and Signifiant Wildlife Habitat Point Location (Turtle Pond)
- HDF Under Study
- Existing Redside Dace Habitat as interpreted from Ont Reg 242/08, 29.1(1) v (Formerly "Occupied" Habitat)
- Contributing Redside Dace Habitat as interpreted from Ont Reg 242/08, 29.1(1) v (Formerly "Contributing" Habitat)

Significant Woodlands
- CORE - significant woodland
- NAC - significant woodland

Medium and High Constraint Stream Designation
- High (Red Stream)
- Medium (Blue Stream)

Headwater Drainage Feature Management Recommendations
- Conservation 3,523 m
- Mitigation 7,613 m
- Protection 3,292 ,m

Lands within the Provincial Greenbelt Area are located within the SWS Study Area but are not part of the City of Brampton Urban Area.

Project 1901516

Heritage Heights Subwatershed Study

Figure T9
Existing Ecological Conditions

0 300 m

1:18,000

N

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Path: C:\SAVANTA\1901516 - Heritage Heights\figures\report_figures\2021 06 03 Phase1FigureUpdates\1901516_rpt_figT9_ExistingEcologicalConditions.mxd Date Saved: Monday, June 7, 2021

Table 4.4.4. ELC Vegetation Community Types

ELC Type	Description
Coniferous Forest (FOC)	
FOC4-1 Fresh-Moist White Cedar Coniferous Forest	A small unit dominated by white cedar, with an admixture of green ash and Manitoba maple. The cedar is also well represented in the shrub layer, however, the ground herbaceous cover is poorly developed.
Mixed Forest (FOM)	
FOM2 Dry-Fresh Mixed Forest	A diverse community of white pine, red oak and sugar maple. Due to disturbance, several other trees join in: white ash, trembling aspen, black walnut, European larch, white spruce and Scots pine. The invasive common buckthorn dominates the shrub layer. The herb layer is composed of many weedy species, including burdock and dame's rocket, in addition to native tall goldenrod and stickseed.
FOM3-2 Dry-Fresh Sugar Maple-Hemlock Mixed Forest	Located on steep slopes of a Credit River tributary, almost a gorge, this community is composed of the dominant sugar maple, sub-dominant hemlock, and several other species, for example white ash, red oak, white cedar, ironwood, white elm, black cherry, beech, white pine and occasional yellow birch. Despite the steepness of the slopes, shrubs are well represented, however, herb cover is low except for the spring aspect of yellow dog's-tooth violet and patches of garlic mustard later in the season.
Deciduous Forest (FOD)	
FOD2-5* Dry-Fresh Oak-Maple-Hardwood Deciduous Forest	Main forest cover on the south and west facing slopes of the Credit River valley. This mature community is dominated by red oak, followed by sugar maple, with occurrences of beech, white pine, hemlock, white ash, bitternut hickory and black cherry. The shrub layer is composed mostly of maple saplings, while the herb cover is poor except in the spring when the ephemerals are in evidence, such as yellow dog's-tooth violet, bloodroot, Virginia water-leaf and may-apple.
FOD4-2 Dry-Fresh White Ash Deciduous Forest	Community dominated by deciduous tree species. White ash most prevalent, with associations of other deciduous tree species. Shrub and ground cover layers present.
FOD4-4* Dry-Fresh Black Walnut Deciduous Forest	Black walnut is essentially the only component of the tree canopy. In the well developed shrub layer grow inserted Virginia creeper, red raspberry and thimbleberry. Herbs are represented by garlic mustard, white avens, tall goldenrod and orchard grass.
FOD5-1 Dry-Fresh Sugar Maple Deciduous Forest	A small young stand representing this type is found on the east side of Heritage Road. The community is composed almost entirely of sugar maple young trees and regeneration, with a few scattered American beech. Old tree stumps are evidence that a mature community used to grow here, before it was cut down. Virtually no understory is present, except for yellow dog's-tooth violet in the spring.
FOD5-2 Dry-Fresh Sugar Maple-Beech Deciduous Forest	The only woodlot representing this type, located at the intersection of Heritage Road and railway tracks, is a mature community of large remnant sugar maple trees and scattered younger beech and ironwood. Although maple saplings are very abundant, there is little development of the shrub and herb layers.
FOD5-3 Dry-Fresh Sugar Maple-Oak Deciduous Forest	Sugar Maple is followed by red oak, and species such as white ash, black cherry, black walnut and white pine. The shrub understory contains common buckthorn, inserted Virginia-creeper, wild grape and choke cherry. Herbaceous ground cover is moderately well developed.
FOD5-8 Dry-Fresh Sugar Maple-White Ash Deciduous Forest	Sugar maple dominates this community, with sub-dominant white ash and minor presence of red oak and shagbark hickory. Sugar maple is also dominant in the tree sub-canopy and shrub layer. Herbs include yellow dog's-tooth violet, garlic mustard, Virginia water-leaf and bloodroot.
FOD7 Fresh-Moist Lowland Deciduous Forest	A diverse unit on creek floodplain, composed of green ash, Manitoba maple, swamp maple and white elm. The understorey shrubs and, especially herbs, are diverse very well developed.

ELC Type	Description
FOD7-2 Fresh-Moist Ash Lowland Deciduous Forest	This type is composed of green ash and hybrid maple, and located on slightly higher ground than the adjacent maple-ash swamp. Basswood, hemlock and beech are associates. Poison ivy is the dominant low shrub, while yellow dog's-tooth violet is the leading spring ephemeral.
FOD7-3 Fresh-Moist Willow Lowland Deciduous Forest	This moist forest community is dominated by hybrid white willow and Manitoba maple, with associations of balsam poplar and black walnut. A well-formed shrub layer includes red-osier dogwood and common buckthorn. The herbaceous layer consists primarily of a variety of forb species, with some grass species.
FOD7-4 Fresh-Moist Black Walnut Lowland Deciduous Forest	Situated on the floodplain and slopes of a Credit River tributary, this is a lush although relatively species-poor community. Tree cover, which opens up in a few places, is dominated by black walnut, followed by green ash and Manitoba maple, and scattered white elm and bur oak. The ground is dominated by garlic mustard, jewelweed, white avens, yellowish enchanter's-nightshade and orchard grass, the latter especially abundant in more open areas.
FOD9-2 Fresh-Moist Oak-Maple Deciduous Forest	Occurring in a complex with unit SWD3-5, this is a rather disturbed forest of sugar maple, red and bur oak, shagbark hickory, beech and green ash. The herb layer is moderately well developed and represented by yellow dog's-tooth violet, bloodroot, Carolina spring beauty and the invasive garlic mustard.
Deciduous Swamp (SWD)	
SWD1/SWD3 Oak Mineral Deciduous Swamp Ecosite/ Maple Mineral Deciduous Swamp Ecosite	This complex of two swamp communities includes areas dominated by bur oak with associations of shagbark hickory, and areas dominated by maple species. Associations include white elm and green ash.
SWD2-2 Green Ash Mineral Deciduous Swamp	This swamp type is dominated by green ash, with occurrences of hybrid and silver maple, basswood and white elm. Herbaceous cover consists of species such as jewelweed, fowl meadow grass and many sedges.
SWD3-2 Silver Maple Mineral Deciduous Swamp	This type is represented by a small stand, essentially a ring of trees around the enlarged floodplain of a small meandering creek. Large and medium size silver maples form the main canopy, while green ash forms a secondary tree layer. The ground cover on the floodplain, which is also likely fed by seepage, is composed almost entirely of jewelweed. Only around the less wet edges of the floodplain are there other species growing, for example field horsetail, redtop, beggar ticks and fowl meadow grass.
SWD3-3 Swamp Maple Mineral Deciduous Swamp	Hybrid swamp maple dominates these communities, with small amounts of green ash, basswood and white elm. Common buckthorn and inserted Virginia creeper are frequent in the shrub layer. Patches of this type are invariably flooded in the spring, and only during the summer months does herbaceous cover becomes evident, with such species as jewelweed, fowl meadow grass, garlic mustard, Tuckerman's sedge, larger straw sedge and yellowish enchanter's nightshade.
SWD3-5* Swamp Maple-Green Ash Mineral Deciduous Swamp	Combinations of swamp maple and green ash compose this homogeneous swamp type. The shrub layer is relatively well developed with such species as running strawberry-bush, bitter nightshade, poison ivy, choke cherry and saplings of tree species. The herb layer is well developed and composed of several sedge species, fowl meadow grass, jewelweed and sensitive fern.
SWD4-1 Willow Mineral Deciduous Swamp	Located on the terrace of the Credit River, this community is dominated by willow trees, with a small representation of black walnut and a secondary canopy of Manitoba maple. The area is dissected by two or three small oxbow depressions. Herb cover is high, with such species as jewelweed, glandular touch-me-not, stinging nettle, beggar-ticks, ostrich fern and dame's-rocket.

ELC Type	Description
THICKET SWAMP (SWT)	
SWT2-5 Red-osier Dogwood Mineral Thicket Swamp	This wetland community is dominated by shrub species, with tree cover less than 25 %. Red-osier dogwood is most prevalent, with associations of other wetland shrub species. Ground cover layer present.
MARSH (MA)	
MAM2-2 Reed-canary Grass Mineral Meadow Marsh	These communities are dominated by reed-canary grass, often to the exclusion of other species. Occasionally, cattail, tall white aster, various sedges and rushes may co-occur.
MAM2-3 Red-top Mineral Meadow Marsh	This wetland community is dominated by red-top grass, with admixtures of other emergent macrophytes. Tree and shrub cover less than 25%.
MAM2-10 Forb Mineral Meadow Marsh	Tall white aster is usually the leading species in this cover type, being accompanied by reed-canary grass, redtop, tall goldenrod, fowl meadow grass and spotted water-hemlock.
MAM2-11* Mixed Mineral Meadow Marsh	This is a group of rich meadows composed of numerous forb and graminoid species growing in various amounts and combinations. The usual leading species are great hairy willow-herb, dark-green bulrush, redtop, tall manna grass, tall white aster, and various sedges and rushes.
MAM2-12* Reed Mannagrass Mixed Mineral Meadow Marsh	These wetland communities are dominated by reed mannagrass along with various other graminoid and forb species. A few scattered trees and shrubs are found within these communities, such as hybrid white willow, Manitoba maple, and heart-leaved willow.
MAS2-1 Cattail Mineral Shallow Marsh	This is a common wetland type dominated by cattail in the tall herb layer. Medium herbs include jewelweed, mint and red-top.
Submerged Shallow Aquatic (SAS)	
SAS1-1 Pondweed Submerged Shallow Aquatic	This aquatic community occurs occasionally in small ponds used as cattle drinking reservoirs, and is dominated by fennel-leaved pondweed.
Cultural (CU)	
CUM1-1 Dry-Moist Old Field Meadow	This is a large group of variously composed cultural meadows on abandoned agricultural land, many undergoing succession to open thickets. Crop grasses and weeds are mixed with exotics and several native species. Common plants include awnless brome, wild carrot, tufted vetch, Kentucky bluegrass, red clover, black medic, bird's-foot trefoil, tall goldenrod and New England aster.
CUT1-7* Hawthorn-Buckthorn Cultural Thicket	These are tall shrub thickets composed of various proportions of common buckthorn and hawthorn species. There are usually other shrub and young trees and saplings also present, for example white ash, choke cherry, Tatarian honeysuckle, multiflora rose, red raspberry or apple trees, the latter often as decadent individuals. The herb layer is variously developed and contains a variety of species, from common to exotic.
CUW Cultural Woodland	This is a composite unit of variously composed semi-open woodlands in various stages of regeneration from disturbance. Tree species composition is extremely variable, with such species as bur oak, sugar maple, black cherry, white elm, shagbark hickory, ironwood, basswood and poplar.
CUP1-11* Deciduous (White Ash) Cultural Plantation	This is a community of planted young white ash trees, into which some black walnut and red oak naturally established themselves. Shrubs are represented by Tatarian honeysuckle, common buckthorn and native red raspberry. The herb layer resembles an old field meadow community with such species as tall goldenrod, red-top, Kentucky bluegrass, tufted vetch, timothy, wild carrot and elecampane.

**not listed in Southern Ontario ELC*

Table T1: Plant List for the Study Area

													LOCAL / REGIONAL STATUS		
FAMILY	LATIN NAME	COMMON NAME	COEFFICIENT OF CONSERVATISM	WETNESS INDEX	OWES WETLAND SPECIES	WEEDINESS INDEX	INVASIVE EXOTIC RANK (Urban Forest Associates 2002)	PROVINCIAL STATUS (S-RANK)	GLOBAL STATUS (G-RANK)	COSSARO (MNRF)	COSEWIC STATUS		PEEL (Varga 2005)	CVC/PEEL (CVC 2002)	AUTHORITY
Adoxaceae	Sambucus canadensis	Common Elderberry	5	-3	T			S5	G5				X		L.
Adoxaceae	Sambucus racemosa ssp. pubens	Red Elderberry	5	3			P	S5	G5				X	X	(Michaux) Hultén
Adoxaceae	Viburnum lentago	Nannyberry	4	0	T			S5	G5				X	X	L.
Adoxaceae	Viburnum opulus ssp. opulus	Cranberry Viburnum		-3		-1	4	SNA	G5				X	I	L.
Amaranthaceae	Amaranthus powellii	Powell's Amaranth		5		-1		SNA	G5				X		S. Watson
Amaranthaceae	Atriplex patula	Spear Saltbush		-3				SNA	G5				X	X	L.
Amaranthaceae	Chenopodium album	Common Lamb's-Quarters		3		-1		SNA	G5T5				X	X	L.
Amaranthaceae	Oxybasis glauca ssp. glauca	Oak-Leaved Goosefoot		-3		-1		SNA	G5				X	X	(L.) S.Fuentes, Uotila & Borsch
Anacardiaceae	Rhus typhina	Staghorn Sumac	1	3				S5	G5				X	X	L.
Anacardiaceae	Toxicodendron radicans var. radicans	Eastern Poison Ivy	2	0	T			S5	GNR				X	X	(L.) Kuntze
Anacardiaceae	Toxicodendron radicans var. rydbergii	Western Poison Ivy	2	0				S5	G5				X	X	(Small ex Rydberg) Erskine
Apiaceae	Aegopodium podagraria	Goutweed		0		-3	1	SNA	GNR				X	X	L.
Apiaceae	Cicuta bulbifera	Bulbous Water-Hemlock	5	-5	I			S5	G5				X	X	L.
Apiaceae	Cicuta maculata var. maculata	Spotted Water-Hemlock	6	-5	I			S5	G5T5				X	X	L.
Apiaceae	Daucus carota	Wild Carrot		5		-2		SNA	GNR				X	X	L.
Apiaceae	Heracleum maximum	American Cow Parsnip	3	-3	T			S5	G5				R4	RL	W. Bartram
Apiaceae	Pastinaca sativa	Wild Parsnip		5		-3	3	SNA	GNR				X	I	L.
Apiaceae	Sanicula marilandica	Maryland Sanicle	5	3				S5	G5				X	X	L.
Apiaceae	Sium suave	Common Water-Parsnip	4	-5	I			S5	G5				X	X	Walter
Apiaceae	Torilis japonica	Erect Hedge-Parsley		3		-3		SNA	GNR				X	I	(Houtt.) de Candolle
Apocynaceae	Apocynum cannabinum var. cannabinum	Hemp Dogbane (var. cannabinum)	3	0				S5	G5T5				X	X	L.
Apocynaceae	Asclepias syriaca	Common Milkweed	0	5				S5	G5				X	X	L.
Apocynaceae	Vinca minor	Lesser Periwinkle		5		-2	2	SNA	GNR				X	I	L.
Araliaceae	Aralia nudicaulis	Wild Sarsaparilla	4	3				S5	G5				X	X	L.
Asteraceae	Achillea millefolium	Common Yarrow		3		-1		SNA	G5				X	X	L.
Asteraceae	Ageratina altissima var. altissima	Common White Snakeroot	5	3	T			S5	G5				X	X	(L.) King & H.E. Robins.
Asteraceae	Ambrosia artemisiifolia	Common Ragweed	0	3				S5	G5				X	X	L.
Asteraceae	Ambrosia trifida	Great Ragweed	0	0				S5	G5				X	X	L.
Asteraceae	Anthemis arvensis	Corn Chamomile		5		-1		SNA	GNR				X	X	L.
Asteraceae	Arctium lappa	Great Burdock		3				SNA	GNR				X	X	L.
Asteraceae	Arctium minus	Common Burdock		3		-2		SNA	G?T?				X	X	(Hill) Bernh.
Asteraceae	Artemisia biennis	Biennial Wormwood		-3		-1		SNA	G5				X	X	Willd.
Asteraceae	Bidens cernua	Nodding Beggarticks	2	-5	I			S5	G5				X	X	L.
Asteraceae	Bidens frondosa	Devil's Beggarticks	3	-3	I			S5	G5				X	X	L.
Asteraceae	Bidens vulgata	Tall Beggarticks	5	0	T			S5	G5				R1	R	Greene
Asteraceae	Carduus acanthoides ssp. acanthoides	Spiny Plumeless Thistle		5		-1		SNA	GNR				X	X	L.
Asteraceae	Carduus nutans	Nodding Thistle		3			3	SNA	GNR						L.
Asteraceae	Centaurea jacea	Brown Knapweed		5		-1		SNA	GNR						L.
Asteraceae	Cichorium intybus	Wild Chicory		5		-1		SNA	GNR				X	X	L.
Asteraceae	Cirsium arvense	Canada Thistle		3		-1	1	SNA	GNR				X	X	(L.) Scop.
Asteraceae	Cirsium vulgare	Bull Thistle		3		-1		SNA	G5				X	X	(Savi) Tenore
Asteraceae	Erigeron annuus	Annual Fleabane	0	3				S5	G5				X	X	(L.) Pers.
Asteraceae	Erigeron canadensis	Canada Horseweed	0	3				S5	G5				X	X	(L.)
Asteraceae	Erigeron philadelphicus var. philadelphicu	Philadelphia Fleabane	1	-3	T			S5	G5				X	X	L.
Asteraceae	Erigeron strigosus var. strigosus	Rough Fleabane (var. strigosus)						SU	G5T5						Muhlenb. ex Willd.
Asteraceae	Eurybia macrophylla	Large-Leaved Aster	5	5				S5	G5				X	X	(L.) Cassini
Asteraceae	Euthamia graminifolia	Grass-Leaved Goldenrod	2	0				S5	G5				X	X	(L.) Nutt.
Asteraceae	Eutrochium maculatum var. maculatum	Spotted Joe Pye Weed	3	-5	I			S5	G5T5				X	X	(L.) E.E. Lamont
Asteraceae	Helianthus tuberosus	Jerusalem Artichoke	1	0		-1		SU	G5				X	I	L.
Asteraceae	Inula helenium	Elecampane		3	T	-2	4	SNA	GNR				X	I	L.
Asteraceae	Lactuca serriola	Prickly Lettuce		3		-1		SNA	GNR				X	I	L.
Asteraceae	Lapsana communis	Common Nipplewort		3		-2	P	SNA	GNR				X	I	L.
Asteraceae	Leucanthemum vulgare	Oxeye Daisy		5		-1		SNA	GNR				X	X	Lam.
Asteraceae	Matricaria discoidea	Pineappleweed		3				SNA	G5				X	I	de Candolle
Asteraceae	Nabalus albus	White Rattlesnakeroot	6	3	T			S5	G5				U	X	(L.) Hooker
Asteraceae	Pilosella caespitosa	Meadow Hawkweed		5		-2	3	SNA	GNR				X	I	(Dumort.) P.D. Sell & C. West
Asteraceae	Pilosella piloselloides	Tall Hawkweed		5				SNA	GNR						(Vill.) Soják
Asteraceae	Solidago altissima var. altissima	Tall Goldenrod	1	3				S5	GNR				X	X	L.
Asteraceae	Solidago caesia var. caesia	Blue-Stemmed Goldenrod	5	3				S5	G5				X	X	L.
Asteraceae	Solidago canadensis	Canada Goldenrod	1	3				S5	G5T5				X	X	L.
Asteraceae	Solidago flexicaulis	Zigzag Goldenrod	6	3				S5	G5				X	X	L.
Asteraceae	Solidago gigantea	Giant Goldenrod	4	-3	T			S5	G5				X	X	Aiton
Asteraceae	Solidago nemoralis var. nemoralis	Grey-Stemmed Goldenrod (var. nemoralis	2	5				S5	G5T?				X	X	Aiton
Asteraceae	Sonchus arvensis ssp. arvensis	Field Sow-Thistle		3				SNA	GNR				X	I	L.
Asteraceae	Symphyotrichum cordifolium	Heart-Leaved Aster	5	5				S5	G5				X	X	(L.) G.L. Nesom
Asteraceae	Symphyotrichum ericoides var. ericoides	White Heath Aster	4	3				S5	G5T5				X	X	(L.) G.L. Nesom
Asteraceae	Symphyotrichum lanceolatum ssp. lancec	Panicled Aster (ssp. lanceolatum)	3	-3	I			S5	G5T5				X	X	(Willd.) G.L. Nesom

													LOCAL / REGIONAL STATUS		
FAMILY	LATIN NAME	COMMON NAME	COEFFICIENT OF CONSERVATISM	WETNESS INDEX	OWES WETLAND SPECIES	WEEDINESS INDEX	INVASIVE EXOTIC RANK (Urban Forest Associates 2002)	PROVINCIAL STATUS (S-RANK)	GLOBAL STATUS (G-RANK)	COSSARO (MNRF)	COSEWIC STATUS		PEEL (Varga 2005)	CVC/PEEL (CVC 2002)	AUTHORITY
Asteraceae	Symphyotrichum lateriflorum var. laterifl	Calico Aster	3	0	T			S5	G5T5				X	X	(L.) Á. & D. Löve
Asteraceae	Symphyotrichum novae-angliae	New England Aster	2	-3				S5	G5				X	X	(L.) G.L. Nesom
Asteraceae	Tanacetum vulgare	Common Tansy		5		-1	3	SNA	GNR				X	I	L.
Asteraceae	Taraxacum officinale	Common Dandelion		3		-2		SNA	G5				X	I	F.H. Wiggers
Asteraceae	Tragopogon dubius	Yellow Goatsbeard		5		-1		SNA	GNR				X	I	Scopoli
Asteraceae	Tragopogon pratensis	Meadow Goatsbeard		5		-1		SNA	GNR				X	I	L.
Balsaminaceae	Impatiens capensis	Spotted Jewelweed	4	-3	I			S5	G5				X	X	Meerburgh
Balsaminaceae	Impatiens glandulifera	Purple Jewelweed		-3		-2	1	SNA	GNR				X	I	Royle
Balsaminaceae	Impatiens pallida	Pale Jewelweed	7	-3	T			S4	G5				R8	L	Nuttall
Berberidaceae	Berberis thunbergii	Japanese Barberry		3		-3	3	SNA	GNR				X	I	de Candolle
Berberidaceae	Caulophyllum giganteum	Giant Blue Cohosh	5	5				S5	G4G5				X	R	(Farw.) Loconte & W.H. Blackw.
Berberidaceae	Podophyllum peltatum	May-Apple	5	3				S5	G5				X	X	L.
Betulaceae	Betula alleghaniensis	Yellow Birch	6	0	T			S5	G5				X	X	Britton
Betulaceae	Betula papyrifera	Paper Birch	2	3	T			S5	G5				X	X	Marshall
Betulaceae	Betula pendula	Weeping Birch		0	T	-3	1	SNA	GNR				X	I	Roth
Betulaceae	Carpinus caroliniana ssp. virginiana	Blue-Beech	6	0	T			S5	G5T				X	X	(Marshall) Furlow
Betulaceae	Ostrya virginiana	Eastern Hop-Hornbeam	4	3				S5	G5				X	X	(Miller) K. Koch
Bignoniaceae	Catalpa speciosa	Northern Catalpa		3		-1		SNA	GU				X	I	Warder ex Engelm.
Boraginaceae	Cynoglossum officinale	Common Hound's-Tongue		5		-1		SNA	GNR				X	X	L.
Boraginaceae	Echium vulgare	Common Viper's Bugloss		5		-2		SNA	GNR				X	X	L.
Boraginaceae	Hackelia virginiana	Virginia Stickseed	5	3				S5	G5				U	X	(L.) I.M. Johnston
Boraginaceae	Hydrophyllum virginianum var. virginianu	Virginia Waterleaf	6	0				S5	G5				X	X	L.
Boraginaceae	Lithospermum officinale	European Gromwell		5		-1		SNA	GNR				X	I	L.
Boraginaceae	Myosotis laxa	Small Forget-Me-Not	6	-5	I			S5	G5				X	X	Lehmann
Boraginaceae	Myosotis scorpioides	True Forget-Me-Not		-5	I		4	SNA	G5				X	I	L.
Brassicaceae	Alliaria petiolata	Garlic Mustard		0		-3	1	SNA	G5				X	X	(M. Bieb.) Cavara & Grande
Brassicaceae	Barbarea vulgaris	Bitter Wintercress		0		-1	3	SNA	GNR				X	X	W.T. Aiton
Brassicaceae	Capsella bursa-pastoris	Common Shepherd's Purse		3		-1		SNA	GNR				X	X	(L.) Medikus
Brassicaceae	Cardamine concatenata	Cut-Leaved Toothwort	6	3				S5	G5				X	X	(Michx.) O. Schwarz
Brassicaceae	Cardamine douglassii	Limestone Bittercress	7	-3	T			S4	G5				U	X	Britton
Brassicaceae	Erysimum cheiranthoides	Wormseed Wallflower		3		-1		S5					X	X	L.
Brassicaceae	Hesperis matronalis	Dame's Rocket		3		-3	1	SNA	G4G5				X	I	L.
Brassicaceae	Lepidium campestre	Field Peppergrass		5		-1		SNA	GNR				X	I	(L.) W.T. Aiton
Brassicaceae	Lepidium densiflorum	Common Peppergrass		3		-2		SNA	G5				X	X	Schrader
Brassicaceae	Nasturtium microphyllum	Small-Leaved Watercress		-5	I	-3		SNA	GNR				X	X	(Boenn.) Reichb.
Brassicaceae	Nasturtium officinale	Watercress		-5		-1		SNA	GNR						R. Br.
Brassicaceae	Rorippa palustris ssp. hispida	Hispid Marsh Yellowcress	3	-5	I			S5	G5T5				X	X	(Desvaux) Jonsell
Brassicaceae	Sinapis arvensis	Corn Mustard		5		-1		SNA	GNR				X	I	L.
Brassicaceae	Sisymbrium altissimum	Tall Tumble Mustard		3		-1		SNA	GNR				X	I	L.
Brassicaceae	Thlaspi arvense	Field Pennycress		5		-1		SNA	GNR				X	I	L.
Campanulaceae	Lobelia inflata	Indian Tobacco	3	3				S5	G5				X	X	L.
Caprifoliaceae	Dipsacus fullonum	Common Teasel		3		-1	3	SNA	G?T?				X	X	L.
Caprifoliaceae	Lonicera tatarica	Tartarian Honeysuckle		3		-3	1	SNA	GNR				X	I	L.
Caprifoliaceae	Lonicera x bella	Showy Fly Honeysuckle		3		-3		HYB_e	GNR				X	I	Zabel
Caprifoliaceae	Symphoricarpos albus var. albus	Common Snowberry (var. albus)	7	3				S5	G5T5				R8	L	(L.) S.F. Blake
Caprifoliaceae	Valeriana officinalis	Common Valerian		3		-1		SNA	GNR				XSR	I	L.
Caryophyllaceae	Arenaria serpyllifolia var. serpyllifolia	Thyme-Leaved Sandwort		0		-2		SNA	GNR				X	X	L.
Caryophyllaceae	Cerastium fontanum ssp. vulgare	Common Mouse-Ear Chickweed		3		-1		SNA	GNR				X	X	(Hartman) Greuter & Burdet
Caryophyllaceae	Dianthus armeria ssp. armeria	Deptford Pink		5		-1		SNA	GNR				X	X	L.
Caryophyllaceae	Saponaria officinalis	Bouncing-Bet		3		-3	3	SNA	GNR				X	I	L.
Caryophyllaceae	Silene latifolia	White Campion		5				SNA	GNR				X	I	Poiret
Caryophyllaceae	Silene vulgaris	Bladder Campion		5		-1		SNA	GNR				X	I	(Moench) Garcke
Caryophyllaceae	Stellaria graminea	Grass-Leaved Starwort		5	T	-2		SNA	GNR				X	I	L.
Celastraceae	Euonymus obovatus	Running Strawberry Bush	6	5				S4	G5				X	X	Nutt.
Convolvulaceae	Calystegia sepium ssp. americana	American False Bindweed	2	0				S5	G5				U	X	(Sims) Brummitt
Convolvulaceae	Convolvulus arvensis	Field Bindweed		5		-1	3	SNA	GNR				X	X	L.
Convolvulaceae	Cuscuta gronovii var. gronovii	Swamp Dodder	4	-3	T			S5?	G5				R5	R	Willd. ex Roemer & Schultes
Cornaceae	Cornus alternifolia	Alternate-Leaved Dogwood	6	3				S5	G5				X	X	L. f.
Cornaceae	Cornus obliqua	Pale Dogwood	2	-3	I			S5	G5T?				R5	L	Rafinesque
Cornaceae	Cornus racemosa	Grey Dogwood	2	0	T			S5	G5?				X	X	Lamarck
Cornaceae	Cornus sericea	Red-Osier Dogwood	2	-3	I*			S5	G5				X	X	L.
Cucurbitaceae	Echinocystis lobata	Wild Cucumber	3	-3	T			S5	G5				X	X	(Michx.) Torr. & A. Gray
Elaeagnaceae	Elaeagnus angustifolia	Russian Olive		3		-1	3	SNA	GNR				X	I	L.
Euphorbiaceae	Acalypha rhomboidea	Common Three-Seed Mercury	0	3				S5	G5				X	X	Raf.
Fabaceae	Amphicarpaea bracteata	American Hog Peanut	4	0	T			S5	G5				X	X	(L.) Fernald
Fabaceae	Lotus corniculatus	Garden Bird's-Foot Trefoil		3		-2	2	SNA	GNR				X	I	L.
Fabaceae	Medicago lupulina	Black Medick		3		-1	4	SNA	GNR				X	I	L.
Fabaceae	Medicago sativa ssp. sativa	Alfalfa (ssp. sativa)		5		-1	4	SNA	GNRTNR				X	I	L.

													LOCAL / REGIONAL STATUS		
FAMILY	**LATIN NAME**	**COMMON NAME**	**COEFFICIENT OF CONSERVATISM**	**WETNESS INDEX**	**OWES WETLAND SPECIES**	**WEEDINESS INDEX**	**INVASIVE EXOTIC RANK** (Urban Forest Associates 2002)	**PROVINCIAL STATUS (S-RANK)**	**GLOBAL STATUS (G-RANK)**	**COSSARO (MNRF)**	**COSEWIC STATUS**		**PEEL** (Varga 2005)	**CVC/PEEL** (CVC 2002)	**AUTHORITY**
Fabaceae	Melilotus albus	White Sweet-Clover		3		-3	2	SNA	GNR				X	I	Medik.
Fabaceae	Robinia pseudoacacia	Black Locust		3		-3	2	SNA	G5				X	I	L.
Fabaceae	Securigera varia	Purple Crown-Vetch		5		-2	1	SNA	GNR				X	X	(L.) Lassen
Fabaceae	Trifolium hybridum	Alsike Clover		3		-1		SNA	GNR				X	I	L.
Fabaceae	Trifolium pratense	Red Clover		3		-2	4	SNA	GNR				X	I	L.
Fabaceae	Trifolium repens	White Clover		3		-1	4	SNA	GNR				X	I	L.
Fabaceae	Vicia cracca	Tufted Vetch		5		-1	2	SNA	GNR				X	I	L.
Fabaceae	Vicia tetrasperma	Four-Seed Vetch		5		-1	3	SNA	GNR				X	I	(L.) Schreber
Fagaceae	Fagus grandifolia	American Beech	6	3				S4	G5				X	X	Ehrhart
Fagaceae	Quercus alba	White Oak	6	3				S5	G5				X	X	L.
Fagaceae	Quercus macrocarpa	Burr Oak	5	3	T			S5	G5				X	X	Michaux
Fagaceae	Quercus rubra	Northern Red Oak	6	3				S5	G5				X	X	L.
Gentianaceae	Centaurium pulchellum	Branching Centaury		0		-1		SNA	GNR				X	X	(Sw.) Druce
Geraniaceae	Geranium robertianum	Herb-Robert	2	3		-2		S5	G5				X	I	L.
Grossulariaceae	Ribes americanum	Wild Black Currant	4	-3	T			S5	G5				X	X	Miller
Grossulariaceae	Ribes cynosbati	Eastern Prickly Gooseberry	4	3				S5	G5				X	X	L.
Grossulariaceae	Ribes rubrum	European Red Currant		5	T	-2		SNA	G4G5				X	I	L.
Hypericaceae	Hypericum perforatum ssp. perforatum	Common St. John's-Wort		5		-3	4	SNA	GNR				X	I	L.
Juglandaceae	Carya cordiformis	Bitternut Hickory	6	0				S5	G5				X	X	(Wangenh.) K. Koch
Juglandaceae	Carya ovata var. ovata	Shagbark Hickory	6	3	T			S5	G5				X	X	(Miller) K. Koch
Juglandaceae	Juglans nigra	Black Walnut	5	3				S4?	G5				X	X	L.
Lamiaceae	Clinopodium vulgare	Wild Basil	4	5				S5	GNR				X	X	L.
Lamiaceae	Galeopsis tetrahit	Common Hemp-Nettle		3		-1		SNA	GNR				X	I	L.
Lamiaceae	Glechoma hederacea	Ground-Ivy		3		-2	4	SNA	GNR				X	I	L.
Lamiaceae	Leonurus cardiaca ssp. cardiaca	Common Motherwort		5		-2		SNA	GNR				X	I	L.
Lamiaceae	Lycopus americanus	American Water-Horehound	4	-5	I			S5	G5				X	X	Muhlenb. ex Bartram
Lamiaceae	Lycopus uniflorus	Northern Water-Horehound	5	-5	I			S5	G5				X	X	Michaux
Lamiaceae	Mentha canadensis	Canada Mint	3	-3	I			S5	G5T5				X	X	L.
Lamiaceae	Mentha x piperita	Peppermint		-5	I	-1	4	HYB_e	GNR				X	I	L.
Lamiaceae	Nepeta cataria	Catnip		3		-2	4	SNA	GNR				X	I	L.
Lamiaceae	Prunella vulgaris ssp. lanceolata	Lance-Leaved Self-Heal	0	0	T			S5	G5T?				X	X	(W.P.C. Barton) Piper & Beattie
Lamiaceae	Prunella vulgaris ssp. vulgaris	Common Self-Heal		0		-1		SNA	G5T?				X		L.
Lythraceae	Lythrum salicaria	Purple Loosestrife		-5	I	-3	1	SNA	G5				X	I	L.
Malvaceae	Abutilon theophrasti	Velvetleaf		3		-1	3	SNA	GNR				X	X	Medikus
Malvaceae	Malva moschata	Musk Mallow		5		-1	4	SNA	GNR				X	I	L.
Malvaceae	Tilia americana	Basswood	4	3				S5	G5				X	X	L.
Malvaceae	Tilia cordata	Little-Leaved Linden		5			P	SNA	GNR						Miller
Montiaceae	Claytonia caroliniana	Carolina Spring Beauty	7	3				S5	G5				R5	R	Michaux
Nymphaeaceae	Nymphaea odorata	Fragrant Water-Lily	5	-5	I			S5?	G5T5				R3	R	Aiton
Oleaceae	Fraxinus americana	White Ash	4	3				S4	G5				X	X	L.
Oleaceae	Fraxinus pennsylvanica	Red Ash	3	-3	T			S4	G5				X	X	Marshall
Oleaceae	Ligustrum vulgare	European Privet		3		-2	4	SNA	GNR				X	I	L.
Oleaceae	Syringa vulgaris	Common Lilac		5		-2	2	SNA	GNR				X	I	L.
Onagraceae	Circaea canadensis ssp. canadensis	Canada Enchanter's Nightshade	2	3				S5	G5T5				X	X	(L.) Hill
Onagraceae	Epilobium ciliatum ssp. ciliatum	Northern Willowherb	3	-3	I*			S5	G5T?				X	X	Raf.
Onagraceae	Epilobium coloratum	Purple-Veined Willowherb	3	-5	I			S5	G5				R6	R	Biehler
Onagraceae	Epilobium hirsutum	Hairy Willowherb		-3	I	-2		SNA	GNR				X	X	L.
Onagraceae	Epilobium parviflorum	Small-Flowered Willowherb		3	T	-1		SNA	GNR				X	X	Schreber
Onagraceae	Oenothera parviflora	Small-Flowered Evening Primrose	1	3				S5	G4?				X	X	L.
Orobanchaceae	Epifagus virginiana	Beechdrops	6	5				S5	G5				X	X	(L.) Barton
Oxalidaceae	Oxalis stricta	European Wood-Sorrel	0	3				S5	G5				X	X	L.
Papaveraceae	Chelidonium majus	Greater Celandine		5		-3		SNA	GNR				X	X	L.
Papaveraceae	Sanguinaria canadensis	Bloodroot	5	3				S5	G5				X	X	L.
Penthoraceae	Penthorum sedoides	Ditch-Stonecrop	4	-5	I			S5	G5				X	X	L.
Plantaginaceae	Linaria vulgaris	Butter-And-Eggs		5		-1	4	SNA	GNR				X	I	Miller
Plantaginaceae	Penstemon hirsutus	Hairy Beardtongue	7	5				S4	G4				R7	RL	(L.) Willdenow
Plantaginaceae	Plantago lanceolata	English Plantain		3		-1		SNA	G5				X	I	L.
Plantaginaceae	Plantago major	Common Plantain		3		-1		SNA	G5				X	I	L.
Plantaginaceae	Plantago rugelii	Rugel's Plantain	1	0				S5	G5				X	X	Decaisne
Plantaginaceae	Veronica arvensis	Corn Speedwell		5		-1		SNA	GNR				X	I	L.
Plantaginaceae	Veronica officinalis	Common Speedwell		5		-2		SNA	G5				X	I	L.
Plantaginaceae	Veronica peregrina ssp. peregrina	Purslane Speedwell (ssp. peregrina)	0	0	T			S5	G5T5				X	X	L.
Polygonaceae	Fallopia convolvulus	Eurasian Black Bindweed		3		-1		SNA	GNR				X	I	(L.) Á. Löve
Polygonaceae	Persicaria hydropiper	Marshpepper Smartweed		-5	I			SNA	GNR				X	I	(L.) Delarbre
Polygonaceae	Persicaria lapathifolia	Pale Smartweed	2	-3	T			S5	G5				X	X	(L.) Delarbre
Polygonaceae	Persicaria maculosa	Spotted Lady's-Thumb		-3	T	-1		SNA	G3G5				X	I	Gray
Polygonaceae	Polygonum aviculare ssp. aviculare	Prostrate Knotweed		3		-1		SNA	GNRTNR				X	I	L.

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Polygonaceae	Rheum rhabarbarum	Rhubarb		5		-1		SNA	GNR				X	I	L.
Polygonaceae	Rumex crispus	Curled Dock		0	T	-2		SNA	GNR				X	I	L.
Polygonaceae	Rumex obtusifolius	Bitter Dock		-3	T	-1		SNA	GNR				X	I	L.
Primulaceae	Lysimachia arvensis	Scarlet Pimpernel		3		-1		SNA	GNR				X	X	(L.) U.Manns & Anderb.
Primulaceae	Lysimachia ciliata	Fringed Yellow Loosestrife	4	-3	T			S5	G5				X	X	L.
Primulaceae	Lysimachia nummularia	Creeping Yellow Loosestrife		-3		-3	2	SNA	GNR				X	I	L.
Primulaceae	Samolus parviflorus	Seaside Brookweed	5	-5	I			S4	G5T5						Rafinesque
Ranunculaceae	Actaea pachypoda	White Baneberry	6	5				S5	G5				X	X	Elliott
Ranunculaceae	Actaea rubra ssp. rubra	Red Baneberry	6	3				S5	G5				X	X	(Aiton) Willdenow
Ranunculaceae	Anemone canadensis	Canada Anemone	3	-3	T			S5	G5				X	X	L.
Ranunculaceae	Clematis virginiana	Virginia Clematis	3	0	T			S5	G5				X	X	L.
Ranunculaceae	Ranunculus abortivus	Kidney-Leaved Buttercup	2	0				S5	G5				X	X	L.
Ranunculaceae	Ranunculus acris	Common Buttercup		0	T	-2		SNA	G5				X	I	L.
Ranunculaceae	Ranunculus repens	Creeping Buttercup		0		-1	3	SNA	GNR				X	I	L.
Ranunculaceae	Ranunculus sceleratus	Cursed Buttercup	2	-5	I			S5	G5				X		L.
Ranunculaceae	Thalictrum dioicum	Early Meadow-Rue	6	3				S5	G5				X	X	L.
Ranunculaceae	Thalictrum pubescens	Tall Meadow-Rue	5	-3	T			S5	G5				X	X	Pursh
Rhamnaceae	Rhamnus cathartica	European Buckthorn		0	T	-3	1	SNA	GNR				X	I	L.
Rosaceae	Agrimonia gryposepala	Hooked Agrimony	2	3				S5	G5				X	X	Wallroth
Rosaceae	Crataegus coccinea var. coccinea	Scarlet Hawthorn	4	5				S4	GNR				X		L.
Rosaceae	Crataegus macracantha	Large-Thorned Hawthorn	4	5				S5	GNR				X	X	Loddiges ex Loudon
Rosaceae	Crataegus macrosperma	Big-Fruit Hawthorn	4	5				S5	G5				R4	RL	Ashe
Rosaceae	Crataegus punctata	Dotted Hawthorn	4	5				S5	G5				X	X	Jacquin
Juglandaceae	Juglans cinerea	Butternut	6	3				S2?	G4	END	END		X	X	L.
Rosaceae	Fragaria vesca	Woodland Strawberry	4	3				S5	G5				X	X	L.
Rosaceae	Fragaria virginiana	Wild Strawberry	2	3				S5	G5				X	X	Miller
Rosaceae	Geum aleppicum	Yellow Avens	2	0	T			S5	G5				X	X	Jacquin
Rosaceae	Geum canadense	White Avens	3	0	T			S5	G5				X	X	Jacquin
Rosaceae	Geum fragarioides	Barren Strawberry	5	5				S5	G5				X	X	(Michx.) Smedmark
Rosaceae	Malus pumila	Common Apple		5		-1		SNA	G5				X	I	Miller
Rosaceae	Potentilla norvegica	Rough Cinquefoil	0	0	T			S5	G5				X	I	L.
Rosaceae	Potentilla recta	Sulphur Cinquefoil		5		-2		SNA	GNR				X	I	L.
Rosaceae	Prunus nigra	Canada Plum	4	3				S4	G4G5				U	X	Aiton
Rosaceae	Prunus serotina var. serotina	Black Cherry	3	3				S5	G5				X	X	Ehrhart
Rosaceae	Prunus virginiana var. virginiana	Chokecherry	2	3				S5	G5T?				X	X	L.
Rosaceae	Pyrus communis	Common Pear		5		-1		SNA	G5				X	I	L.
Rosaceae	Rosa multiflora	Multiflora Rose		3		-3	1	SNA	GNR				X	I	Thunberg
Rosaceae	Rosa palustris	Swamp Rose	7	-5	I			S5	G5				R3	RL	Marshall
Rosaceae	Rubus allegheniensis	Alleghany Blackberry	2	3				S5	G5				X	X	Porter
Rosaceae	Rubus idaeus ssp. strigosus	North American Red Raspberry	2	3				S5	G5T5				X	X	(Michaux) Focke
Rosaceae	Rubus occidentalis	Black Raspberry	2	5				S5	G5				X	X	L.
Rosaceae	Sorbus aucuparia	European Mountain-Ash		5		-2	4	SNA	G5				X	I	L.
Rubiaceae	Galium mollugo	Smooth Bedstraw		5		-2	2	SNA	GNR				X		L.
Rubiaceae	Galium palustre	Common Marsh Bedstraw	5	-5	I			S5	G5				X	X	L.
Rubiaceae	Galium trifidum ssp. trifidum	Three-Petalled Bedstraw (ssp. trifidum)	5	-3	I			S5	G5T5						L.
Salicaceae	Populus alba	White Poplar		5		-3	2	SNA	G5				X	I	L.
Salicaceae	Populus balsamifera	Balsam Poplar	4	-3	T			S5	G5				X	X	L.
Salicaceae	Populus grandidentata	Large-Toothed Aspen	5	5				S5	G5				X	X	Michaux
Salicaceae	Populus tremuloides	Trembling Aspen	2	0	T			S5	G5				X	X	Michaux
Salicaceae	Salix bebbiana	Bebb's Willow	4	-3	I			S5	G5				X	X	Sargent
Salicaceae	Salix discolor	Pussy Willow	3	-3	I			S5	G5				X	X	Muhlenberg
Salicaceae	Salix eriocephala	Cottony Willow	4	-3	T			S5	G5				X	X	Michaux
Salicaceae	Salix interior	Sandbar Willow	1	-3	T			S5	GNR				R5	L	Rowlee
Salicaceae	Salix lucida	Shining Willow	5	-3	I			S5	G5				R5	L	Muhlenberg
Salicaceae	Salix petiolaris	Meadow Willow	3	-3	I			S5	G5				X	X	J.E. Smith
Salicaceae	Salix x fragilis	Hybrid Crack Willow			T	-3	3	HYB_e	GNA				XSR	I	L.
Sapindaceae	Acer negundo	Manitoba Maple	0	0	T		1	S5	G5				X	X	L.
Sapindaceae	Acer nigrum	Black Maple	7	3				S4?	G5				X	X	F. Michaux
Sapindaceae	Acer platanoides	Norway Maple		5		-3	2	SNA	GNR				X	I	L.
Sapindaceae	Acer rubrum	Red Maple	4	0	T			S5	G5				X	X	L.
Sapindaceae	Acer saccharinum	Silver Maple	5	-3	I			S5	G5				X	X	L.
Sapindaceae	Acer saccharum	Sugar Maple	4	3				S5	G5				X	X	Marshall
Sapindaceae	Acer x freemanii	Freeman's Maple	6	-5	I			HYB_n	GNA				XSR		E. Murray
Scrophulariaceae	Verbascum thapsus ssp. thapsus	Common Mullein		5		-2		SNA	GNR				X	I	L.
Solanaceae	Solanum dulcamara	Bittersweet Nightshade		0	T	-2	3	SNA	GNR				X	I	L.
Solanaceae	Solanum emulans	Eastern Black Nightshade	1	3				S5	G5				X	X	Rafinesque
Ulmaceae	Ulmus americana	White Elm	3	-3	T			S5	G5				X	X	L.
Urticaceae	Boehmeria cylindrica	Small-Spike False Nettle	4	-5	I			S5	G5				X	X	(L.) Swartz

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Urticaceae	Laportea canadensis	Canada Wood Nettle	6	-3	T			S5	G5				X	X	(L.) Weddell
Urticaceae	Pilea fontana	Lesser Clearweed	5	-3	I			S4	G5				R3	RL	(Lunnell) Rydberg
Urticaceae	Pilea pumila	Dwarf Clearweed	5	-3	I			S5	G5				X	X	(L.) A. Gray
Urticaceae	Urtica dioica ssp. dioica	European Stinging Nettle		0		-1	3	SNA	G5T5?				XSR		L.
Urticaceae	Urtica dioica ssp. gracilis	Slender Stinging Nettle	2	0	T			S5	G5T5				X	X	(Aiton) Selander
Verbenaceae	Verbena hastata	Blue Vervain	4	-3	I			S5	G5				X	X	L.
Verbenaceae	Verbena urticifolia	White Vervain	4	0	T			S5	G5				X	X	L.
Violaceae	Viola arvensis	European Field Pansy		5				SNA	GNR				X	I	Murray
Violaceae	Viola pubescens	Downy Yellow Violet	5	3				S5	G5				X	X	Aiton
Violaceae	Viola sororia	Woolly Blue Violet	4	0	T			S5	G5				X	X	Willdenow
Vitaceae	Parthenocissus vitacea	Thicket Creeper	4	3				S5	G5				X	X	(Knerr) Hitchcock
Vitaceae	Vitis riparia	Riverbank Grape	0	0				S5	G5				X	X	Michaux
Cupressaceae	Juniperus virginiana var. virginiana	Eastern Red Cedar	4	3				S5	G5T				R5	L	L.
Cupressaceae	Thuja occidentalis	Eastern White Cedar	4	-3	T			S5	G5				X	X	L.
Pinaceae	Larix decidua	European Larch		5		-1		SNA	GNR				X	I	Miller
Pinaceae	Picea abies	Norway Spruce		5		-1		SNA	GNR				X	I	(L.) Karsten
Pinaceae	Picea glauca	White Spruce	6	3	T			S5	G5				R3	L	(Moench) Voss
Pinaceae	Pinus nigra	Austrian Pine		5		-1		SNA	GNR						Arnold
Pinaceae	Pinus resinosa	Red Pine	8	3				S5	G5				R1	RL	Aiton
Pinaceae	Pinus strobus	Eastern White Pine	4	3	T			S5	G5				X	X	L.
Pinaceae	Pinus sylvestris	Scots Pine		3		-3	2	SNA	GNR				X	I	L.
Pinaceae	Tsuga canadensis	Eastern Hemlock	7	3	T			S5	G5				X	X	(L.) Carrière
Alismataceae	Alisma subcordatum	Southern Water-Plantain	1	-5	I			S4?	G5				X		Raf.
Amaryllidaceae	Allium tricoccum var. tricoccum	Wild Leek	7	3				S4	G5				X	X	Aiton
Araceae	Arisaema triphyllum ssp. triphyllum	Jack-In-The-Pulpit	5	-3	T			S5	G5				X	X	(L.) Schott
Araceae	Lemna minor	Small Duckweed	5	-5	I			S5	G5				X	X	L.
Araceae	Lemna turionifera	Turion Duckweed	5	-5				S5?	G5						Landolt
Asparagaceae	Asparagus officinalis	Garden Asparagus		3		-1		SNA	G5?				X	X	L.
Asparagaceae	Maianthemum racemosum	Large False Solomon's Seal	4	3				S5	G5T				X	X	(L.) Link
Asparagaceae	Polygonatum pubescens	Hairy Solomon's Seal	5	5				S5	G5				X	X	(Willd.) Pursh
Colchicaceae	Uvularia grandiflora	Large-Flowered Bellwort	6	5				S5	G5				X	X	J.E. Smith
Cyperaceae	Carex arctata	Drooping Woodland Sedge	5	5				S5	G5?				X	X	Boott
Cyperaceae	Carex bebbii	Bebb's Sedge	3	-5	I			S5	G5				X	X	(L.H. Bailey) Olney ex Fern.
Cyperaceae	Carex bromoides ssp. bromoides	Brome-Like Sedge	7	-3	I			S5	G5				R3	RL	Schkuhr ex Willdenow
Cyperaceae	Carex crinita var. crinita	Fringed Sedge	6	-5	I			S5	G5				U	X	Lamarck
Cyperaceae	Carex cristatella	Crested Sedge	3	-3	I			S5	G5				X	X	Britton
Cyperaceae	Carex gracillima	Graceful Sedge	4	3	T			S5	G5				X	X	Schweinitz

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Cyperaceae	Carex intumescens	Bladder Sedge	6	-3	I			S5	G5				X	X	Rudge
Cyperaceae	Carex lupulina	Hop Sedge	6	-5	I			S5	G5				X	X	Muhlenb. ex Willdenow
Cyperaceae	Carex normalis	Larger Straw Sedge	6	-3				S4	G5						Mackenzie
Cyperaceae	Carex pensylvanica	Pennsylvania Sedge	5	5				S5	G5				X	X	Lamarck
Cyperaceae	Carex projecta	Necklace Sedge	5	-3	I			S5	G5				R4	L	Mackenzie
Cyperaceae	Carex radiata	Eastern Star Sedge	4	0	T			S5	G5				X	X	(Wahlenb.) Small
Cyperaceae	Carex retrorsa	Retrorse Sedge	5	-5	I			S5	G5				X	X	Schweinitz
Cyperaceae	Carex stipata var. stipata	Awl-Fruited Sedge	3	-5	I			S5	G5				X	X	Muhlenb. ex Willdenow
Cyperaceae	Carex tenera	Tender Sedge	4	0	T			S5	G5				X	X	Dewey
Cyperaceae	Carex tribuloides var. tribuloides	Blunt Broom Sedge	5	-3	I			S4	G5				R5	RL	Wahlenberg
Cyperaceae	Carex tuckermanii	Tuckerman's Sedge	7	-5	I			S5	G4				R6	L	Dewey
Cyperaceae	Carex vulpinoidea	Fox Sedge	3	-5	I			S5	G5				X	X	Michaux
Cyperaceae	Cyperus esculentus var. leptostachyus	Perennial Yellow Flatsedge	1	-3	T			S5	G5				X	X	Boeckeler
Cyperaceae	Schoenoplectus tabernaemontani	Soft-Stemmed Bulrush	5	-5	I			S5	G5				X	X	(C.C. Gmelin) Palla
Cyperaceae	Scirpus atrovirens	Dark-Green Bulrush	3	-5	T			S5	G5?				X	X	Willdenow
Cyperaceae	Scirpus cyperinus	Common Woolly Bulrush	4	-5	I			S5	G5				X	X	(L.) Kunth
Iridaceae	Iris pseudacorus	Yellow Iris		-5	I	-2	4	SNA	GNR				X	I	L.
Juncaceae	Juncus canadensis	Canada Rush	6	-5	I			S5	G5				E		J. Gay ex Laharpe
Juncaceae	Juncus dudleyi	Dudley's Rush	1	-3	T			S5	G5				X	X	Wiegand
Juncaceae	Juncus effusus ssp. solutus	Soft Rush (ssp. solutus)	4	-5	I			S5?	G5T5				X	X	(Fernald & Wiegand) Hämet-Ahti
Juncaceae	Juncus tenuis	Path Rush	0	0				S5	G5				X	X	Willdenow
Juncaceae	Juncus torreyi	Torrey's Rush	3	-3	T			S5	G5				X	X	Coville
Liliaceae	Erythronium americanum ssp. americanu	Yellow Trout Lily	5	5				S5	G5T5				X	X	Ker Gawler
Liliaceae	Lilium michiganense	Michigan Lily	7	-3	T			S4	G5				U	X	Farwell
Melanthiaceae	Trillium erectum	Red Trillium	6	3				S5	G5				X	X	L.
Melanthiaceae	Trillium grandiflorum	White Trillium	5	3				S5	G5				X	X	(Michx.) Salisbury
Orchidaceae	Epipactis helleborine	Broad-Leaved Helleborine		3		-2		SNA	GNR				X	X	(L.) Crantz
Poaceae	Agrostis gigantea	Redtop		-3		-2		SNA	G4G5				X	I	Roth
Poaceae	Agrostis stolonifera	Creeping Bentgrass		-3	T			SNA	G5				X	X	L.
Poaceae	Alopecurus pratensis	Meadow Foxtail		-3		-1		SNA	GNR				X	I	L.
Poaceae	Bromus ciliatus	Fringed Brome	6	-3	T			S5	G5				U	X	L.
Poaceae	Bromus inermis	Smooth Brome		5		-3	4	SNA	G5TNR				X	I	Leysser
Poaceae	Bromus latiglumis	Broad-Glumed Brome	7	-3	T			S4	G5				U	X	(Scribner ex Shear) Hitchcock
Poaceae	Dactylis glomerata	Orchard Grass		3		-1	3	SNA	GNR				X	I	L.
Poaceae	Digitaria ischaemum	Smooth Crabgrass		3		-1		SNA	GNR				X	I	(Schreb.) Muhlenberg
Poaceae	Digitaria sanguinalis	Hairy Crabgrass		3		-1		SNA	G5				X	I	(L.) Scopoli
Poaceae	Echinochloa crus-galli	Large Barnyard Grass		-3	T	-1		SNA	GNR				X	I	(L.) Palisot de Beauvois
Poaceae	Elymus repens	Quackgrass		3		-3	3	SNA	GNR				X	I	(L.) Gould
Poaceae	Elymus virginicus var. virginicus	Virginia Wildrye	5	-3	T			S5	G5T5				X	X	L.
Poaceae	Glyceria grandis var. grandis	Tall Mannagrass	5	-5	I			S5	G5				X	X	S. Watson
Poaceae	Glyceria maxima	Rough Mannagrass		-5	I	-1	1	SNA	GNR				X	I	(Hartm.) Holmberg
Poaceae	Glyceria striata	Fowl Mannagrass	3	-5	I			S5	G5				X	X	(Lam.) Hitchcock
Poaceae	Holcus lanatus	Common Velvetgrass		3		-1		SNA	GNR				X	I	L.
Poaceae	Hordeum jubatum ssp. jubatum	Foxtail Barley	0	0	T			S5?	G5T5				X	I	L.
Poaceae	Leersia oryzoides	Rice Cutgrass	3	-5	I			S5	G5				X	X	(L.) Swartz
Poaceae	Lolium arundinaceum	Tall Fescue		3		-1	3	SNA	GNR				X	I	(Schreber) Darbyshire
Poaceae	Lolium pratense	Meadow Fescue		3		-1		SNA	G5				X	I	(Hudson) Darbyshire
Poaceae	Oryzopsis asperifolia	Rough-Leaved Mountain Rice	6	5				S5	G5				X	X	Michaux
Poaceae	Panicum capillare ssp. capillare	Common Panicgrass	0	0				S5	G5				X	X	L.
Poaceae	Panicum dichotomiflorum ssp. dichotomi	Fall Panicgrass		-3		-1		SNA	G5				X	I	Michaux
Poaceae	Phalaris arundinacea var. arundinacea	Reed Canary Grass	0	-3	T		P	S5	GNR				X	X	L.
Poaceae	Phleum pratense ssp. pratense	Common Timothy		3		-1		SNA	GNR				X	I	L.
Poaceae	Phragmites australis ssp. australis	European Reed		-3	T		1	SNA	G5T5				X		(Cav.) Trinius ex Steudel
Poaceae	Poa annua	Annual Bluegrass		3		-2		SNA	GNR				X	I	L.
Poaceae	Poa compressa	Canada Bluegrass		3				SNA	GNR				X	X	L.
Poaceae	Poa nemoralis	Eurasian Woodland Bluegrass		3		-1		SNA	G5				X	I	L.
Poaceae	Poa palustris	Fowl Bluegrass	5	-3	I			S5	G5				X	X	L.
Poaceae	Poa pratensis	Kentucky Bluegrass	0	3			2	S5	G5				X	X	L.
Poaceae	Setaria faberi	Giant Foxtail		3		-1	4	SNA	GNR						R.A.W. Herrmann
Poaceae	Setaria pumila ssp. pumila	Yellow Foxtail		0		-1	4	SNA	GNR				X	I	(Poir.) Roemer & Schultes
Poaceae	Setaria verticillata	Bristly Foxtail		3		-1	4	SNA	GNR				X	I	(L.) Palisot de Beauvois
Poaceae	Setaria viridis var. viridis	Green Foxtail		5		-1	4	SNA	GNR				X	I	(L.) Palisot de Beauvois
Potamogetonaceae	Stuckenia pectinata	Sago Pondweed	4	-5	I			S5	G5				U	X	(L.) Börner
Smilacaceae	Smilax herbacea	Herbaceous Carrionflower	5	0				S4?	G5				X	X	L.
Typhaceae	Typha angustifolia	Narrow-Leaved Cattail		-5	I		P	SNA	G5				X	X	L.
Typhaceae	Typha latifolia	Broad-Leaved Cattail	1	-5	I			S5	G5				X	X	L.
Typhaceae	Typha x glauca	Blue Cattail		-5	I		P	HYB_n	GNA				X	X	Godron
Xanthorrhoeaceae	Hemerocallis fulva	Orange Daylily		5		-3	4	SNA	GNR				X	I	(L.) L.

													LOCAL / REGIONAL STATUS		
FAMILY	LATIN NAME	COMMON NAME	COEFFICIENT OF CONSERVATISM	WETNESS INDEX	OWES WETLAND SPECIES	WEEDINESS INDEX	INVASIVE EXOTIC RANK (Urban Forest Associates 2002)	PROVINCIAL STATUS (S-RANK)	GLOBAL STATUS (G-RANK)	COSSARO (MNRF)	COSEWIC STATUS		PEEL (Varga 2005)	CVC/PEEL (CVC 2002)	AUTHORITY
Dryopteridaceae	Dryopteris carthusiana	Spinulose Wood Fern	5	-3	T			S5	G5				X	X	(Vill.) H.P. Fuchs
Equisetaceae	Equisetum arvense	Field Horsetail	0	0	T			S5	G5				X	X	L.
Onocleaceae	Matteuccia struthiopteris var. pensylvani	Ostrich Fern	5	0	T			S5	G5				X	X	(Willd.) C.V. Morton
Onocleaceae	Onoclea sensibilis	Sensitive Fern	4	-3	I			S5	G5				X	X	L.
Thelypteridaceae	Thelypteris palustris var. pubescens	Eastern Marsh Fern	5	-3	I			S5	G5T?				X	X	(Lawson) Fernald

STATISTICS		
Species Diversity		
Total Number of Species:	380	
Native Species:	224	59%
Exotic Species:	156	41%
S1-S3 Species:	1	0%
S4 Species:	20	9%
S5 Species:	199	90%
Floristic Quality Indices		
Mean Co-efficient of Conservatism (CC)	3.8	
CC 0 - 3 = lowest sensitivity	84	38%
CC 4 - 6 = moderate sensitivity	123	56%
CC 7 - 8 = high sensitivity	14	6%
CC 9 - 10 = highest sensitivity	0	0%
Floristic Quality Index (FQI)	57	
Weedy & Invasive Species		
Mean Weediness Index (Oldham et al):	-1.6	
-1 = low potential invasiveness	83	58%
-2 = moderate potential invasiveness	35	24%
-3 = high potential invasivenss	26	18%
Mean Exotic Rank (Urban Forest Associates):	3	
Category 1	14	19%
Category 2	12	16%
Category 3	19	26%
Wetland Species		
Mean Wetness Index	0.8	
Upland	78	21%
Facultative upland	128	34%
Facultative	53	14%
Facultative wetland	71	19%
Obligate wetland	48	13%

Table 2: Amphibian Species Observed on the Heritage Heights Lands

COMMON NAME	SCIENTIFIC NAME	Srank	Grank
American Toad	*Bufo americanus*	S5	G5
American Bullfrog	*Rana catesbeiana*	S4	G5
Gray Treefrog	*Hyla versicolor*	S5	G5
Green Frog	*Rana Clamitans*	S5	G5
Northern Leopard Frog	*Rana pipiens*	S5	G5
Spring Peeper	*Pseudacris crucifer*	S5	G5
Wood Frog	*Rana sylvatica*	S5	G5
Northern Redback Salamander	*Plethodon cinereus*	S5	G5

S ranks: Provincial ranks are from the Natural Heritage Information Centre; S1 (critically imperiled), S2 (imperlied), S3 (vulnerable), S4 (apparently secure), S5 (secure); ranks were updated using NHIC species list. 2020.

G ranks: National ranks are from the Natural Heritage Information Centre; G1 (extremely rare), G2 (very rare), G3 (rare to uncommon), G4 (common), G5 (very common); ranks were updated using NHIC species list. 2020.

Table T3: Master Bird Species Observed in the Study Area

Common Name	Species Code	Scientific Name	Status[1]	Breeding Evidence[2]	National Status (Grank)	Provincial Status (Srank)	COSSARO (MNRF)	COSEWIC	CVC 2002 (Local)	Savanta 2008	Savanta 2009	Savanta 2010	Savanta 2011	Savanta 2012	Savanta 2017	Ages 2009	Dougan 2005-2006	MNR 2006
Anseriformes																		
Anserinae																		
Canada Goose	CANG	*Branta canadensis*	SR	CO	G5	S5				x	x	x		x	x			
Anatinae																		
Mallard	MALL	*Anas platyrhynchos*	SR	CO	G5	S5				x	x	x		x			x	
Wood Duck	WODU	*Aix sponsa*	SR	PR	G5	S5						x						
American Black Duck	ABDU	*Anas rubripes*	MI	O-X	G5	S4			CC			x						
Common Goldeneye	COGO	*Bucephala clangula*	WV	O-X	G5	S5						x						
Galliformes																		
Meleagridinae																		
Wild Turkey	WITU	*Meleagris gallopavo*	PR	CO-FY	G5	S5			CC	x	x	x		x	x			x
Pelecaniformes																		
Ardeidae																		
Great Blue Heron	GBHE	*Ardea herodias*	SR	PO	G5	S4			CC	x	x	x		x			x	
Accipitriformes																		
Cathartidae																		
Turkey Vulture	TUVU	*Cathartes aura*	SR	PO	G5	S5B			CC	x	x	x		x				
Pandionidae																		
Osprey	OSPR	*Pandion haliaetus*	SR	PR-SV	G5	S5B			CC					x				
Accipitridae																		
Northern Harrier	NOHA	*Circus cyaneus*	PR	PO	G5	S4B	NAR	NAR	CC	x								
Cooper's Hawk	COHA	*Accipiter cooperii*	PR	PR	G5	S4	NAR	NAR	CC		x	x		x				
Red-tailed Hawk	RTHA	*Buteo jamaicensis*	PR	CO	G5	S5	NAR	NAR		x	x	x		x	x		x	x
Rough-legged Hawk	RLHA	*Buteo lagopus*	MI	O-X	G4	S1B,S4N	NAR	NAR					x					
Falconiformes																		
Falconinae																		
American Kestrel	AMKE	*Falco sparverius*	SR	PO	G5	S4						x						
Charadriiformes																		
Charadriidae																		
Charadriinae																		
Killdeer	KILL	*Charadrius vociferus*	SR	CO-FY	G5	S5B,S5N				x	x	x		x	x	x	x	
Scolopacidae																		
Scolopacinae																		
Spotted Sandpiper	SPSA	*Actitis macularius*	SR	CO-NE	G5	S5				x	x	x		x	x	x	x	
American Woodcock	AMWO	*Scolopax minor*	SR	PR	G5	S4B				x	x	x		x				
Wilson's Snipe	COSN	*Bartramia longicauda*	SR	PO	G5	S5B			CC									
Laridae																		
Larinae																		
Ring-billed Gull	RBGU	*Larus delawarensis*	SR	PR-SV	G5	S5B,S4N						x		x	x	x	x	
Columbiformes																		
Columbidae																		
Rock Pigeon	ROPI	*Columba livia*	PR	CO	G5	SNA				x	x	x		x	x	x		
Mourning Dove	MODO	*Zenaida macroura*	SR	CO	G5	S5				x	x	x		x	x	x	x	
Strigiformes																		
Strigidae																		
Great Horned Owl	GHOW	*Bubo virginianus*	PR	PR	G5	S4								x				

Common Name	**Species Code**	**Scientific Name**	**Status[1]**	**Breeding Evidence[2]**	**National Status (Grank)**	**Provincial Status (Srank)**	**COSSARO (MNRF)**	**COSEWIC**	**CVC 2002 (Local)**	Savanta 2008	Savanta 2009	Savanta 2010	Savanta 2011	Savanta 2012	Savanta 2017	Ages 2009	Dougan 2005-2006	MNR 2006
Eastern Screech-Owl	EASO	*Megascops asio*	PR	PR	G5	S4	NAR	NAR				x		x				
Apodiformes																		
Chaeturinae																		
Chimney Swift	CHSW	*Chaetura pelagica*	SR	PR-P	G4G5	S4B,S4N	THR	THR	CC			x		x				
Trochilidae																		
Trochilinae																		
Ruby-throated Hummingbird	RTHU	*Archilochus colubris*	SR	PO-H	G5	S5B								x				
Coraciiformes																		
Alcedinidae																		
Cerylinae																		
Belted Kingfisher	BEKI	*Megaceryle alcyon*	SR	PO-H	G5	S4B			CC			x		x				
Piciformes																		
Picidae																		
Picinae																		
Red-bellied Woodpecker	RBWO	*Melanerpes carolinus*	SR	CO	G5	S4									x			
Yellow-bellied Sapsucker	YBSA	*Sphyrapicus varius*	SR	PO-H	G5	S5B								x				
Downy Woodpecker	DOWO	*Picoides pubescens*	PR	CO-NY	G5	S5						x		x	x		x	x
Hairy Woodpecker	HAWO	*Picoides villosus*	PR	CO-NY	G5	S5			CC			x		x	x		x	x
Northern Flicker	NOFL	*Colaptes auratus*	SR	CO	G5	S4B				x	x	x		x	x		x	
Pileated Woodpecker	PIWO	*Dryocopus pileatus*	PR	CO	G5	S5			CC	x		x					x	x
Passeriformes																		
Fluvicolinae																		
Eastern Wood-Pewee	EAWP	*Contopus virens*	SR	CO	G5	S4B	SC	SC	CC	x	x	x		x	x	x	x	x
Alder Flycatcher	ALFL	*Empidonax alnorum*	SR	PO	G5	S5B			CC									
Willow Flycatcher	WIFL	*Empidonax traillii*	SR	CO	G5	S5B						x		x	x		x	
Least Flycatcher	LEFL	*Empidonax minimus*	SR	PR	G5	S4B			CC	x	x							
Eastern Phoebe	EAPH	*Sayornis phoebe*	SR	CO	G5	S5B				x	x	x						
Tyranninae																		
Great Crested Flycatcher	GCFL	*Myiarchus crinitus*	SR	CO	G5	S4B				x	x	x		x	x	x	x	
Eastern Kingbird	EAKI	*Tyrannus tyrannus*	SR	CO	G5	S4B			CC	x	x	x		x	x	x	x	
Vireonidae																		
Warbling Vireo	WAVI	*Vireo gilvus*	SR	PR-P	G5	S5B								x	x	x	x	
Red-eyed Vireo	REVI	*Vireo olivaceus*	SR	PR-P	G5	S5B						x		x	x	x	x	x
Corvidae																		
Blue Jay	BLJA	*Cyanocitta cristata*	PR	CO	G5	S5						x		x	x		x	
American Crow	AMCR	*Corvus brachyrhynchos*	PR	CO	G5	S5B						x		x	x	x	x	x
Alaudidae																		
Horned Lark	HOLA	*Eremophila alpestris*	SR	CO	G5	S5B			CC	x	x	x		x	x	x	x	
Hirundinidae																		
Hirundininae																		
Tree Swallow	TRES	*Tachycineta bicolor*	SR	CO	G5	S4B				x	x	x		x	x	x		
Northern Rough-winged Swallow	NRWS	*Stelgidopteryx serripennis*	SR	CO-FY	G5	S4B						x		x			x	

Common Name	**Species Code**	**Scientific Name**	**Status**^{1}	**Breeding Evidence**^{2}	**National Status (Grank)**	**Provincial Status (Srank)**	**COSSARO (MNRF)**	**COSEWIC**	**CVC 2002 (Local)**	Savanta 2008	Savanta 2009	Savanta 2010	Savanta 2011	Savanta 2012	Savanta 2017	Ages 2009	Dougan 2005-2006	MNR 2006
Cliff Swallow	CLSW	*Petrochelidon pyrrhonota*	SR	PR-P	G5	S4B			CC					x			x	
Barn Swallow	BARS	*Hirundo rustica*	SR	CO-NY	G5	S5B	THR	THR	CC	x	x	x		x	x	x		
Paridae																		
Black-capped Chickadee	BCCH	*Poecile atricapillus*	PR	CO-FY	G5	S5						x		x	x	x	x	x
Sittidae																		
Sittinae																		
Red-breasted Nuthatch	RBNU	*Sitta canadensis*	PR	PR-P	G5	S5			CC					x	x			
White-breasted Nuthatch	WBNU	*Sitta carolinensis*	PR	CO-FY	G5	S5						x		x	x	x	x	x
Troglodytidae																		
Carolina Wren	CAWR	*Thryothorus*	PR	PO-H	G5	S4			CC					x				
House Wren	HOWR	*Troglodytes aedon*	SR	CO	G5	S5B						x		x	x		x	
Sedge Wren	SEWR	*Cistothorus platensis*	SR	CO	G5	S4B	NAR	NAR	CC								x	
Ruglidae																		
Ruby-crowned Kinglet	RCKI	*Regulus calendula*	MI		G5	S4B												
Turdidae																		
Eastern Bluebird	EABL	*Sialia sialis*	SR	CO-FY	G5	S5B	NAR	NAR	CC			x		x	x			
Veery	VEER	*Catharus fuscescens*	SR	PO	G5	S4B			CC								x	
Hermit Thrush	HETH	*Catharus guttatus*	MI		G5	S5B											x	
Wood Thrush	WOTH	*Hylocichla mustelina*	SR	PR-A	G4	S4B	SC	THR	CC					x			x	
American Robin	AMRO	*Turdus migratorius*	SR	CO-FY	G5	S5B						x		x	x	x	x	x
Mimidae																		
Gray Catbird	GRCA	*Dumetella carolinensis*	SR	CO	G5	S4B			CC	x		x		x	x	x	x	
Northern Mockingbird	NOMO	*Mimus polyglottos*	SR	CO	G5	S4			CC	x	x	x		x			x	
Brown Thrasher	BRTH	Toxostoma rufum	SR	CO	G5	S4B			CC	x	x			x	x		x	
Sturnidae																		
European Starling	EUST	*Sturnus vulgaris*	SR	CO-FY	G5	SNA						x		x	x	x	x	
Bombycillidae																		
Cedar Waxwing	CEDW	*Bombycilla cedrorum*	SR	PR-P	G5	S5B						x		x	x		x	x
Calcariidae																		
Snow Bunting	SNBU	*Plectrophenax nivalis*	WV		G5	SNA												
Parulidae																		
Ovenbird	OVEN	*Seiurus aurocapilla*	SR	PO-S	G5	S4B			CC					x				
Black-and-white Warbler	BAWW	*Mniotilta varia*	SR	PO	G5	S5B			CC								x	
Mourning Warbler	MOWA	*Geothlypis philadelphia*	SR	CO-CF	G5	S4B			CC			x		x	x			
Common Yellowthroat	COYE	*Geothlypis trichas*	SR	CO-CF	G5	S5B						x		x	x			
American Redstart	AMRE	*Setophaga ruticilla*	SR	CO	G5	S5B			CC			x		x				
Chestnut-sided Warbl	CSWA	*Setophaga pensylvanica*	SR	CO	G5	S5B			CC			x						
Bay-breasted Warbler	BBWA	*Setophaga castanea*	MI		G5	S5B											x	
Yellow Warbler	YWAR	*Setophaga petechia*	SR	CO	G5	S5B						x			x	x	x	
Yellow-rumped Warbl	YRWA	*Setophaga coronata*	MI		G5	S5B			CC								x	
Emberizidae																		

Common Name	**Species Code**	**Scientific Name**	**Status**[1]	**Breeding Evidence**[2]	**National Status (Grank)**	**Provincial Status (Srank)**	**COSSARO (MNRF)**	**COSEWIC**	**CVC 2002 (Local)**	Savanta 2008	Savanta 2009	Savanta 2010	Savanta 2011	Savanta 2012	Savanta 2017	Ages 2009	Dougan 2005-2006	MNR 2006
Eastern Towhee	EATO	*Pipilo erythrophthalmus*	SR	CO	G5	S4B			CC			x					x	
American Tree Sparro	ATSP	*Spizella arborea*	WV	O-X	G5	S4B						x						
Chipping Sparrow	CHSP	*Spizella passerina*	SR	CO	G5	S5B						x		x	x			
Field Sparrow	FISP	*Spizella pusilla*	SR	CO	G5	S4B						x		x	x			
Vesper Sparrow	VESP	*Pooecetes gramineus*	SR	CO	G5	S4B			CC	x	x	x		x		x	x	
Savannah Sparrow	SAVS	*Passerculus sandwichensis*	SR	CO-FY	G5	S4B			CC	x	x	x		x	x	x	x	
Song Sparrow	SOSP	*Melospiza melodia*	SR	CO-CF	G5	S5B						x		x	x	x	x	x
Swamp Sparrow	SWSP	*Melospiza melodia*	MI		G5	S5B												
White-throated Sparrow	WTSP	*Zonotrichia albicollis*	MI	O-X	G5	S5B			CC			x					x	
Cardinalidae																		
Northern Cardinal	NOCA	*Cardinalis cardinalis*	PR	CO	G5	S5						x		x	x	x	x	x
Rose-breasted Grosbeak	RBGR	*Pheucticus ludovicianus*	SR	CO	G5	S4B						x		x			x	x
Indigo Bunting	INBU	*Passerina cyanea*	SR	CO	G5	S4B				x	x	x		x	x	x	x	x
Icteridae																		
Bobolink	BOBO	*Dolichonyx oryzivorus*	SR	CO-FY	G5	S4B	THR	THR	CC	x	x	x		x	x		x	
Red-winged	RWBL	*Agelaius phoeniceus*	SR	CO-NE	G5	S4						x		x	x	x	x	x
Eastern Meadowlark	EAME	*Sturnella magna*	SR	CO	G5	S4B	THR	THR	CC	x	x	x		x				
Common Grackle	COGR	*Quiscalus quiscula*	SR	CO-FY	G5	S5B			CC			x		x	x	x	x	x
Brown-headed Cowbird	BHCO	*Molothrus ater*	SR	CO-FY	G5	S4B						x		x	x	x	x	
Orchard Oriole	OROR	*Icterus spurius*	SR	PO	G5	S4B			CC			x						
Baltimore Oriole	BAOR	*Icterus galbula*	SR	CO-FY	G5	S4B				x	x	x		x	x	x	x	x
Carduelinae																		
American Goldfinch	AMGO	*Spinus tristis*	SR	CO	G5	S5B						x		x	x	x	x	x
Passeridae																		
House Sparrow	HOSP	*Passer domesticus*	PR	CO	G5	SNA						x		x				

Species Common Name and Scientific Name: consistent with the Natural Heritage Information Centre (NHIC) Ontario species List.2020. Accessed February 2021.

Species Code: consistent with the American Ornithologists' Union. 2012. Species 4-Letter-Codes. Accessed February 2021. Available online: www.birdsontario.org/atlas/codes.jsp?lang=en&pg=species/

Status[1]: PR - Permanent Resident; MI - Migrant; WV - Winter Visitor; SR - Summer Resident; SV - Summer Visitor (non-breeding)

Breeding Evidence[2]: Codes assigned for breeding evidence are consistent with the Ontario Breeding Bird Atlas (OBBA). 2021. Breeding Evidence Codes. Accessed February 2021. Available online: http://www.birdsontario.org/dataentry/codes.jsp?page=breeding/. Several different types of breeding evidence are often recorded for any given species over the course of surveys and incidental observations - this table reports only the highest level of breeding evidence

S ranks: Provincial ranks are from the Natural Heritage Information Centre; S1 (critically imperiled), S2 (imperlied), S3 (vulnerable), S4 (apparently secure), S5 (secure); ranks were updated using NHIC species list. 2020.

G ranks: National ranks are from the Natural Heritage Information Centre; G1 (extremely rare), G2 (very rare), G3 (rare to uncommon), G4 (common), G5 (very common); ranks were updated using NHIC species list. 2020.

COSSARO (MNR): Ontario Species at Risk as listed by the Committee on the Status of Species at Risk in Ontario (from NHIC Table Feb 17, 2012); END - Endangered, THR - Threatened, SC - Special Concern, NAR - Not at Risk; Candidate Species at Risk to be assessed by COSSARO are listed online: www.mnr.gov.on.ca/en/Business/Species/2ColumnSubPage/STDPROD_068707.html/.

COSEWIC: Canada Species at Risk as listed by the Committee on the Status of Endangered Wildlife in Canada (from NHIC Table Feb 17, 2012); END - Endangered, THR - Threatened, SC - Special Concern, NAR - Not at Risk; Candidate Species at Risk to be assessed by COSEWIC are listed online: www.cosewic.gc.ca/eng/sct3/index_e.cfm/. Note, the listing of a species as 'at risk' by COSEWIC does not necessarily mean the species will be formally listed on Ontario's Species at Risk list (SARO).

Table T4: Mammal Species Observed on the Study Area

COMMON NAME	SCIENTIFIC NAME	TRCA Local Rank (2019)	Grank	Srank
American Mink	*Mustela vison*	L4	G5	S4
Beaver	*Castor canadensis*	L4	G5	S5
Canid species	*Canis sp.*	n/a	G5	S5
Coyote	*Canis latrans*	L5	G5	S5
Deer Mouse	*Peromyscus maniculatus*	L4	G5	S5
Eastern Chipmunk	*Tamias striatus*	L4	G5	S5
Eastern Gray Squirrel	*Sciurus carolinensis*	L5	G5	S5
Eastern Cottontail	*Sylvilagus floridanus*	L4	G5	S5
Ermine	*Mustela erminea*	L3	G5	S5
Meadow Vole	*Microtus pennsylvanicus*	L4	G5	S5
Muskrat	*Ondatra zibethicus*	L4	G5	S5
North American River Otter	*Lontra canadensis*	L2	G5	S5
Northern Raccoon	*Procyon lotor*	L5	G5	S5
Red squirrel	*Sciurus vulgaris*	L4	G5	S5
Striped Skunk	*Mephitis mephitis*	L5	G5	S5
Weasel species	*Mustela sp.*	L3-L4	G5	S5-S4
Mouse species	*Peromyscus sp.*	L4	G5	S5
White-tailed Deer	*Odocoileus virginianus*	L4	G5	S5
Big Brown Bat	*Eptesicus fuscus*	L4	G5	S4
Silver-haired Bat	*Lasionycteris noctivagans*	n/a	G3G4	S4
Hoary Bat	*Lasiurus cinereus*	LX	G3G4	S4
Eastern Red Bat	*Lasiurus borealis*	LX	G3G4	S4
Eastern Small-footed Myotis	*Myotis leibii*	n/a	G4	S2S3

TRCA Local Ranking: Local ranks are from the TRCA Fauna Ranks and Scores for the TRCA Jurisdiction. 2019; L1 (regionally scarce due to either accidental occurrence or extreme sensitivity to human impacts), L2 (somewhat more abundant and generally less sensitive than L1 species), L3 (generally less sensitive and more abundant than L1 and L2 ranked species), L4 (occur throughout the region but could show declines if urban impacts are not mitigated), L5 (species that are considered secure throughout the region), LX (species not

S ranks: Provincial ranks are from the Natural Heritage Information Centre; S1 (critically imperiled), S2 (imperlied), S3 (vulnerable), S4 (apparently secure), S5 (secure); ranks were updated using NHIC species list. 2020.

G ranks: National ranks are from the Natural Heritage Information Centre; G1 (extremely rare), G2 (very rare), G3 (rare to uncommon), G4 (common), G5 (very common); ranks were updated using NHIC species list. 2020.

Table 5: Reptile Species Observed on the Study Area

COMMON NAME	SCIENTIFIC NAME	Srank	Grank	COSSARO
Snapping Turtle	*Chelydra serpentina*	S3	G5	SC
Midland Painted Turtle	*Chrysemys picta marginata*	S4	G5	N/A
Eastern Gartersnake	*Thamnophis sirtalis sirtalis*	S5	G5	N/A
Dekay's Brownsnake	*Storeria dekayi*	S5	G5	N/A
Eastern Milksnake	*Lampropeltis triangulum triar*	S4	G5	NAR

Notes

S-Rank and G-rank from NHIC - January 17, 2020

SC - Special Concern, protected under Ontario's Endangered Species Act, 2007

Appendix E

Stream Morphology

Year: 1954 Location: Brampton, ON Easting: Northing:	Aerial ID: 1954-4329-23-211 Scale: 1:15,840 Source: University of Waterloo

Year: 1954

Location: Brampton, ON

Easting:
Northing:

Aerial ID: 1954-4330-23-118

Scale: 1:15,840

Source: University of Waterloo

Year: 1971

Location: Brampton, ON

Easting:
Northing:

Aerial ID: 1971-4327-53-106

Scale: 1:15,840

Source: University of Waterloo

Year: 1971

Location: Brampton, ON

Easting:
Northing:

Aerial ID: 1971-4328-52-10

Scale: 1:15,840

Source: University of Waterloo

Year: 1978

Location: Brampton, ON

Easting:
Northing:

Aerial ID: 1978-4345-54-220

Scale: 1:10,000

Source: University of Waterloo

Year: 1978

Location: Brampton, ON

Easting:
Northing:

Aerial ID: 1978-4346-14-11

Scale: 1:10,000

Source: University of Waterloo

Year: 1978 Location: Brampton, ON Easting: Northing:	Aerial ID: 1978-4347-53-162 Scale: 1:10,000 Source: University of Waterloo

Year: 1982

Location: Brampton, ON

Easting:
Northing:

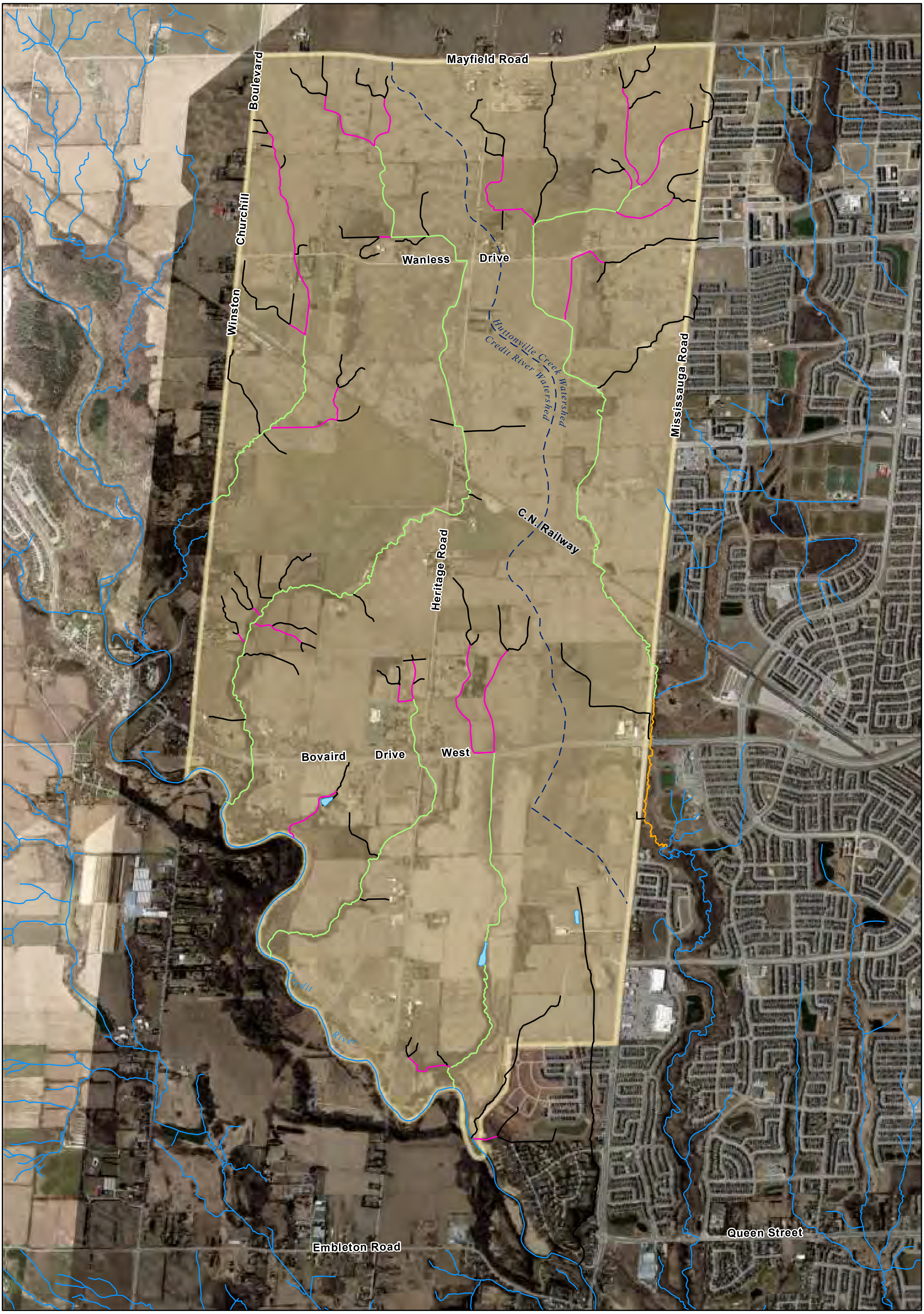
Aerial ID: 1982-30-163-113

Scale: 1:30,000

Source: University of Waterloo

Year: 1990 Location: Brampton, ON Easting: Northing:	Aerial ID: 1990-AF4090-L5-118 Scale: 1:30,000 Source: University of Waterloo

Year: 2009 Location: Brampton, ON Easting: Northing:	Aerial ID: N/A Scale: N/A Source: Google Earth Pro®



Legend

- Approx. Watershed Divide
- Watercourse or Drainage Swale
- Hydraulic Connection
- Waterbody
- Study Area

Stream Order

- First
- Second
- Third
- Fourth

Paper Size ANSI B

0 150 300 450 600

Meters

Map Projection: Transverse Mercator
Horizontal Datum: North American 1983
Grid: NAD 1983 UTM Zone 17N

CITY OF BRAMPTON
HERITAGE HEIGHTS
SUBWATERSHED STUDY

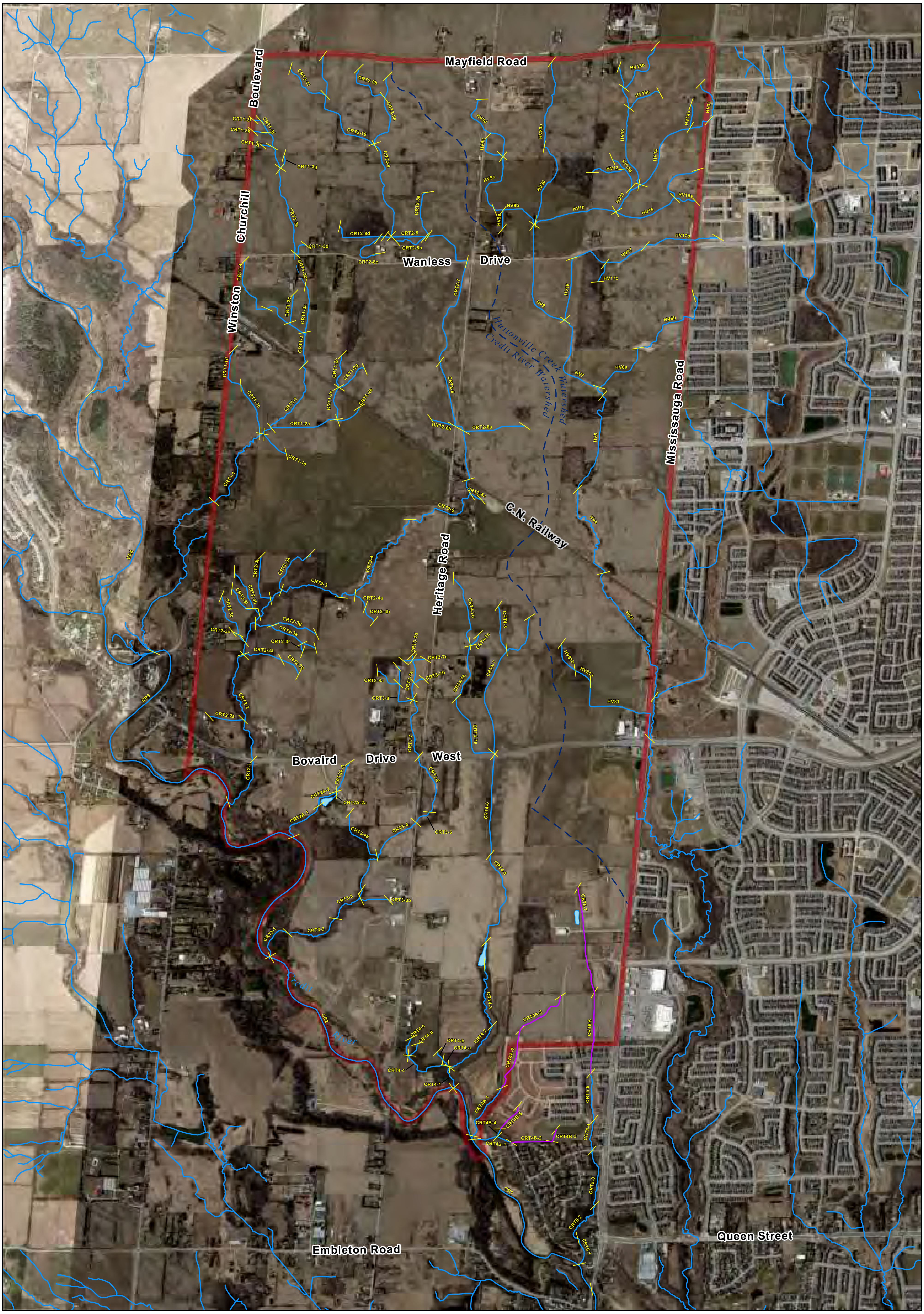
STREAM ORDER

Project No.	2820898
Revision No.	-
Date	Mar 15, 2021

FIGURE E-2

N:\CA\Mississauga\Projects\Legacy\Geomorphic\projects\2011\11348 HERITAGE HEIGHTS SUBWATERSHED STUDY\GIS\MXD\2820898_Appendix_E2_Stream_order_no_reach_labels.mxd
Print date: 15 Mar 2021 - 07:38

Data source: Imagery: City of Brampton, 2020, Conservation Halton, 2019; Watershed Divide: CVC, 2011, GHD, 2012; Watercourse or Drainage Swale, and Hydraulic Connection: CVC, 2012, Savanta, 2012, GHD, 2012; Waterbody: MNR, 2010; Study Area: AMEC, 2012; Stream Order: GHD, 2012.



Legend

- Reach Break and ID
- Approx. Watershed Divide
- Watercourse or Drainage Swale
- Hydraulic Connection
- Reaches to be removed as delineated in the Metrus 4X EIR
- Study Area
- Waterbody

Paper Size ANSI B

0 150 300 450 600

Meters

Map Projection: Transverse Mercator
Horizontal Datum: North American 1983
Grid: NAD 1983 UTM Zone 17N

N

CITY OF BRAMPTON
HERITAGE HEIGHTS
SUBWATERSHED STUDY

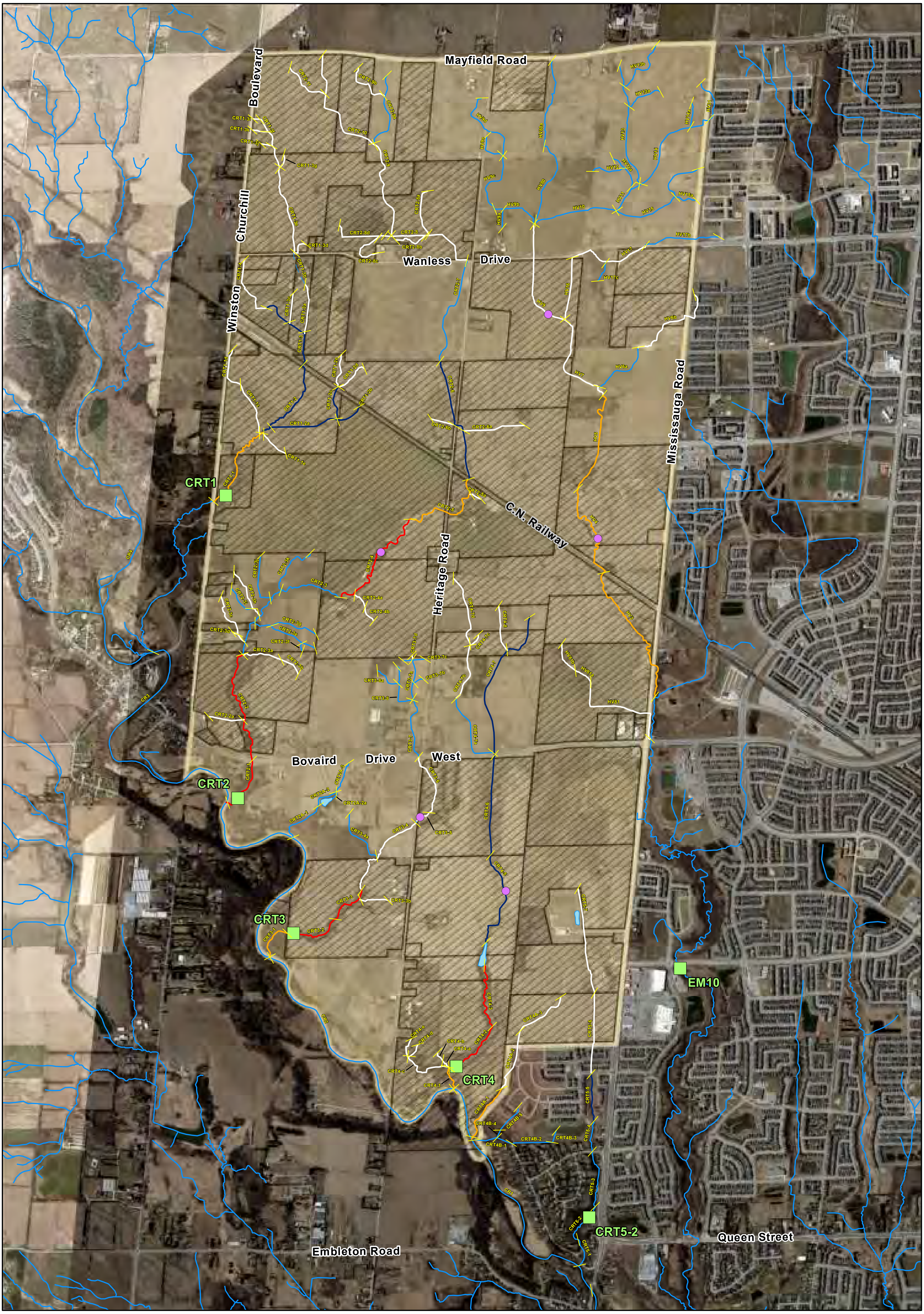
REACH DELINEATION

Project No.	2820898
Revision No.	-
Date	Mar 16, 2021

FIGURE E-3

N:\CA\Mississauga\Projects\Legacy\Geomorphic\projects\2011\11348 HERITAGE HEIGHTS SUBWATERSHED STUDY\GIS\MXD\2820898_Appendix_E4_Reach_Delineation.mxd
Print date: 16 Mar 2021 - 15:13

Data source: Imagery: City of Brampton, 2020, Conservation Halton, 2019; Reach Break and ID: GHD, 2012; Study Area: AMEC, 2012; Watershed Divide: CVC, 2011, GHD, 2012; Watercourse or Drainage Swale, and Hydraulic Connection: CVC, 2012, Savanta, 2012, GHD, 2012; Waterbody: MNR, 2010.



Legend

- Reach Break and ID
- Detailed Field Site
- Geomorphic Monitoring Site
- Watercourse or Drainage Swale
- Hydraulic Connection
- Waterbody
- Study Area
- Access Granted for Field Work

RGA Condition

- In Adjustment
- In Transition/Stress
- In Regime
- N/A - Swale

Paper Size ANSI B

0 150 300 450 600

Meters

Map Projection: Transverse Mercator
Horizontal Datum: North American 1983
Grid: NAD 1983 UTM Zone 17N

CITY OF BRAMPTON
HERITAGE HEIGHTS
SUBWATERSHED STUDY

CHANNEL STABILITY, DETAILED FIELD SITES, AND GEOMORPHIC MONITORING SITES

Project No. 2820898
Revision No. -
Date Mar 15, 2021

FIGURE E-4

N:\CA\Mississauga\Projects\Legacy\Geomorphic\projects\2011\11348 HERITAGE HEIGHTS SUBWATERSHED STUDY\GIS\MXD\2820898_Appendix_E5_RGA_and_Detailed_Sites.mxd
Print date: 15 Mar 2021 - 08:39

Data source: Imagery: City of Brampton, 2020, Conservation Halton, 2019; Reach Break and ID, and Field Site: GHD, 2012; Study Area: AMEC, 2012; Geomorphic Monitoring Site: Savanta, 2012, GHD, 2009, and HFSWS (AMEC et al., 2011); Watercourse and Hydraulic Connection: CVC, 2012, Savanta, 2012, GHD, 2012; Waterbody: MNR, 2010; Field Work Access: Savanta, 2012; RGA Condition: GHD, 2011.

Photo 1.

CRT1-1

November 24, 2011

Looking towards the downstream limit of the reach. Note the gabion basket retaining wall Winston Churchill Boulevard Road embankment.

Photo 2.

CRT1-1

November 24, 2011

Looking downstream along reach. Note the point bar at the left side of the photograph. Also note bank erosion and exposed bedrock on the bed.

Photo 3.

CRT1-1c

November 16, 2011

Reach occurred as a depression within an actively farmed agricultural field. Note the poorly defined channel and lack of riparian vegetation.

Photo 4.

CRT1-1d

November 16, 2011

Looking downstream along the roadside ditch that forms much of this reach.

Photo 5.

CRT1-1e

November 16, 2011

Reach occurred as a poorly defined channel within an agricultural field. Looking upstream, from the confluence at the downstream end.

Photo 6.

CRT1-2

November 16, 2011

Looking towards the downstream limit of reach.

Photo 7.

CRT1-2

November 16, 2011

Looking upstream at general channel conditions.

Photo 8.

CRT1-2a

November 16, 2011

Relatively well-defined channel found in a wooded area, near the upstream end. Photo facing downstream.

Photo 9.

CRT1-2b

November 16, 2011

Looking downstream from the railway tracks at the upstream end of the reach. The channel occurred within a swale adjacent to farm fields in this section of the reach.

Photo 10.

CRT1-2c

November 16, 2011

Looking upstream into the box culvert located at the railway crossing over this reach.

Photo 11.

CRT1-2d

December 19, 2011

Looking upstream along reach. The channel was found within an agricultural field, with grasses as the dominant vegetation type.

Photo 12.

CRT1-2e

December 19, 2011

Looking downstream towards the railway crossing located along this reach.

Photo 13.

CRT1-3

December 19, 2011

Looking downstream towards a corrugated steel pipe culvert located at the railway crossing over the reach.

Photo 14.

CRT1-3

December 19, 2011

Looking upstream along CRT1-3. The channel flows through an agricultural field.

Photo 15.

CRT1-3a

December 19, 2011

Reach occurred as a small swale within an agricultural field.

Photo 16.

CRT1-3c

December 19, 2011

Looking upstream at the confluence with CRT1-3. The channel was poorly defined, within an agricultural field.

Photo 17.

CRT1-3d

November 16, 2011

Reach occurred as a small swale within an agricultural field.

Photo 18.

CRT1-3e

November 16, 2011

Looking downstream along CRT1-3e, from the upstream limit of the reach.

Photo 19.

CRT1-3g

November 15, 2011

Looking upstream along reach.

Photo 20.

CRT1-3j

November 15, 2011

Reach occurred as a small swale within an agricultural field, with the channel formed by tractor tracks. Photo facing upstream.

Photo 21.

CRT1-3k

November 15, 2011

Looking towards a corrugated steel pipe culvert at the upstream end of reach.

Photo 22.

CRT1-3l

November 15, 2011

Looking downstream from the previous photograph. The channel took the form of tracks in an agricultural field.

Photo 23.

CRT1-4

December 19, 2011

Looking upstream along CRT1-4, from the pond located at the downstream limit of the reach.

Photo 24.

CRT1-4

December 19, 2011

Looking upstream from a corrugated steel pipe culvert located at a farm crossing over the reach.

Photo 25.

CRT2-1

November 10, 2011

Looking upstream along CRT2-2. Note the exposed shale and bank undercutting. A concrete weir structure was also noted.

Photo 26.

CRT2-1

November 10, 2011

Looking downstream towards a chute located along this reach. Note also the leaning and fallen trees.

Photo 27.

CRT2A-1

November 10, 2011

Looking downstream towards the confluence with the Credit River. This reach lies within a gully feature, with steep banks commonly observed.

Photo 28.

CRT2A-1

November 10, 2011

Looking upstream towards a concrete weir structure located at the downstream end of a pond at the upstream limit of the reach. Water from the weir falls into a corrugated steel pipe (bottom left), which conveys flows into the gully.

Photo 29.

CRT2-A3

November 10, 2011

Looking upstream along reach, from the driveway located at the downstream extent of the reach. A corrugated steel pipe is present here, discharging into a pond downstream of the driveway.

Photo 30.

CRT2-A3

November 10, 2011

Looking upstream towards the upstream extent of the reach. The channel is poorly defined north of Bovaird Drive, existing as a grassy swale.

Photo 31.

CRT2-2

November 17, 2011

Looking downstream, from near the upstream limit of the reach. Note the occurrence of bank erosion along this reach.

Photo 32.

CRT2-2

November 10, 2011

Looking upstream towards a chute formed along CRT2-2. Note the multiple flow paths.

Photo 33.

CRT2-2a

November 17, 2011

Looking downstream towards end of reach – channel displayed discernible flow path in hedgerow.

Photo 34.

CRT2-3a

November 17, 2011

Looking downstream along reach. The channel flows within a woodlot near the downstream limit, leading to the confluence with CRT2-2.

Photo 35.

CRT2-3b

November 17, 2011

Rills forming in a knickpoint near the upstream limit of the reach. Further upstream, the channel occurs within an agricultural field, with small cobbles and gravel lining the channel bed.

Photo 36.

CRT2-4

November 17, 2011

Looking downstream towards the downstream extent of CRT8-3.

Photo 37.

CRT2-4

November 17, 2011

Looking downstream towards a valley wall contact on the right bank near the upstream limit of the reach.

Photo 38.

CRT2-4a

November 17, 2011

Looking downstream towards the confluence of CRT2-4a with CRT2-4. Photo taken from a farm crossing, with a corrugated steel pipe culvert directing flows beneath the crossing.

Photo 39.

CRT2-5

November 17, 2011

Looking downstream towards the convergence of multiple flow paths.

Photo 40.

CRT2-5

November 17, 2011

Looking upstream, near the rail line at the upstream extent of the reach.

Photo 41.

CRT2-5a

December 19, 2011

Looking downstream towards the limit of reach and confluence with main tributary.

Photo 42.

CRT2-6

November 18, 2011

Looking upstream, towards an online pond. Photo taken from the downstream limit of the study area.

Photo 43.

CRT2-6

November 18, 2011

Box culvert at Heritage Road.

Photo 44.

CRT2-6a

November 18, 2011

Looking downstream along this reach. This channel was poorly defined, occurring within an agricultural field

Photo 45.

CRT2-6b

November 18, 2011

This reach occurred as a poorly defined channel in an agricultural field, with some water observed in tractor tracks.

Photo 46.

CRT2-7

November 18, 2011

Looking downstream from a farm crossing located over CRT8-7. A corrugated steel pipe was found at this crossing.

Photo 47.

CRT2-8

November 16, 2011

Looking upstream along a section of the reach where the channel has been maintained.

Photo 48.

CRT2-9

November 16, 2011

Looking downstream along a section of the reach where the channel had excavated.

Photo 49.

CRT2-9a

November 16, 2011

Looking downstream towards reach from Mayfield Road. The channel occurred in tractor tracks within an agricultural field.

Photo 50.

CRT2-9b

November 16, 2011

Looking downstream towards reach. A discernible drainage feature was not observed at the time of survey.

Photo 51.

CRT2-9c

November 16, 2011

Looking upstream along reach. This channel occurs as a swale in a grassy field.

Photo 52.

CRT2-9d

November 16, 2011

Looking downstream at general reach characteristics.

Photo 53.

CRT2-10

November 16, 2011

Looking towards the upstream limit of the reach where feature exhibited greatest degree of definition. Note the actively farmed field further upstream.

Photo 54.

CRT2-11

November 16, 2011

Looking downstream. The channel was found to flow through tractor tracks in an agricultural field. No culvert was found at the edge of the field.

Photo 55.

CRT3-1

December 1, 2011

Looking upstream along reach, near the confluence with the Credit River. Note the absence of defined banks and riffle-pool morphology.

Photo 56.

CRT3-1

December 1, 2011

Looking downstream from the upstream limit of the reach.

Photo 57.

CRT3-2

December 1, 2011

Looking upstream, near the downstream limit. Note bank erosion and presence of woody debris in channel.

Photo 58.

CRT3-2

December 1, 2011

Looking upstream towards a pair of corrugated steel pipe culverts beneath a farm crossing near the upstream limit of the reach. The culverts were worn out, and water was flowing from underneath.

Photo 59.

CRT3-3

December 1, 2011

Looking downstream along CRT3-3, with water flowing through depressions formed as a result of tire tracks.

Photo 60.

CRT3-3b

November 15, 2011

Looking downstream from a farm crossing located at the upstream end of the reach.

Photo 61.

CRT3-4a

November 15, 2011

Looking upstream, from the downstream limit of reach.

Photo 62.

CRT3-5

November 15, 2011

Poorly defined channel observed in forested area.

Photo 63.

CRT3-6

November 15, 2011

Looking downstream from Heritage Road, near the upstream end of the reach.
Feature displayed minimal definition with distance downstream.

Photo 64.

CRT3-7

December 19, 2011

The channel, as it appears near the upstream limit of the reach. Photo facing downstream.

Photo 65.

CRT3-8

December 19, 2011

Looking upstream, near the downstream limit. Channel flows through manicured grass field.

Photo 66.

CRT3-8a

December 19, 2011

Looking upstream along reach. Note the absence of a defined channel.

Photo 67.

CRT4-a

November 18, 2011

Looking upstream along the gully that forms reach.

Photo 68.

CRT-4b

November 18, 2011

Small depression observed at the top of the gully.

Photo 69.

CRT4-c

November 18, 2011

Reach exists as a grassy swale through field.

Photo 70.

CRT4-d

November 18, 2011

Looking downstream towards reach.

Photo 71.

CRT4-e

November 18, 2011

Looking upstream towards reach.

Photo 72.

CRT4-1

November 18, 2011

Looking downstream towards the confluence of reach with the Credit River.

Photo 73.

CRT4-1

November 18, 2011

Looking upstream along CRT4-1. Note the woody debris within the channel

Photo 74.

CRT4-2

November 18, 2011

Debris blocking the channel near the upstream limit of the reach.

Photo 75.

CRT4-2

November 18, 2011

Looking upstream along CRT4-2. Note the exposed shale and series of knickpoints on the channel bed.

Photo 76.

CRT4-3

November 18, 2011

Exposed shale along channel bed and banks, near the downstream end of the reach.

Photo 77.

CRT4-5

November 15, 2011

Photo taken at downstream limit. Corrugated steel pipe under a farm crossing, discharging into a pond downstream.

Photo 78.

CRT4-5

November 15, 2011

Looking upstream along CRT4-5, where the channel appears as a swale adjacent to agricultural fields.

Photo 79.

CRT4-6

November 15, 2011

Looking downstream along the reach, from the left bank.

Photo 80.

CRT4-7

December 1, 2011

View of CRT4-7, facing upstream.

Photo 81.

CRT4-7a

December 1, 2011

Tractor tracks crossing reach. Photo facing west.

Photo 82.

CRT4-7b

December 1, 2011

Photo taken looking upstream, near the downstream end of the reach.

Photo 83.

CRT4-7c

December 1, 2011

Looking upstream, from the downstream limit of the reach.

Photo 84.

CRT4-8

December 1, 2011

Looking downstream along CRT4-8, from the upstream limit of the reach.

Photo 85.

CRT4A-1

October 24, 2011

Looking down into a gully feature typical of this reach, from the upstream limit.

Photo 86.

CRT4A-3

October 24, 2011

General reach conditions. Looking upstream.

Photo 87.

CRT5-6

November 15, 2011

Poorly defined channel within CRT5-6. Photo facing upstream.

Photo 88.

CRT5-7

November 15, 2011

View of the channel from the downstream limit of the reach. Photo facing upstream.

Photo 89.

HV3

February 12, 2010

Looking towards a box culvert at the downstream end of the reach, located at the Mississauga Road crossing.

Photo 90.

HV3

February 12, 2010

Looking further upstream along HV3. Note the presence of woody debris on the banks, and vegetation encroachment into the channel.

Photo 91.

HV4

December 19, 2011

Looking downstream along HV4. The pooling of water was due to a woody debris jam further downstream.

Photo 92.

HV4

December 19, 2011

Looking upstream along the channel, as it flows parallel to the railway tracks near the downstream end. Note the relatively poorly defined channel and flattened grasses.

Photo 93.

HV5

December 19, 2011

Looking downstream along HV5. Photo taken downstream of an online pond located along this reach.

Photo 94.

HV5

December 19, 2011

Looking towards a crossing over the channel.

Photo 95.

HV6a

November 24, 2011

Looking upstream along reach. This reach occurred as a swale flowing adjacent to actively farmed agricultural fields.

Photo 96.

HV6b

November 24, 2011

Looking towards the downstream limit of reach. The reach was found as a shallow depression over the ground, which was saturated.

Photo 97.

HV7

November 24, 2011

Looking upstream along a swale that forms much of this reach. Note the lack of a defined channel.

Photo 98.

HV9

November 24, 2011

Looking downstream from Wanless Drive. The channel occurs as a swale adjacent to actively farmed agricultural fields. Note the presence of two corrugated steel pipe culverts at the road crossing.

Photo 99.

HV9a

November 23, 2011

Looking upstream along reach. The channel was poorly defined, found in a pasture.

Photo 100.

HV9b

November 23, 2011

Looking downstream along reach. The channel was poorly defined, found in an actively farmed field.

Photo 101.

HV9c

November 23, 2011

Looking downstream along reach. The channel appeared to be dug out, flowing through an actively farmed field.

Photo 102.

HV9d

November 23, 2011

Photo looking downstream of Heritage Road. The channel was poorly defined, located in an actively farmed agricultural field.

Photo 103.

HV9e

November 23, 2011

Looking upstream along reach. The channel was poorly defined, found as a depression in an actively farmed agricultural field.

Photo 104.

HV10

November 23, 2011

Looking upstream along the channel. The reach was found adjacent to actively farmed fields. The channel appeared to have been excavated.

Photo 105.

HV11

November 23, 2011

Looking upstream along reach, from the downstream limit of the reach. The channel was relatively well-defined and was found adjacent to an agricultural field.

Photo 106.

HV11a

November 23, 2011

Looking towards the upstream limit of reach. The channel was poorly defined, flowing through an actively farmed agricultural field.

Photo 107.

HV13

November 23, 2011

Looking upstream along HV13, from the downstream limit of the reach. The channel was found adjacent to actively farmed fields.

Photo 108.

HV13-b

November 23, 2011

Reach occurred as a poorly defined channel within an actively farmed agricultural field.

Photo 109.

HV13a

November 23, 2011

Reach occurred as a depression within an actively farmed agricultural field. Note the poorly defined channel.

Photo 110.

HV14

November 23, 2011

Looking downstream along reach. This reach occurred as a small swale adjacent to actively farmed agricultural fields.

Photo 111.

HV14a

November 23, 2011

Reach occurred as a depression within an actively farmed agricultural field. Note the poorly defined channel and lack of riparian vegetation.

Photo 112.

HV15

November 23, 2011

Looking upstream along HV15. This reach was found as a poorly-defined channel within an actively farmed agricultural field. Water was noted in tractor tire tracks over the field.

Photo 113.

HV15a

November 23, 2011

Looking downstream along reach from the upstream limit at Mississauga Road. This reach occurred as a depression in an agricultural field.

Photo 114.

HV16

November 24, 2011

Looking towards the upstream limit of HV16. This reach occurred as a small swale adjacent to actively farmed agricultural fields.

Photo 115.

HV17

November 24, 2011

Looking downstream along HV17, from the upstream limit of the reach, at Wanless Road. The channel occurred as a small swale, flowing adjacent to agricultural fields.

Photo 116.

HV17b

February 12, 2010

Looking upstream, from the downstream limit of the reach. Note the lack of a defined channel.

Photo 117.

HV17c

November 24, 2011

Reach occurred as a depression in an agricultural field.

Photo 118.

HV31

February 12, 2010

Looking upstream along the roadside ditch that forms much of this reach.

Photo 119.

HV80

November 23, 2011

Looking downstream along HV80. The channel appeared to be dredged, and located in an actively farmed agricultural field.

Photo 120.

HV80a

November 23, 2011

Looking downstream along reach. The channel was found to flow through a field of tall grasses.

Photo 121.

HV81

December 1, 2011

Looking towards the upstream limit of HV81. The channel was relatively well-defined, flowing adjacent to agricultural fields.

Photo 122.

HV81a

December 1, 2011

Looking upstream through wooded area, where channel displayed a degree of definition. Majority of reach through agricultural field was poorly defined.

Fluvial Geomorphology Summary
CRT2-4, Credit River Watershed

Location:	**Heritage Heights, Brampton**	Date:	**July 10, 2012**
Length Surveyed:	**110 m**	Number of Cross Sections:	**8**

GENERAL SITE CHARACTERISTICS

Drainage Area:	**Not measured**	Riparian Vegetation:	
Geology/Soils:	**Halton Till**	Dominant Vegetation Type:	**Trees, grasses**
Surrounding Land Use:	**Pasture**	Extent of Riparian Buffer Zone:	**Fragmentary**
Channel Disturbances:	**None**	Width of Riparian Buffer Zone:	**>5 channel widths**
Aquatic Vegetation:		Age Class of Riparian Vegetation:	**Mature**
Dominant Vegetation Type:	**Rooted emergent**	Extent of Encroachment into Channel:	**Minimal**
Portion of Reach with Vegetation:	**60%**	Large Woody Debris:	**Present at low density**

HYDROLOGY

Measured Discharge:	**Not measured** m^3/s	Calculated Bankfull Discharge:	**0.85** m^3/s
Modeled 2-year Discharge:	**Not calculated** m^3/s	Calculated Bankfull Velocity:	**0.72** m/s
Modeled 2-year Velocity:	**Not calculated** m/s		

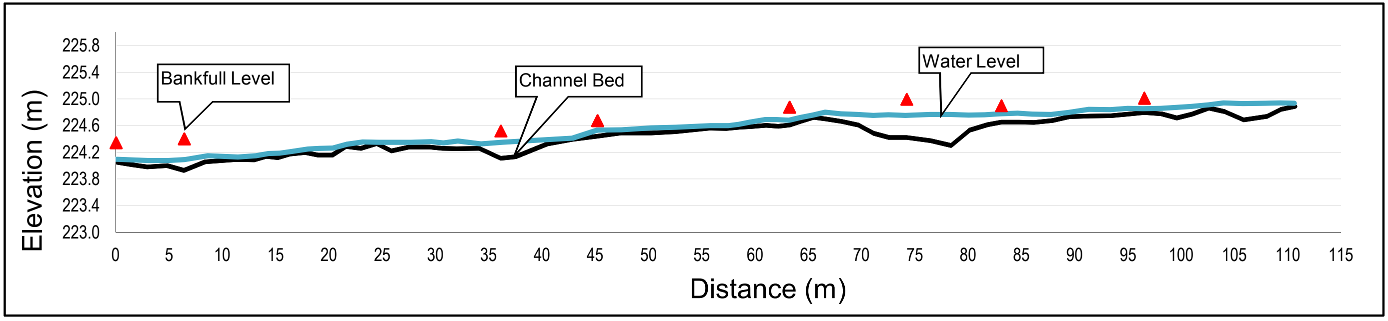
PLANFORM CHARACTERISTICS

Profile ** Water level used as surrogate for bankfull grade

Bankfull Gradient:	**0.82**	%	Sinuosity:	**1.48**	
Channel Bed Gradient:	**0.74**	%	Belt Width:	**Not applicable - confined**	m
Riffle Gradient:	**1.54**	%	Radius of Curvature:	**Not measured**	m
Riffle Length:	**7.66**	m	Amplitude:	**Not measured**	m
Riffle-Pool Spacing:	**27-42**	m	Wavelength:	**Not measured**	m

Meander Geometry

Longitudinal Profile



BANK CHARACTERISTICS

	Minimum	*Maximum*	*Average*
Bank Height (m):	**0.1**	**2.0**	**0.5**
Bank Angle (degrees):	**10.0**	**90.0**	**51.9**
Root Depth (m):	**0.1**	**2.0**	**0.4**
Root Density (%):	**30.0**	**100.0**	**73.1**
Undercut Banks (%)		**<10%**	
Depth of Undercut (m):	**0.0**	**0.5**	**0.0**

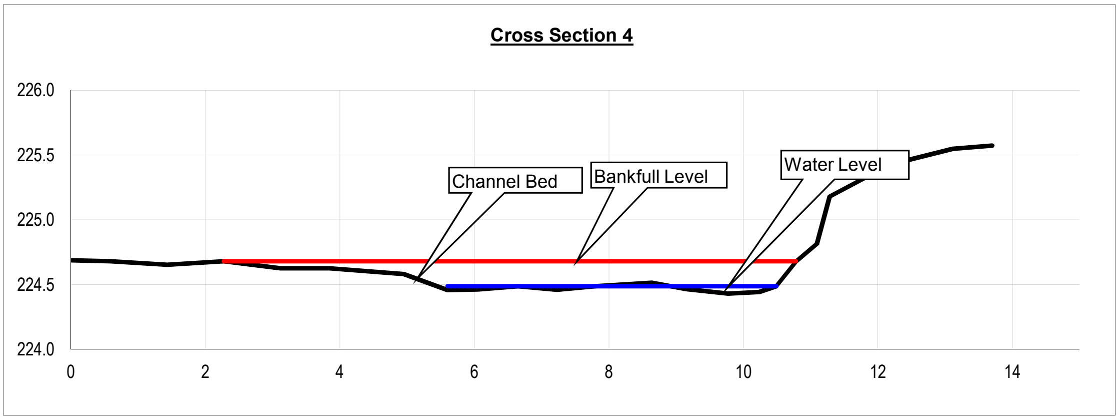
	Minimum	*Maximum*	*Average*
Torvane Value (kg/cm^2):		**Not measured**	
Penetrometer Value (kg/cm^2):		**Not measured**	
Bank Material (range):		**Organics, small amounts of gravel**	

CROSS-SECTIONAL CHARACTERISTICS

	Minimum	*Maximum*	*Average*
Bankfull Width (m):	**3.8**	**8.5**	**5.5**
Average Bankfull Depth (m):	**0.1**	**0.3**	**0.2**
Bankfull Width/Depth:	**12.1**	**47.9**	**29.9**
Wetted Width (m):	**1.7**	**4.9**	**3.2**
Average Water Depth (m):	**0.02**	**0.2**	**0.1**
Wetted Width/Depth:	**0.0**	**287.4**	**90.0**
Entrenchment (m):		**Not measured**	
Entrenchment Ratio:		**Not measured**	
Max. Wetted Depth (m):	**0.02**	**0.30**	**0.12**
Manning's n:		**0.045**	

** Note - Bankfull dimensions include measured cross-sections where the active channel was poorly defined, with multiple flow paths.

Representative Cross-Section (#4)



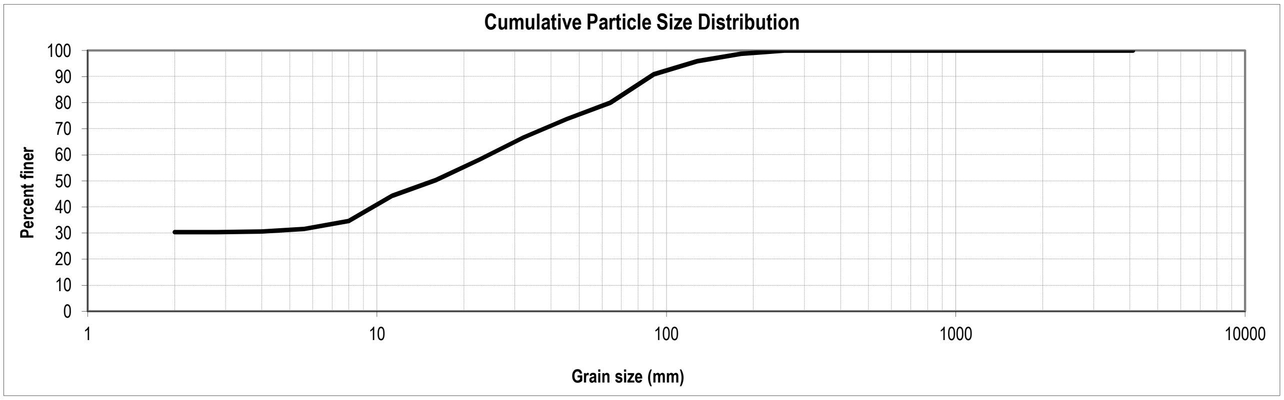
SUBSTRATE CHARACTERISTICS

Particle size

D_{10}	**< 2**	mm
D_{50}	**17**	mm
D_{90}	**89**	mm

Subpavement:	**Sand, gravel**
Particle shape:	**Rounded, sub-rounded, sub-angular**
Embeddedness (%):	**<10 - 20**
Particle range (riffle):	**0.2 - 24.0**
Particle Range (pool):	**silt - 10.0**

Grain Size Distribution



CHANNEL THRESHOLDS

Flow Competency:			Tractive Force at Bankfull:	**17.0**	N/m^2
for D_{50}:	**0.7**	m/s	Tractive Force at 2-year flow:	**Not calculated**	N/m^2
for D_{84}:	**1.4**	m/s	Critical Shear Stress:	**To be determined**	N/m^2
Unit Stream Power at Bankfull:	**12.20**	W/m^2			

GENERAL FIELD OBSERVATIONS

Channel flows through deciduous forest within a confined valley setting. Valley contacts and toe erosion were observed. Evidence of active adjustment included development of chutes and multiple flow paths.

Downstream view of cross section # 4

Fluvial Geomorphology Summary

CRT3-5, Credit River Watershed

Location: **Heritage Heights, Brampton**

Date: **June 24, 2012**

Length Surveyed: **87**

Number of Cross Sections: **5**

GENERAL SITE CHARACTERISTICS

Drainage Area: **Not Measured**

Geology/Soils: **Halton Till**

Surrounding Land Use: **Forested and Agricultural**

Channel Disturbances: **None**

Aquatic Vegetation:

- Dominant Vegetation Type: **Rooted Emergent**
- Portion of Reach with Vegetation: **100%**

Riparian Vegetation:

- Dominant Vegetation Type: **Grasses and Herbaceous**
- Extent of Riparian Buffer Zone: **Continuous**
- Width of Riparian Buffer Zone: **1-5 Channel Widths**
- Age Class of Riparian Vegetation: **Immature**
- Extent of Encroachment into Channel: **Extreme**

Large Woody Debris: **Not Present**

HYDROLOGY

Measured Discharge: **Not measured** m^3/s

Modeled 2-year Discharge: **Not calculated** m^3/s

Modeled 2-year Velocity: **Not calculated** m/s

Calculated Bankfull Discharge: **0.05** m^3/s

Calculated Bankfull Velocity: **0.36** m/s

PLANFORM CHARACTERISTICS

Profile ** Bed gradient used as surrogate for bankfull grade

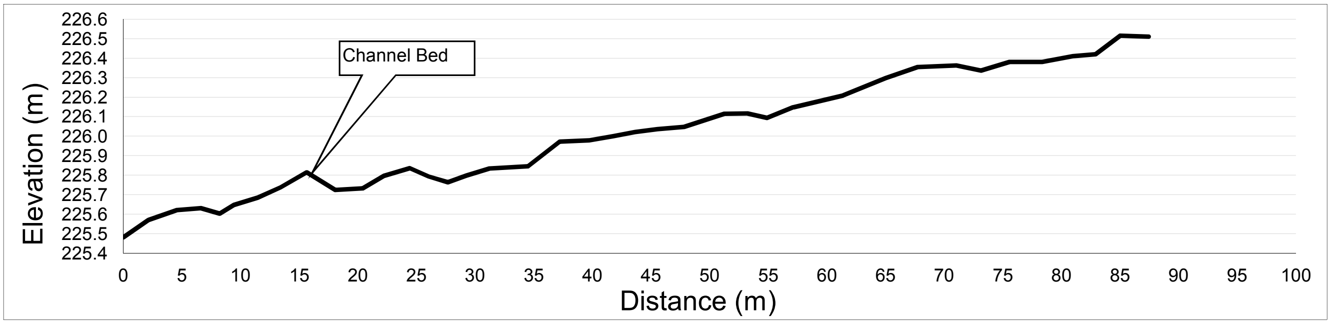
- Bankfull Gradient: **1.11** %
- Channel Bed Gradient: **1.11** %
- Riffle Gradient: **N/A Swale** %
- Riffle Length: **N/A Swale** m
- Riffle-Pool Spacing: **N/A Swale** m

** Note - feature dry at time of survey

Meander Geometry

- Sinuosity: **1.09**
- Belt Width: **Not measured** m
- Radius of Curvature: **Not measured** m
- Amplitude: **Not measured** m
- Wavelength: **Not measured** m

Longitudinal Profile



BANK CHARACTERISTICS

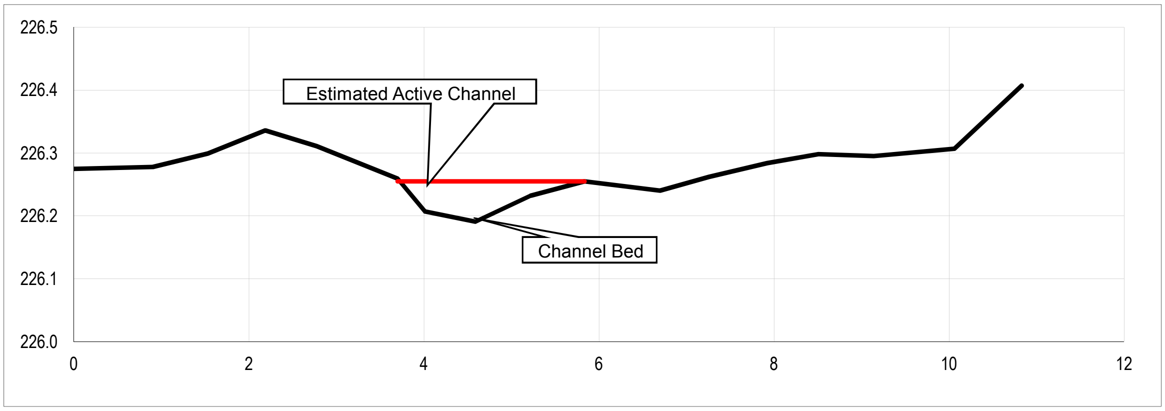
	Minimum	*Maximum*	*Average*
Bank Height (m):		**No defined banks**	
Bank Angle (degrees):		**No defined banks**	
Root Depth (m):		**No defined banks**	
Root Density (%):		**No defined banks**	
Undercut Banks (%)		**No defined banks**	
Depth of Undercut (m):		**No defined banks**	

	Minimum	*Maximum*	*Average*
Torvane Value (kg/cm^2):		**Not measured**	
Penetrometer Value (kg/cm^2):		**Not measured**	
Bank Material (range):		**No defined banks**	

CROSS-SECTIONAL CHARACTERISTICS

	Minimum	*Maximum*	*Average*
Bankfull Width (m):	**2.0**	**2.4**	**2.2**
Average Bankfull Depth (m):	**0.03**	**0.08**	**0.06**
Bankfull Width/Depth:	**24.6**	**81.4**	**46.4**
Wetted Width (m):	**Dry at time of survey**		
Average Water Depth (m):	**Dry at time of survey**		
Wetted Width/Depth:	**Dry at time of survey**		
Entrenchment (m):	**Not measured**		
Entrenchment Ratio:	**Not measured**		
Max. Wetted Depth (m):	**Dry at time of survey**		
Manning's n:	**0.045**		

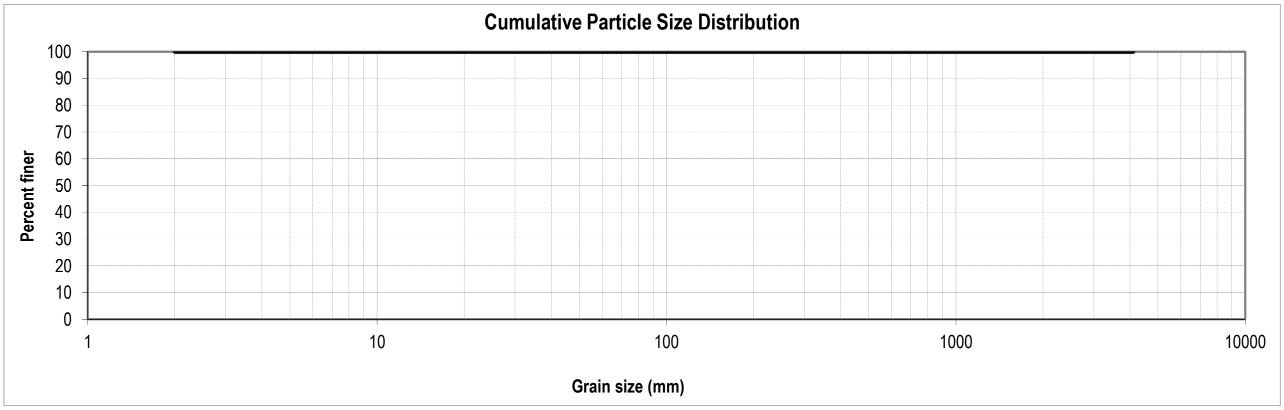
Representative Cross-Section (#5)



SUBSTRATE CHARACTERISTICS

Particle size		Subpavement:	**Clay**
D_{10}	**<2** mm	Particle shape:	**Clay**
D_{50}	**<2** mm	Embeddedness (%):	**N/A Swale**
D_{90}	**<2** mm	Particle range (riffle):	**N/A Swale**
		Particle Range (pool):	**N/A Swale**

Grain Size Distribution



CHANNEL THRESHOLDS

Flow Competency:			Tractive Force at Bankfull:	**6.50**	N/m^2
for D_{50}:	**na**	m/s	Tractive Force at 2-year flow:	**Not calculated**	N/m^2
for D_{84}:	**na**	m/s	Critical Shear Stress:	**To be determined**	N/m^2
Unit Stream Power at Bankfull:	**2.35**	W/m^2			

GENERAL FIELD OBSERVATIONS

Feature took the form of a densely vegetated swale feature, lacking a defined channel or bed morphology. No water present at time of inspection.

LB to RB view of cross section # 4

Fluvial Geomorphology Summary

CRT4-5, Credit River Watershed

Location:	**Heritage Heights, Brampton**	Date:	**July 13, 2012**
Length Surveyed:	**183**	Number of Cross Sections:	**5**

GENERAL SITE CHARACTERISTICS

Drainage Area:	**Not Measured**	Riparian Vegetation:	
Geology/Soils:	**Halton Till**	Dominant Vegetation Type:	**Grasses and Herbaceous**
Surrounding Land Use:	**Agricultural**	Extent of Riparian Buffer Zone:	**Continuous**
Channel Disturbances:	**Agricultural ditch**	Width of Riparian Buffer Zone:	**1-5 Channel Widths**
Aquatic Vegetation:		Age Class of Riparian Vegetation:	**Immature**
Dominant Vegetation Type:	**Cattails**	Extent of Encroachment into Channel:	**Extreme**
Portion of Reach with Vegetation:	**30%**	Large Woody Debris:	**None**

HYDROLOGY

Measured Discharge:	**Not measured** m^3/s	Calculated Bankfull Discharge:	**0.11** m^3/s
Modeled 2-year Discharge:	**Not calculated** m^3/s	Calculated Bankfull Velocity:	**0.54** m/s
Modeled 2-year Velocity:	**Not calculated** m/s		

PLANFORM CHARACTERISTICS

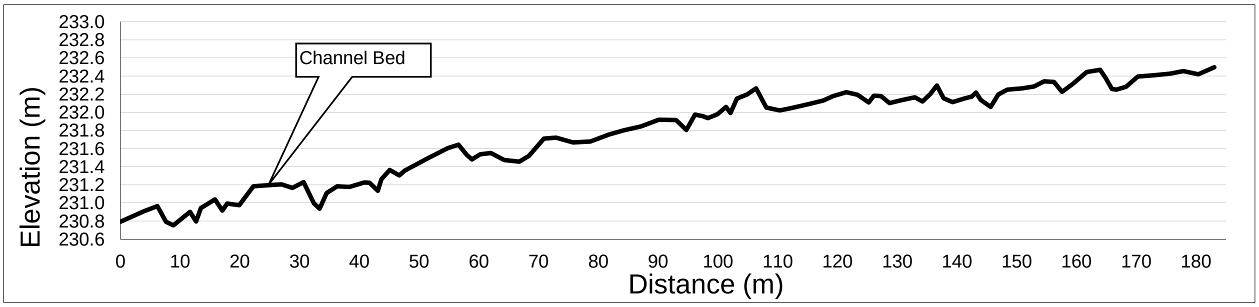
Profile ** Bed gradient used as surrogate for bankfull grade

Meander Geometry

Bankfull Gradient:	**0.94**	%	Sinuosity:	**1.14**	
Channel Bed Gradient:	**0.94**	%	Belt Width:	**Not measured**	m
Riffle Gradient:	**N/A Swale**	%	Radius of Curvature:	**Not measured**	m
Riffle Length:	**N/A Swale**	m	Amplitude:	**Not measured**	m
Riffle-Pool Spacing:	**N/A Swale**	m	Wavelength:	**Not measured**	m

* Note - feature was dry at time of survey

Longitudinal Profile



BANK CHARACTERISTICS

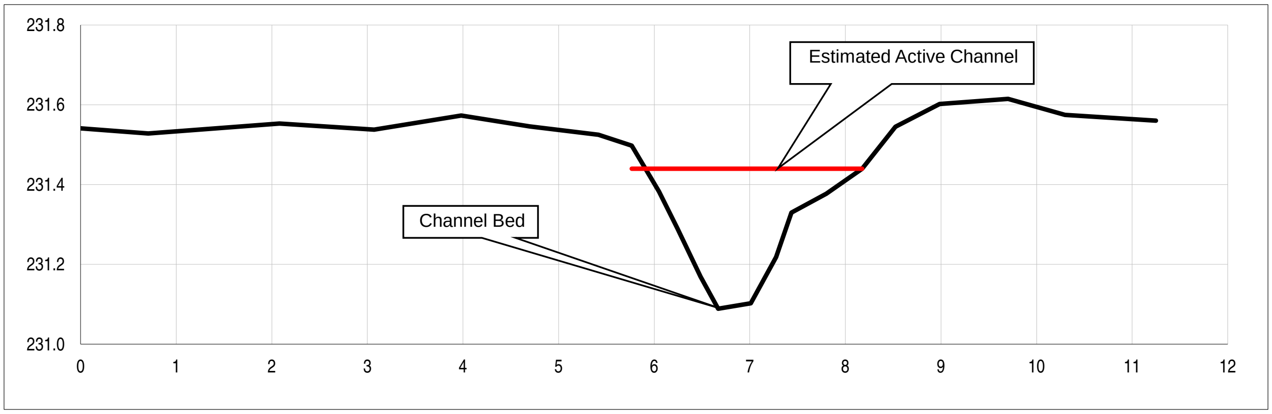
	Minimum	*Maximum*	*Average*
Bank Height (m):	**0.2**	**0.5**	**0.3**
Bank Angle (degrees):	**20.0**	**60.0**	**35.5**
Root Depth (m):	**0.2**	**0.5**	**0.3**
Root Density (%):	**10.0**	**100.0**	**85.5**
Undercut Banks (%)		**none**	
Depth of Undercut (m):	**0.0**	**0.0**	**N/A**

	Minimum	*Maximum*	*Average*
Torvane Value (kg/cm^2):		**Banks too compact**	
Penetrometer Value (kg/cm^2):		**Banks too compact**	
Bank Material (range):		**Clay**	

CROSS-SECTIONAL CHARACTERISTICS

	Minimum	*Maximum*	*Average*
Discernible Width (m):	**1.2**	**2.5**	**1.9**
Average Depth (m):	**0.1**	**0.2**	**0.1**
Width/Depth:	**11.0**	**18.7**	**15.9**
Wetted Width (m):	**Dry at time of survey**		
Average Water Depth (m):	**Dry at time of survey**		
Wetted Width/Depth:	**Dry at time of survey**		
Entrenchment (m):	**Not measured**		
Entrenchment Ratio:	**Not measured**		
Max. Wetted Depth (m):	**Dry at time of survey**		
Manning's n:	**0.045**		

Representative Cross-Section (#5)



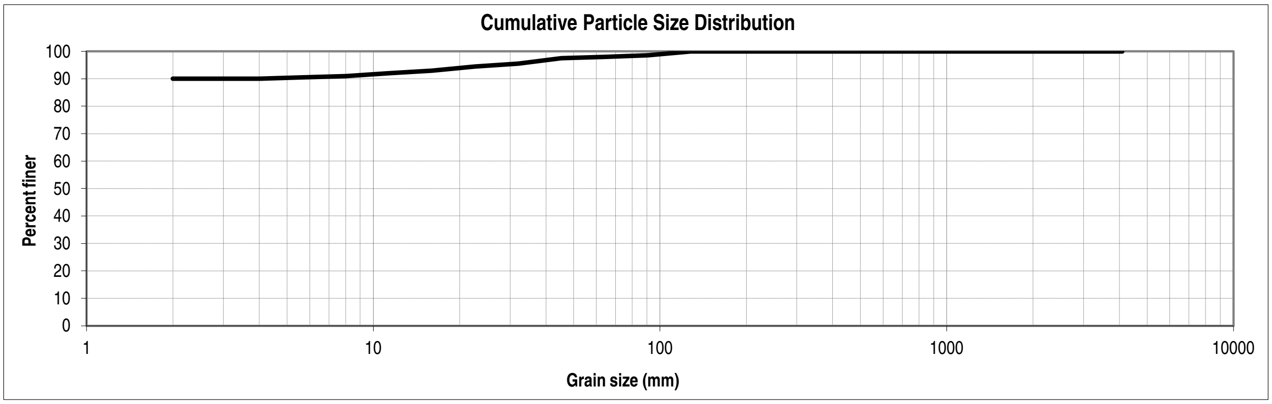
SUBSTRATE CHARACTERISTICS

Particle size

D_{10}	**< 2** mm
D_{50}	**< 2** mm
D_{90}	**2.5** mm

Subpavement:	**Compact Clay**
Particle shape:	**Sub-Angular**
Embeddedness (%):	**10**
Particle range (riffle):	**N/A No Riffle Pool development**
Particle Range (pool):	

Grain Size Distribution



CHANNEL THRESHOLDS

Flow Competency:			Tractive Force at Bankfull:	**11.50**	N/m^2
for D_{50}:	**na**	m/s	Tractive Force at 2-year flow:	**Not calculated**	N/m^2
for D_{84}:	**0.30**	m/s	Critical Shear Stress:	**To be determined**	N/m^2
Unit Stream Power at Bankfull:	**6.20**	W/m^2			

GENERAL FIELD OBSERVATIONS

Drainage feature took the form of a vegetated swale that was actively maintained to facilitate drainage of adjacent agricultural lands. Feature was dry at time of survey with dense instream vegetation growth. Evidence of active morphologic processes within the reach included the intitiation of longitudinal sorting of bed materials. In general, however, the drainage feature lacked a well-defined channel or bed morphology.

Downstream view of cross section # 4

Fluvial Geomorphology Summary

CRT4-6, Credit River Watershed

Location: **Heritage Heights, Brampton**
Date: **July 13, 2012**
Length Surveyed: **183**
Number of Cross Sections: **5**

GENERAL SITE CHARACTERISTICS

Drainage Area: **Not Measured**
Geology/Soils: **Halton Till**
Surrounding Land Use: **Agricultural**
Channel Disturbances: **Agricultural ditch**
Aquatic Vegetation:
  Dominant Vegetation Type: **Cattails**
  Portion of Reach with Vegetation: **30%**

Riparian Vegetation:
  Dominant Vegetation Type: **Grasses and Herbaceous**
  Extent of Riparian Buffer Zone: **Continuous**
  Width of Riparian Buffer Zone: **1-5 Channel Widths**
  Age Class of Riparian Vegetation: **Immature**
  Extent of Encroachment into Channel: **Extreme**
Large Woody Debris: **None**

HYDROLOGY

Measured Discharge: **Not measured** m^3/s
Modeled 2-year Discharge: **Not calculated** m^3/s
Modeled 2-year Velocity: **Not calculated** m/s

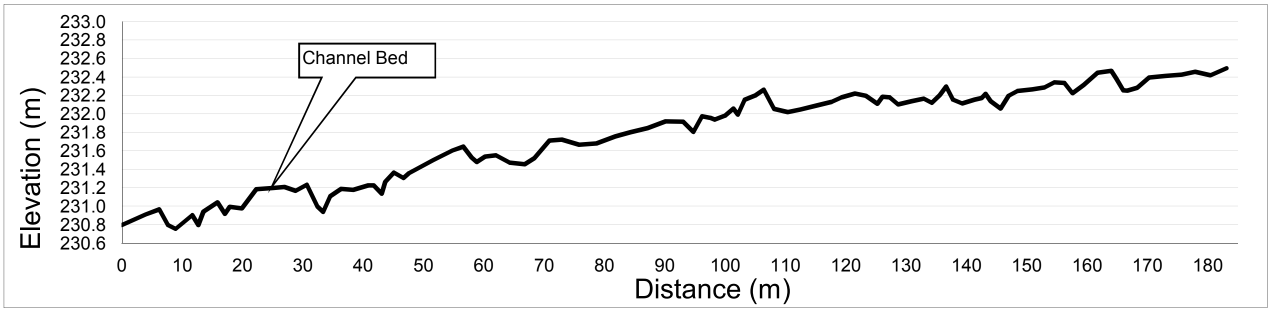
Calculated Bankfull Discharge: **0.11** m^3/s
Calculated Bankfull Velocity: **0.54** m/s

PLANFORM CHARACTERISTICS

Profile ** Bed gradient used as surrogate for bankfull grade
  Bankfull Gradient: **0.94** %
  Channel Bed Gradient: **0.94** %
  Riffle Gradient: **N/A Swale** %
  Riffle Length: **N/A Swale** m
  Riffle-Pool Spacing: **N/A Swale** m
  * Note - feature was dry at time of survey

Meander Geometry
Sinuosity: **1.14**
Belt Width: **Not measured** m
Radius of Curvature: **Not measured** m
Amplitude: **Not measured** m
Wavelength: **Not measured** m

Longitudinal Profile



BANK CHARACTERISTICS

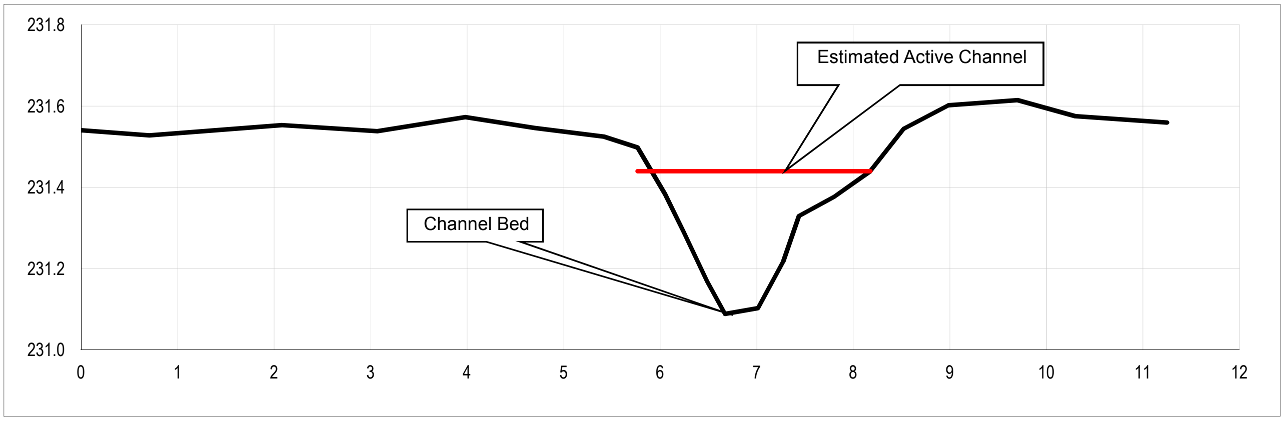
	Minimum	*Maximum*	*Average*
Bank Height (m):	**0.2**	**0.5**	**0.3**
Bank Angle (degrees):	**20.0**	**60.0**	**35.5**
Root Depth (m):	**0.2**	**0.5**	**0.3**
Root Density (%):	**10.0**	**100.0**	**85.5**
Undercut Banks (%)		**none**	
Depth of Undercut (m):	**0.0**	**0.0**	**N/A**

	Minimum	*Maximum*	*Average*
Torvane Value (kg/cm^2):		**Banks too compact**	
Penetrometer Value (kg/cm^2):		**Banks too compact**	
Bank Material (range):		**Clay**	

CROSS-SECTIONAL CHARACTERISTICS

	Minimum	*Maximum*	*Average*
Discernible Width (m):	**1.2**	**2.5**	**1.9**
Average Depth (m):	**0.1**	**0.2**	**0.1**
Width/Depth:	**11.0**	**18.7**	**15.9**
Wetted Width (m):	**Dry at time of survey**		
Average Water Depth (m):	**Dry at time of survey**		
Wetted Width/Depth:	**Dry at time of survey**		
Entrenchment (m):	**Not measured**		
Entrenchment Ratio:	**Not measured**		
Max. Wetted Depth (m):	**Dry at time of survey**		
Manning's n:	**0.045**		

Representative Cross-Section (#5)

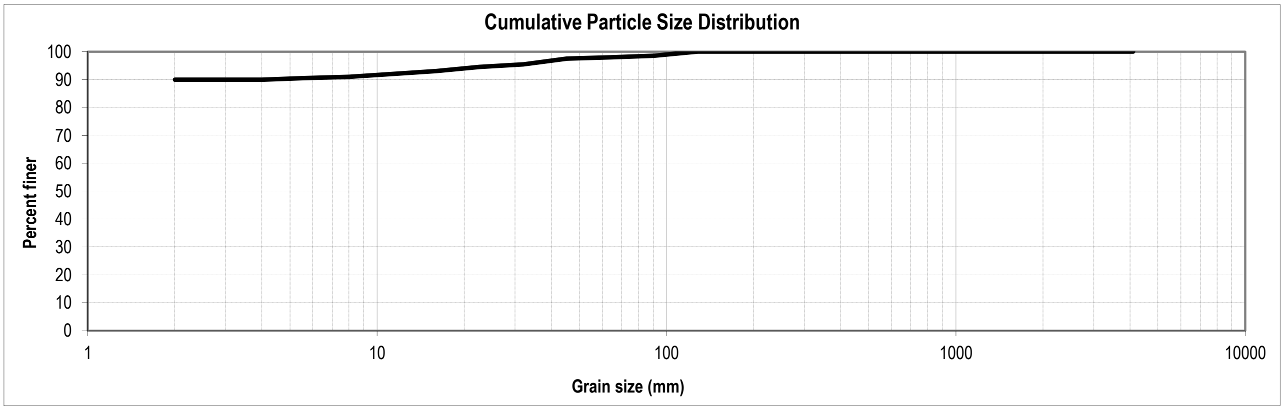


SUBSTRATE CHARACTERISTICS

Particle size	
D_{10}	**< 2** mm
D_{50}	**< 2** mm
D_{90}	**2.5** mm

Subpavement:	**Compact Clay**
Particle shape:	**Sub-Angular**
Embeddedness (%):	**10**
Particle range (riffle):	**N/A No Riffle Pool development**
Particle Range (pool):	

Grain Size Distribution



CHANNEL THRESHOLDS

Flow Competency:

for D_{50}: **na** m/s

for D_{84}: **0.30** m/s

Unit Stream Power at Bankfull: **6.20** W/m^2

Tractive Force at Bankfull: **11.50** N/m^2

Tractive Force at 2-year flow: **Not calculated** N/m^2

Critical Shear Stress: **To be determined** N/m^2

GENERAL FIELD OBSERVATIONS

Drainage feature took the form of a vegetated swale that was actively maintained to facilitate drainage of adjacent agricultural lands. Feature was dry at time of survey with dense instream vegetation growth. Evidence of active morphologic processes within the reach included the intitiation of longitudinal sorting of bed materials. In general, however, the drainage feature lacked a well-defined channel or bed morphology.

Downstream view of cross section # 4

Fluvial Geomorphology Summary
Reach HV4, Huttonville Creek Watershed

Location:	**Heritage Heights, Brampton**	Date:	**July 18, 2012**
Length Surveyed:	**100 m**	Number of Cross Sections:	**5**

GENERAL SITE CHARACTERISTICS

Drainage Area:	**Not measured**	Riparian Vegetation:	
Geology/Soils:	**Halton Till**	Dominant Vegetation Type:	**Grass**
Surrounding Land Use:	**Agriculture**	Extent of Riparian Buffer Zone:	**continuous**
Channel Disturbances:	**none observed**	Width of Riparian Buffer Zone:	**>5 channel widths**
Aquatic Vegetation:		Age Class of Riparian Vegetation:	**immature**
Dominant Vegetation Type:	**Grasses**	Extent of Encroachment into Channel:	**extreme**
Portion of Reach with Vegetation:	**100%**	Large Woody Debris:	**None**

HYDROLOGY

Measured Discharge:	**Not measured** m^3/s	Calculated Bankfull Discharge:	**0.50** m^3/s
Modeled 2-year Discharge:	**Not calculated** m^3/s	Calculated Bankfull Velocity:	**0.50** m/s
Modeled 2-year Velocity:	**Not calculated** m/s		

PLANFORM CHARACTERISTICS

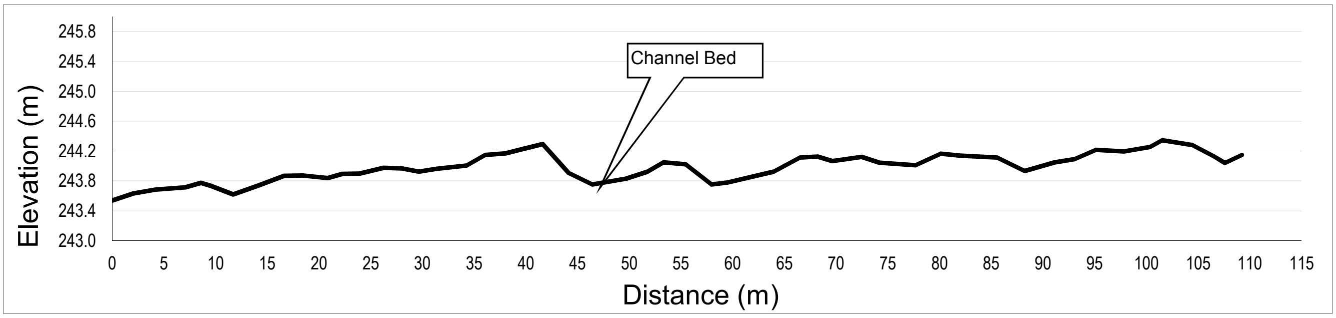
Profile ** Bed gradient used as surrogate for bankfull grade

Meander Geometry

Bankfull Gradient:	**0.42**	%	Sinuosity:	**1.10**	
Channel Bed Gradient:	**0.42**	%	Belt Width:	**Not measured**	m
Riffle Gradient:	**swale**	%	Radius of Curvature:	**Not measured**	m
Riffle Length:	**swale**	m	Amplitude:	**Not measured**	m
Riffle-Pool Spacing:	**swale**	m	Wavelength:	**Not measured**	m

* Note - Feature was dry at time of survey with extensive vegetative encroachment

Longitudinal Profile



BANK CHARACTERISTICS

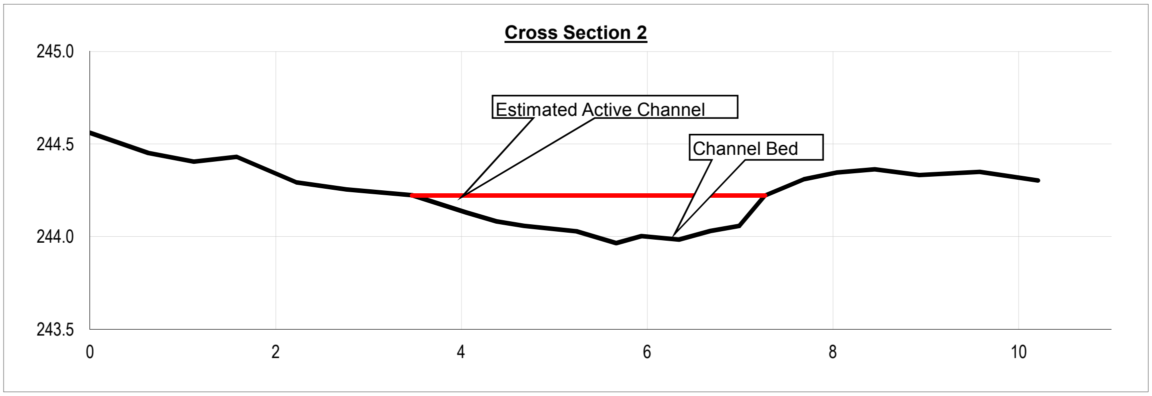
	Minimum	*Maximum*	*Average*
Bank Height (m):	**0.2**	**0.4**	**0.3**
Bank Angle (degrees):	**20.0**	**70.0**	**43.5**
Root Depth (m):	**0.2**	**0.4**	**0.3**
Root Density (%):	**100.0**	**100.0**	**100.0**
Undercut Banks (%)		**none**	
Depth of Undercut (m):	**0.0**	**0.0**	**0.0**

	Minimum	*Maximum*	*Average*
Torvane Value (kg/cm^2):		**Not measured**	
Penetrometer Value (kg/cm^2):		**Not measured**	
Bank Material (range):		**Silt, clay**	

CROSS-SECTIONAL CHARACTERISTICS

	Minimum	*Maximum*	*Average*
Discernible Width (m):	**3.8**	**6.0**	**4.9**
Average Depth (m):	**0.0**	**0.4**	**0.2**
Width/Depth:	**16.5**	**25.3**	**15.7**
Wetted Width (m):	**Dry at time of survey**		
Average Water Depth (m):	**Dry at time of survey**		
Wetted Width/Depth:	**Dry at time of survey**		
Entrenchment (m):	**Not measured**		
Entrenchment Ratio:	**Not measured**		
Max. Wetted Depth (m):	**Dry at time of survey**		
Manning's n:	**0.045**		

Representative Cross-Section (#2)



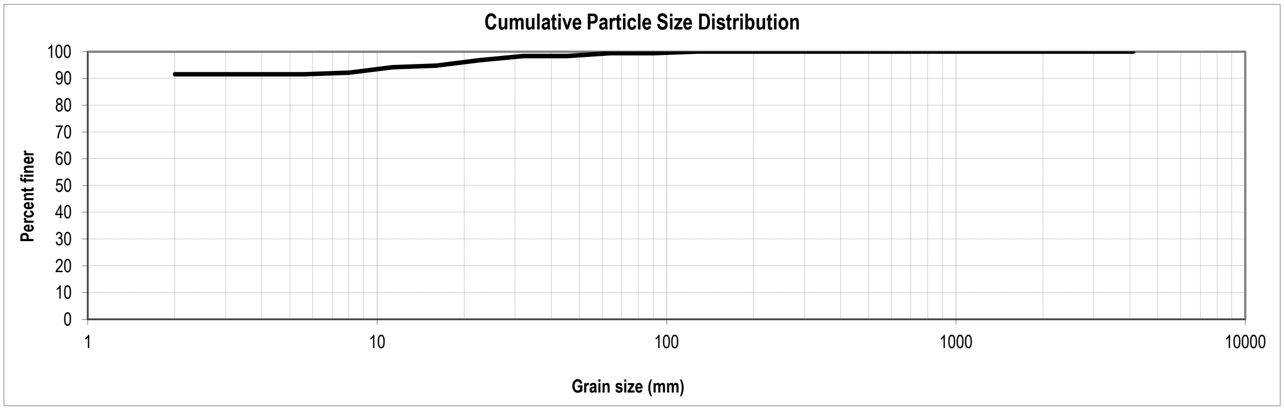
SUBSTRATE CHARACTERISTICS

Particle size

D_{10}	**< 2** mm
D_{50}	**< 2** mm
D_{90}	**< 2** mm

Subpavement:	**Clay**
Particle shape:	**Sub-rounded**
Embeddedness (%):	**low**
Particle range (riffle):	**not applicable**
Particle Range (pool):	**not applicable**

Grain Size Distribution



CHANNEL THRESHOLDS

Flow Competency:			Tractive Force at Bankfull:	**8.5**	N/m^2
for D_{50}:	**na**	m/s	Tractive Force at 2-year flow:	**Not calculated**	N/m^2
for D_{84}:	**na**	m/s	Critical Shear Stress:	**To be determined**	N/m^2
Unit Stream Power at Bankfull:	**4.30**	W/m^2			

GENERAL FIELD OBSERVATIONS

Feature took the form of a densely vegated swale and was dry at the time of survey. Degree of vegetative encroachment made reliable identification of the thalweg location difficult. Overall, the drainage feature lacked a defined active channel or bed morphology.

Upstream view of cross section # 2

Fluvial Geomorphology Summary

HV9, Huttonville Creek Watershed

Location:	**Heritage Heights, Brampton**	Date:	**June 22, 2012**
Length Surveyed:	**197**	Number of Cross Sections:	**6**

GENERAL SITE CHARACTERISTICS

Drainage Area:	**Not Measured**	Riparian Vegetation:	
Geology/Soils:	**Halton Till**	Dominant Vegetation Type:	**Grasses and Herbaceous**
Surrounding Land Use:	**Agricultural**	Extent of Riparian Buffer Zone:	**Fragmentary**
Channel Disturbances:	**Actively farmed**	Width of Riparian Buffer Zone:	**<1 Channel Width**
Aquatic Vegetation:		Age Class of Riparian Vegetation:	**Immature**
Dominant Vegetation Type:	**None**	Extent of Encroachment into Channel:	**DS Extreme, US None**
Portion of Reach with Vegetation:	**0%**	Large Woody Debris:	**Not Present**

HYDROLOGY

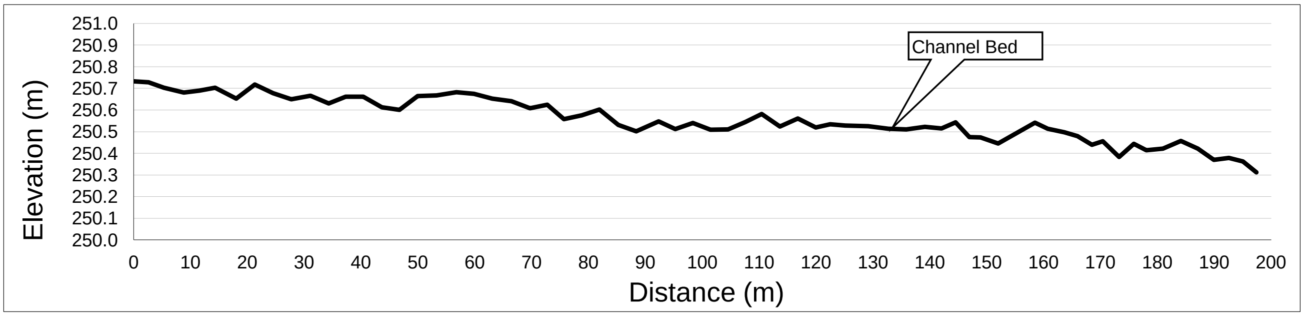
Measured Discharge:	**Not measured** m^3/s	Calculated Bankfull Discharge:	**0.02** m^3/s
Modeled 2-year Discharge:	**Not calculated** m^3/s	Calculated Bankfull Velocity:	**0.15** m/s
Modeled 2-year Velocity:	**Not calculated** m/s		

PLANFORM CHARACTERISTICS

Profile ** Bed gradient used as surrogate for bankfull grade			*Meander Geometry*		
Bankfull Gradient:	**0.16**	%	Sinuosity:	**1.10**	
Channel Bed Gradient:	**0.16**	%	Belt Width:	**Not measured**	m
Riffle Gradient:	**N/A Swale**	%	Radius of Curvature:	**Not measured**	m
Riffle Length:	**N/A Swale**	m	Amplitude:	**Not measured**	m
Riffle-Pool Spacing:	**N/A Swale**	m	Wavelength:	**Not measured**	m

** Note - feature dry at time of survey

Longitudinal Profile



BANK CHARACTERISTICS

	Minimum	*Maximum*	*Average*		*Minimum*	*Maximum*	*Average*
Bank Height (m):		**swale**					
Bank Angle (degrees):		**swale**		Torvane Value (kg/cm^2):		**Not measured**	
Root Depth (m):		**swale**		Penetrometer Value (kg/cm^2):		**Not measured**	
Root Density (%):		**swale**		Bank Material (range):		**Organics**	
Undercut Banks (%)		**swale**		**Feature lacked defined banks			
Depth of Undercut (m):		**swale**					

CROSS-SECTIONAL CHARACTERISTICS

	Minimum	*Maximum*	*Average*
Discernible Width (m):	**1.0**	**3.0**	**1.9**
Average Depth (m):	**0.1**	**0.1**	**0.1**
Width/Depth:	**16.9**	**36.0**	**24.6**

Wetted Width (m): **Dry at time of survey**

Average Water Depth (m): **Dry at time of survey**

Wetted Width/Depth: **Dry at time of survey**

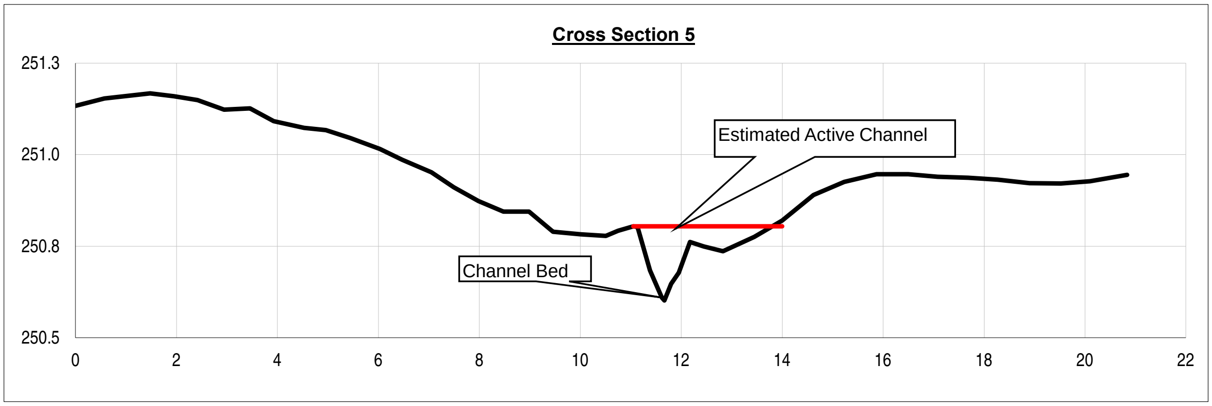
Entrenchment (m): **Not measured**

Entrenchment Ratio: **Not measured**

Max. Wetted Depth (m): **Dry at time of survey**

Manning's n:

Representative Cross-Section (#5)

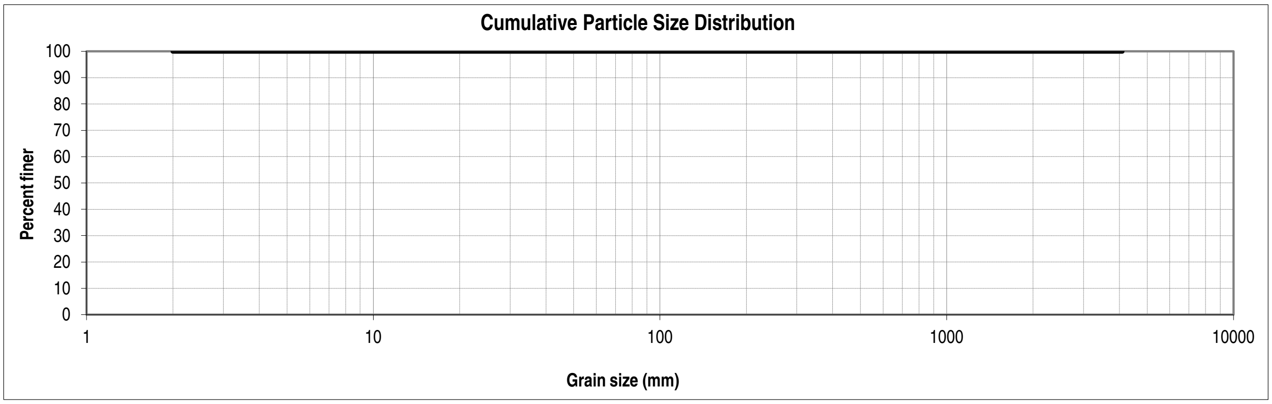


SUBSTRATE CHARACTERISTICS

Particle size

D_{10}	**<2** mm	Subpavement:	**Clay**
D_{50}	**<2** mm	Particle shape:	**Clay**
D_{90}	**<2** mm	Embeddedness (%):	**N/A Swale**
		Particle range (riffle):	**N/A Swale**
		Particle Range (pool):	**N/A Swale**

Grain Size Distribution



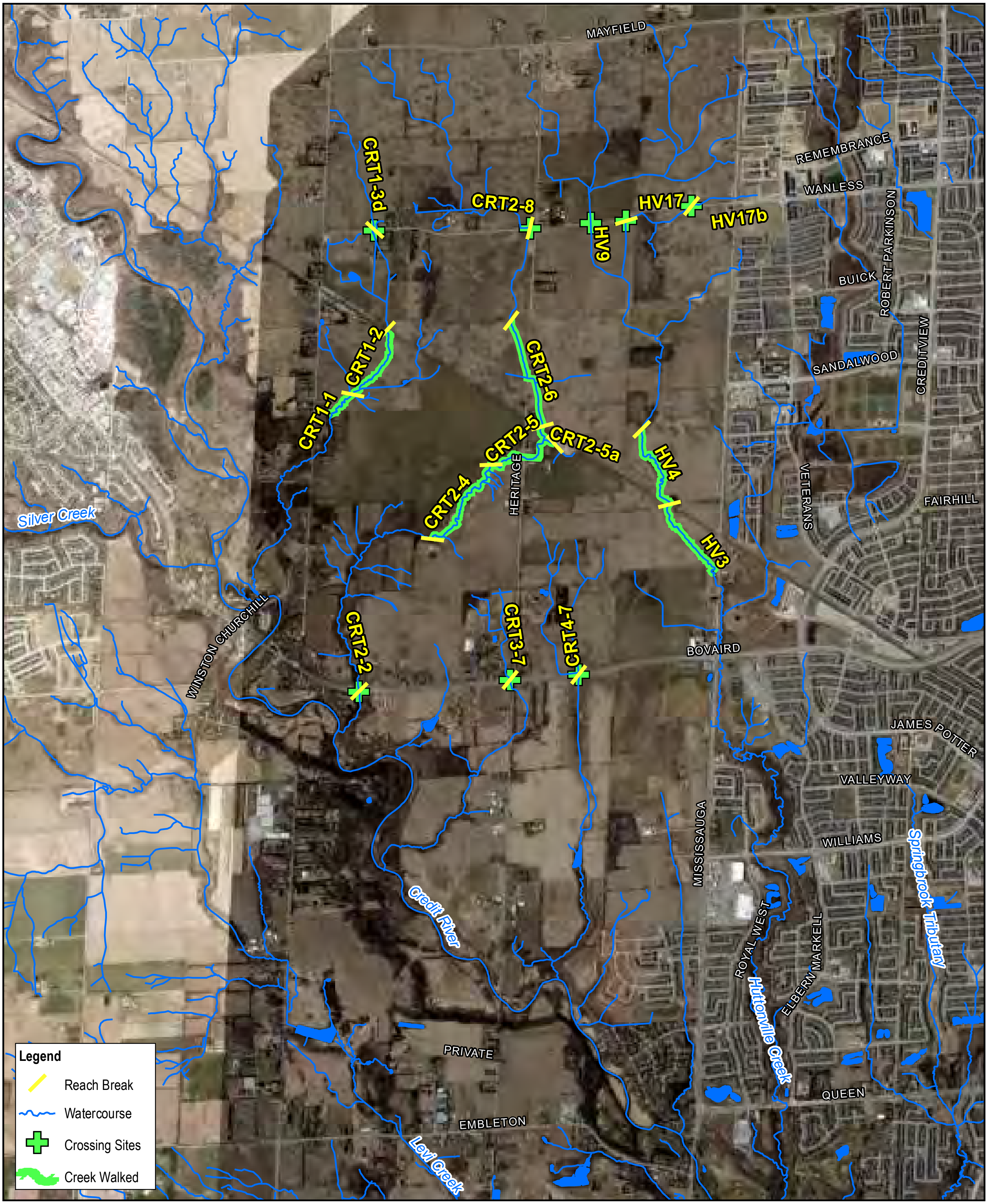
CHANNEL THRESHOLDS

Flow Competency:			Tractive Force at Bankfull:	**2.9** N/m^2
for D_{50}:	**na**	m/s	Tractive Force at 2-year flow:	**Not calculated** N/m^2
for D_{84}:	**na**	m/s	Critical Shear Stress:	**To be determined** N/m^2
Unit Stream Power at Bankfull:	**0.54**	W/m^2		

GENERAL FIELD OBSERVATIONS

Feature took the form of an actively farmed swale. At time of survey, feature was dry and had been recently maintained. Minimal riparian zone present.

Downstream view of cross section # 5



Paper Size ANSI A

0 240 480 720 960

Meters

Map Projection: Transverse Mercator
Horizontal Datum: North American 1983
Grid: NAD 1983 UTM Zone 17N

CITY OF BRAMPTON
HERITAGE HEIGHTS
SUBWATERSHED STUDY

2017 FIELD ASSESSMENT

Project No.	**2820898**
Revision No.	**-**
Date	**Mar 15, 2021**

FIGURE E-7

N:\CA\Mississauga\Projects\Legacy\Geomorphic\projects\2011\11348 HERITAGE HEIGHTS SUBWATERSHED STUDY\GIS\MXD\2820898_Visited_Sites.mxd
Print date: 15 Mar 2021 - 08:54

Data source: MNRF NRVIS, 2018. Produced by GHD under licence from Ontario Ministry of Natural Resources and Forestry, © Queen's Printer 2021, Imagery - City of Brampton 2020, Conservation Halton, 2019.

CRT1 – 1


12 20 2017 10:23

Photo 1 - Example of valley wall contact in CRT1 – 1.

Photo 2 - Example of angled banks with vegetation growing up to edges.

CRT1 – 2

Photo 3 - Watercourse flows near large tree. Extensive herbaceous riparian vegetation throughout reach.

Photo 4 - Facing north, watercourse flowing along the north side of a steep incline separating two fields.

CRT2 – 4

Photo 5 - Valley wall contact and bank material slumping. Exposed and submerged trees.

Photo 6 - Example of undercut bank with exposed tree roots.

CRT2 – 5

Photo 7 - Example of exposed tree roots and leaning tree.

Photo 8 - Facing north, towards a closed bottom culvert crossing under Heritage Road.

Site Photographs

CRT2 – 5a

Photo 9 - View of typical conditions at confluence of CRT2 – 5 and CRT2 – 5a.

Photo 10 - Exposed tree roots near the confluence of CRT2 – 5 and CRT2 – 5a.

Site Photographs

CRT2 – 6

Photo 11 - Facing south towards CN Railway, typical conditions in riparian area.

Photo 12 - Extensive vegetation makes watercourse indistinguishable from riparian area near the Heritage Road culvert. Increase in riparian vegetation since 2011 assessment.

HV3


12 20 2017 14 36

Photo 13 - Watercourse submerges a tree base.


12 20 2017 14 42

Photo 14 - Defined channel flow through vegetation.

HV4

Photo 15 - Typical conditions west of culvert crossing under CN railway.

Photo 16 - Facing downstream, south towards CN Railway crossing. Debris stuck to tree branches at height above observed bankfull. Watercourse in contact with base of valley wall.

Road Crossings

Photo 17 - Wanless Drive crossing HV17b.

Photo 18 - Wanless Drive crossing HV17b.

Photo 19 - Wanless Drive crossing HV9.

Photo 20 - Wanless Drive crossing HV9.

Photo 21 - Wanless Drive crossing CRT2-7.

Photo 22 - Wanless Drive crossing 4 CRT2-7.

Site Photographs

Photo 23 - Wanless Drive crossing CRT1-3b.

Photo 24 - Wanless Drive crossing CRT1-3b.

Site Photographs

Photo 25 - Bovaird Drive West crossing CRT4-6.

Photo 26 - Bovaird Drive West crossing CRT4-6.

Site Photographs

Photo 27 - Bovaird Drive West crossing CRT3-6.

Photo 28 - Bovaird Drive West crossing CRT3-6.

Photo 29 - Bovaird Drive West crossing CRT2-1.

Photo 30 - Bovaird Drive West crossing CRT2-2. Stabilization at the downstream end of CRT2-2 has occurred since the original field assessment in 2011.

Site Photographs

Table E-1: Reach characteristics – North West Brampton Heritage Heights lands.

Reach	Length (m)	Gradient (%)	Sinuosity
CRT1-1	661.25	1.70	1.27
CRT1-1c	338.77	0.81	1.03
CRT1-1d	275.33	1.00	1.23
CRT1-1e	198.26	0.88	1.02
CRT1-2	581.49	1.72	1.20
CRT1-2a	422.24	1.36	1.03
CRT1-2b	183.04	0.55	1.11
CRT1-2c	214.96	1.74	1.07
CRT1-2d	219.93	1.02	1.11
CRT1-2e	218.29	0.69	1.08
CRT1-3	513.38	0.54	1.24
CRT1-3a	313.30	1.04	1.02
CRT1-3b	207.05	0.48	1.01
CRT1-3c	189.68	1.85	1.00
CRT1-3d	122.76	1.02	1.32
CRT1-3e	554.52	0.72	1.04
CRT1-3f	335.72	0.89	1.05
CRT1-3g	91.69	0.27	1.10
CRT1-3j	71.16	2.46	1.00
CRT1-3k	94.58	1.59	1.01
CRT1-3l	43.12	1.74	1.00
CRT1-4	406.53	0.49	1.25
CRT2-1	367.93	6.79	1.22
CRT2-2	771.46	1.62	1.18
CRT2-2a	223.66	4.36	1.01
CRT2-3	951.97	1.58	1.35
CRT2-3a	255.89	6.64	1.07
CRT2-3b	148.00	3.04	1.06
CRT2-3c	362.25	3.93	1.13
CRT2-3d	33.45	1.49	1.02
CRT2-3e	425.26	4.00	1.04
CRT2-3f	55.27	4.07	1.04
CRT2-3g	298.81	3.43	1.08
CRT2-3h	338.97	3.54	1.06
CRT2-3i	199.40	3.13	1.11
CRT2-3j	332.33	2.56	1.24
CRT2-3k	370.75	3.71	1.29
CRT2-4	839.67	0.95	1.31
CRT2-4a	111.04	4.28	1.07
CRT2-4b	110.57	1.13	1.08
CRT2-5	653.31	1.03	1.50
CRT2-5a	81.66	0.61	1.03
CRT2-6	788.96	0.48	1.06
CRT2-6a	387.24	0.39	1.01
CRT2-6b	150.34	0.67	1.00
CRT2-7	690.95	0.43	1.08
CRT2-8	575.71	0.30	1.18
CRT2-8a	305.66	0.33	1.13
CRT2-8b	222.81	0.11	1.17
CRT2-8c	310.05	0.32	3.11
CRT2-8d	385.41	0.06	1.18
CRT2-9	640.55	0.47	1.11
CRT2-9a	496.11	1.11	1.16
CRT2-9b	319.59	1.23	1.32
CRT2-10	761.50	0.92	1.20
CRT2-11	305.80	1.47	1.11
CRT2A-1	316.39	11.62	1.26
CRT2A-2	163.82	2.75	1.17
CRT2A-3	202.96	0.99	1.05
CRT3-1	250.17	2.10	1.35
CRT3-2	375.76	4.99	1.21
CRT3-3	281.45	3.55	1.17
CRT3-3b	186.81	6.16	1.03
CRT3-4	613.85	1.34	1.16
CRT3-4a	374.79	3.60	1.15
CRT3-5	91.25	0.55	1.08
CRT3-6	410.93	2.49	1.15
CRT3-7	391.70	1.28	1.11
CRT3-7a	258.32	0.97	1.03
CRT3-7b	78.69	0.64	1.05
CRT3-7c	135.32	0.92	1.00
CRT3-7d	22.79	1.69	1.00

CRT3-8	322.30	1.01	1.42
CRT3-8a	180.55	2.49	1.12
CRT4-1	153.18	3.43	1.18
CRT4-2	400.05	3.94	1.09
CRT4-3	469.66	4.36	1.23
CRT4-5	645.33	1.20	1.20
CRT4-6	620.15	0.48	1.01
CRT4-7	991.21	0.83	1.13
CRT4-7a	495.75	0.50	1.22
CRT4-7b	362.14	0.62	1.07
CRT4-7c	87.86	0.57	1.07
CRT4-7d	459.66	1.47	1.08
CRT4-8	292.71	1.37	1.04
CRT4-a	69.68	27.98	1.08
CRT4A-1	397.62	8.61	1.10
CRT4A-2	396.40	1.58	1.05
CRT4A-3	348.77	1.43	1.08
CRT4-b	64.38	4.66	1.08
CRT4B-1	246.17	9.44	1.04
CRT4B-2	248.14	1.61	1.00
CRT4B-3	81.89	3.36	1.03
CRT4B-4	53.78	16.73	1.00
CRT4B-5	173.84	4.31	1.03
CRT4-c	324.76	4.77	1.28
CRT4-d	105.37	13.05	1.05
CRT4-e	131.74	11.39	1.12
CRT5-5	296.33	2.95	1.03
CRT5-6	502.20	1.00	1.00
CRT5-7	659.34	1.02	1.01
HV10	536.68	0.28	1.03
HV11	223.78	0.11	1.04
HV11a	249.89	0.50	1.11
HV12	219.43	0.23	1.10
HV13	780.63	0.64	1.05
HV13a	235.82	1.06	1.10
HV13b	390.86	1.15	1.21
HV14	657.68	0.61	1.14
HV14a	157.55	1.75	1.02
HV15	725.65	0.79	1.29
HV15a	146.47	0.85	1.08
HV16	386.43	0.32	1.01
HV17	527.46	0.62	1.15
HV17b	469.50	0.48	1.04
HV17c	138.15	0.36	1.06
HV3	1003.56	1.15	1.21
HV31	285.32	1.14	1.20
HV4	717.92	0.66	1.32
HV5	676.38	0.30	1.14
HV6a	390.97	0.38	1.14
HV6b	625.66	1.08	1.31
HV7	652.85	0.23	1.26
HV80	553.56	0.59	1.17
HV80a	559.05	0.63	1.06
HV81	699.71	0.71	1.37
HV81a	122.46	0.61	1.03
HV81b	199.93	0.75	1.09
HV9	705.29	0.32	1.14
HV9a	116.97	<0.05	1.00
HV9b	306.00	0.41	1.18
HV9c	417.49	0.24	1.26
HV9d	511.76	0.39	1.35
HV9e	202.09	0.49	1.29

Table E-2: Rapid assessment results – North West Brampton Heritage Heights lands.

Reach	Rapid Geomorphic Assessment (RGA)			Rapid Stream Assessment Technique (RSAT)			Down's Classification
	Score	Condition	Dominant Systematic Adjustment	Score	Condition	Limiting Feature(s)	
CRT1-1	0.40	Transitional	Widening	27.5	Good	Channel Stability	'U' Undercutting
CRT1-2	0.03	In Regime	Planimetric Adjustment	15	Fair	Physical Instream Habitat, Riparian Habitat Conditions	'S' Stable
CRT1-2a	0.03	In Regime	Planimetric Adjustment	15	Fair	Physical Instream Habitat, Riparian Habitat Conditions	'S' Stable
CRT1-2b	0.03	In Regime	Planimetric Adjustment	15	Fair	Physical Instream Habitat, Riparian Habitat Conditions	'S' Stable
CRT1-2c	0.03	In Regime	Planimetric Adjustment	15	Fair	Physical Instream Habitat, Riparian Habitat Conditions	'S' Stable
CRT1-3	0.03	In Regime	Aggradation	15	Fair	Physical Instream Habitat, Riparian Habitat Conditions	'S' Stable
CRT2-1	0.43	In Adjustment	Degradation	27	Good	Channel Stability	'E' Enlarging
CRT2-2	0.48	In Adjustment	Widening	26	Good	Channel Stability	'U' Undercutting
CRT2-4	0.40	In Adjustment	Planimetric Adjustment	18.5	Fair	Riparian Habitat Conditions, Channel Stability	'M' Lateral Migration
CRT2-5	0.28	Transitional	Planimetric Adjustment	18	Fair	Riparian Habitat Conditions	'm' lateral migration
CRT2-6	0.03	In Regime	Planimetric Adjustment	15	Fair	Physical Instream Habitat, Riparian Habitat Conditions	'S' Stable
CRT3-1	0.28	Transitional	Widening	20	Fair	Physical Instream Habitat	'E' Enlarging
CRT3-2	0.46	In Adjustment	Planimetric Adjustment	27.5	Good	Channel Stability	'U' Undercutting
CRT3-3	0.46	In Adjustment	Planimetric Adjustment	25	Good	Channel Stability	'U' Undercutting
CRT4-1	0.37	Transitional	Widening	26	Good	Channel Stability	'E' Enlarging
CRT4-2	0.44	In Adjustment	Widening	26.5	Good	Physical Instream Habitat	'M' Lateral Migration
CRT4-3	0.42	In Adjustment	Widening	26	Good	Physical Instream Habitat	'M' Lateral Migration
CRT4-5	0.03	In Regime	Planimetric Adjustment	15	Fair	Physical Instream Habitat, Riparian Habitat Conditions	'S' Stable
CRT4-6	0.03	In Regime	Planimetric Adjustment	15	Fair	Physical Instream Habitat, Riparian Habitat Conditions	'S' Stable
CRT4-7	0.03	In Regime	Planimetric Adjustment	15	Fair	Physical Instream Habitat, Riparian Habitat Conditions	'S' Stable
CRT4A-1	0.21	Transitional	Widening	27	Good	Physical Instream Habitat	'e' enlarging
CRT5-5	0.10	In Regime	Degradation	15	Fair	Physical Instream Habitat, Riparian Habitat Conditions	'S' Stable
HV3	0.21	Transitional	Aggradation	17.5	Fair	Physical Instream Habitat, Riparian Habitat Conditions	'm' lateral migration
HV4	0.38	Transitional	Widening, Planimetric Adjustment	24	Good	Physical Instream Habitat, Riparian Habitat Conditions	'M' Lateral Migration
HV5	0.25	Transitional	Widening, Planimetric Adjustment	19	Fair	Physical Instream Habitat, Riparian Habitat Conditions	'm' lateral migration

Table E-3: 2017 Field assessment results.

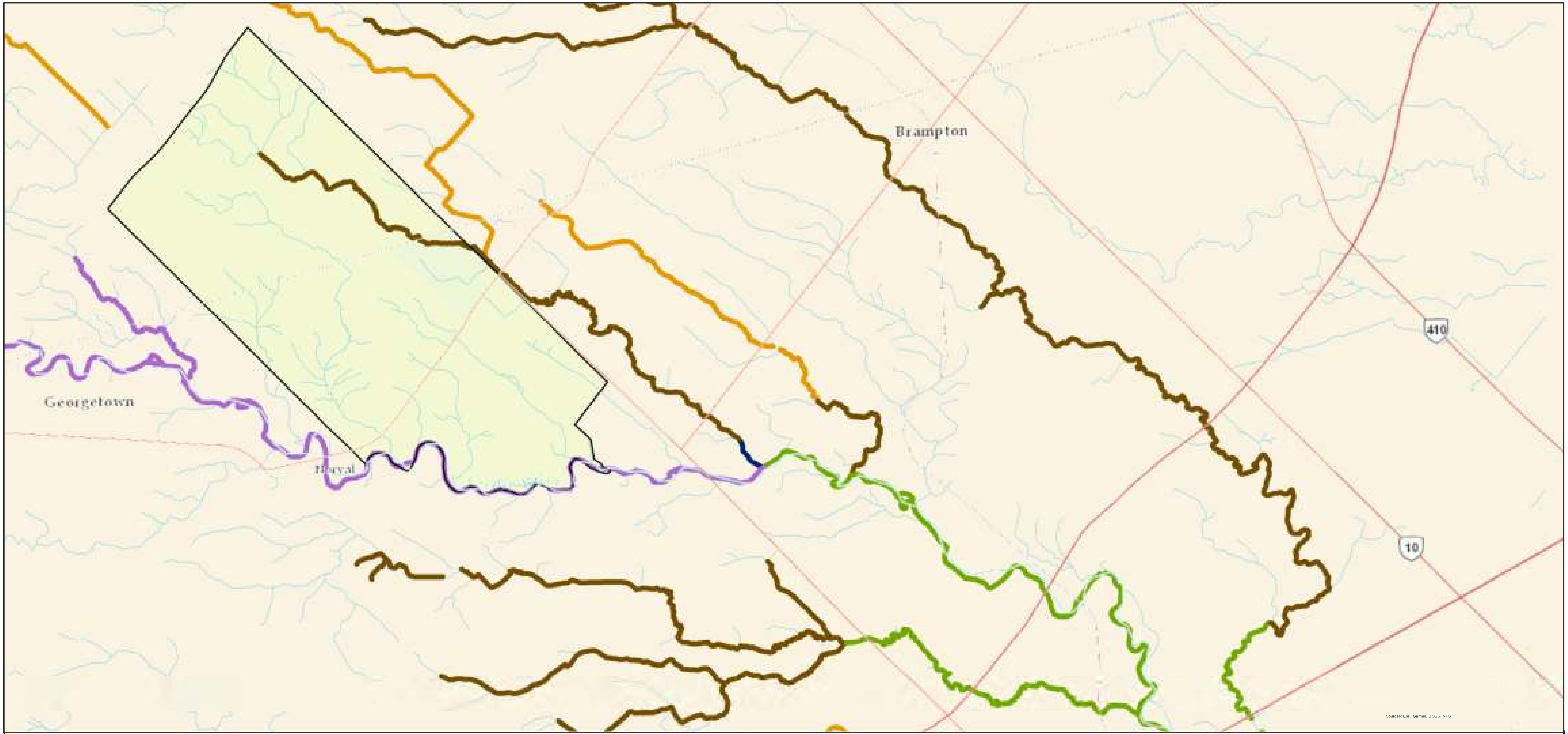
Reach	Observations from December 20, 2017 field assessment
CRT1-1	Watercourse remains in contact with valley wall directly north of residential property near site. Bank at valley wall has a mix of exposed young roots and moss growing on it. Banks appear steeper with some undercuts evident in the 2017 field assessment; no bank angles or undercuts were noted in the 2011 rapid assessment. Riparian vegetation continues to grow up to the edge of the watercourse in 2017.
CRT1-2	Increase in riparian vegetation (i.e., cattails) since 2011. Defined watercourse is indistinguishable from the surrounding area throughout most of the reach due to extensive, tall herbaceous and riparian vegetation.
CRT2-4	Southwest side of watercourse makes contact with valley wall and exposes tree roots; a tree that was previously on the outside of a meander bend is now submerged. Ground in the southern portion of this reach was generally covered in trimmed grass and saturated. Some parts of the watercourse had no distinguishable banks or margins, while others were defined by steep, exposed banks. A moderate to high amount of instream vegetation was observed throughout the reach, which was not noted in the 2011 rapid assessment. A steep, tall bank that existed in 2011 appears to be migrating north towards a fence line where there is drainage entering the watercourse from a field to the north. Evidence of this is slumping, vegetated bank materials and exposed bank materials where the bank was previously vegetated, as observed in the 2011 field assessment. New undercuts, valley wall contacts, angled banks, and exposed roots were observed throughout the reach.
CRT2-5	Exposed tree roots and leaning trees were observed in 2011 and 2017 field assessments. Exposed bank materials and some sections of undefined watercourse were observed in both field assessments as well.
CRT2-5a	Exposed roots and roots in contact with active watercourse were observed in 2011 and 2017 field assessments. Some sections of undefined watercourse were observed in both field assessments as well.
CRT2-6	Vegetation in riparian area surrounding watercourse as it flows through fields has increased from none – low to moderate – high. Conditions throughout the reach are similar in 2011 and 2017.
HV3	Submerged trees and evidence of bankfull flow reaching the base of valley walls just upstream of Mississauga Road crossing were observed in 2011 and 2017. Evidence includes flattened vegetation oriented in the direction of flow and debris jams beyond defined banks. In-stream vegetation observed in 2017.
HV4	Railway embankment shows evidence of degradation, as exposed roots and undercuts were observed just west of the CN Railway culvert following a sharp change in flow direction from southeast to east. Debris comprised of thick grasses and dried silt/clay were observed stuck to tree bases and branches above visible bankfull level. Smaller amounts of debris comprised of just grasses stuck to hanging tree branches around bankfull level were observed in 2011. Watercourse was observed to be in contact with base of valley wall in multiple places within the reach; in the upstream half a defined section of the watercourse is in contact with a steep slope at the edge of an active farm field. It is not clear whether this was also observed in 2011. Submerged trees were observed in some parts of the reach.

Appendix F

Surface Water Quality

Appendix G

Aquatics Resources



NOTES:

1. Coordinate System: NAD 1983 UTM Zone 17N.
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3. Place names and boundaries from ESRI's 'World Terrain Reference' Tile Layer (Sources: Esri, Garmin, USGS, NPS)
4. Fish Community Types adapted from Figure 12 of the Credit River Fisheries Management Plan (CVC and MNR, 2002).

Legend

▨ Mount Pleasant Heights Lands
🟩 Heritage Heights Study Area

Fish Community Type

🟦 Coldwater community
🟪 Mixed cool/cold community
🟩 Mixed cool/warm community
🟧 Small warmwater community
🟫 Warmwater community (dominated by Cyprinids)

Lands within the Provincial Greenbelt Area are located within the SWS Study Area but are not part of the City of Brampton Urban Area.

Project 1901516

Heritage Heights Subwatershed Study

Figure F1
Existing Fish Communities of the Credit River Watershed

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GEI Consultants
Savanta Division

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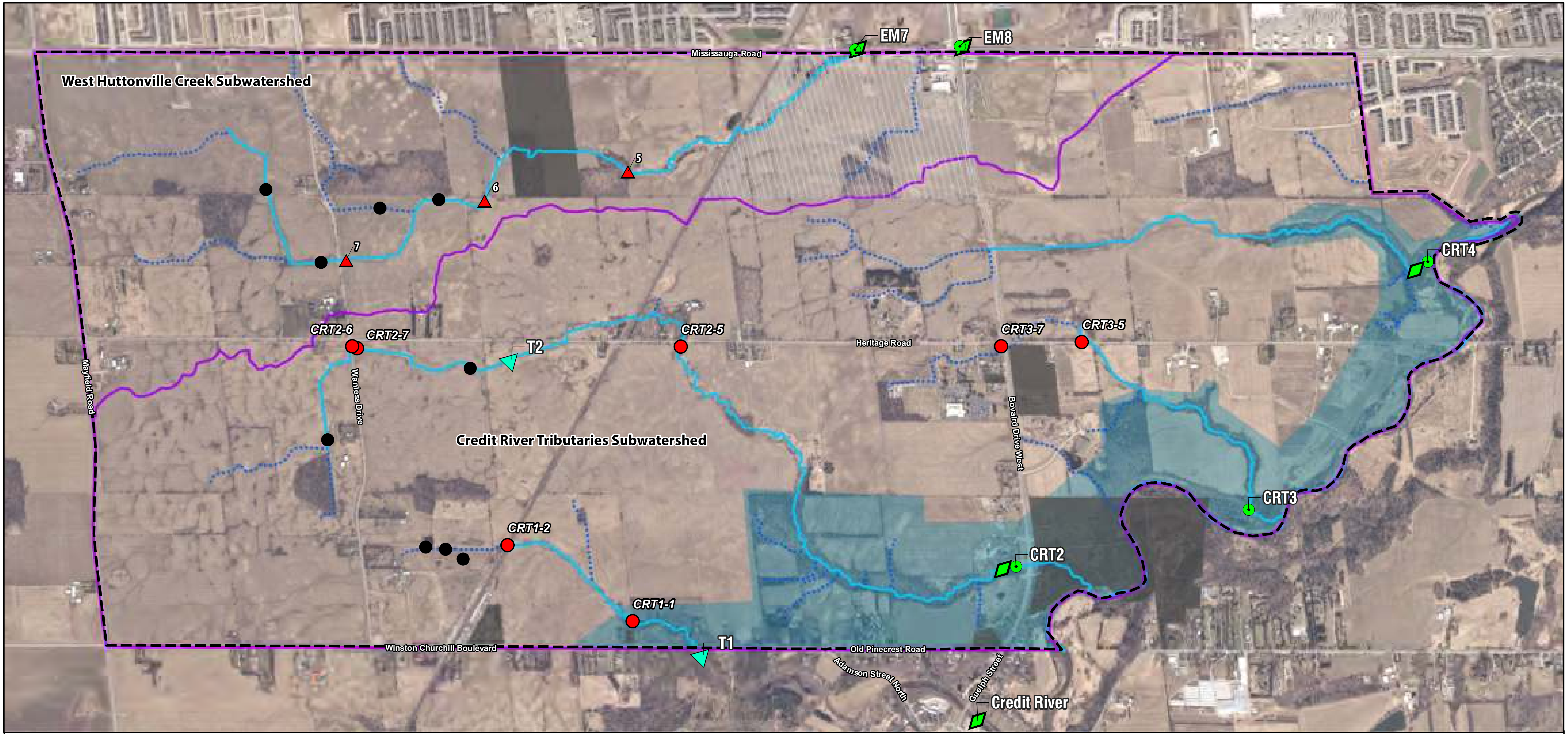

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Legend

- ▬ ▬ Study Area
- ▨ Mount Pleasant Heights Lands
- ■ Land Access Denied 2017
- ■ Greenbelt Plan Area
- ☐ Watershed Boundary
- ─ Watercourse
- ┅ Headwater Drainage Feature

Monitoring Locations

- ⊙ CVC Fish Community Monitoring Locations
- ◆ CVC Benthic Invertebrate Monitoring Stations

- ▲ Temperature Logger Locations (2012, Savanta)
- ● Stickleback Visual Observations (2017, Savanta)
- ● Electrofishing Fish Community Sampling Locations (2017, Savanta)
- ▲ GoPro Fish Community Sampling Locations (2017, Savanta)

Lands within the Provincial Greenbelt Area are located within the SWS Study Area but are not part of the City of Brampton Urban Area.

Project 1901516

Heritage Heights Subwatershed Study

Figure F2
Aquatic Resources Sampling Locations

0 300 m

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GEI Consultants Savanta Division

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Legend

- Study Area
- Mount Pleasant Heights Lands
- Greenbelt Plan Area
- Land Access Unavailable
- Reach Break
- HDF Under Study

Headwater Drainage Feature Management Recommendations

- Conservation 3,523 m
- Mitigation 7,613 m
- Protection 3,292 m
- No Management Required 16,152 m

Medium and High Constraint Stream Designation

- High (Red Stream)
- Medium (Blue Stream)

Project 1901516

Heritage Heights Subwatershed Study

Figure F3
Headwater Drainage Features and Watercourses

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GEI Consultants Savanta Division

Lands within the Provincial Greenbelt Area are located within the SWS Study Area but are not part of the City of Brampton Urban Area.

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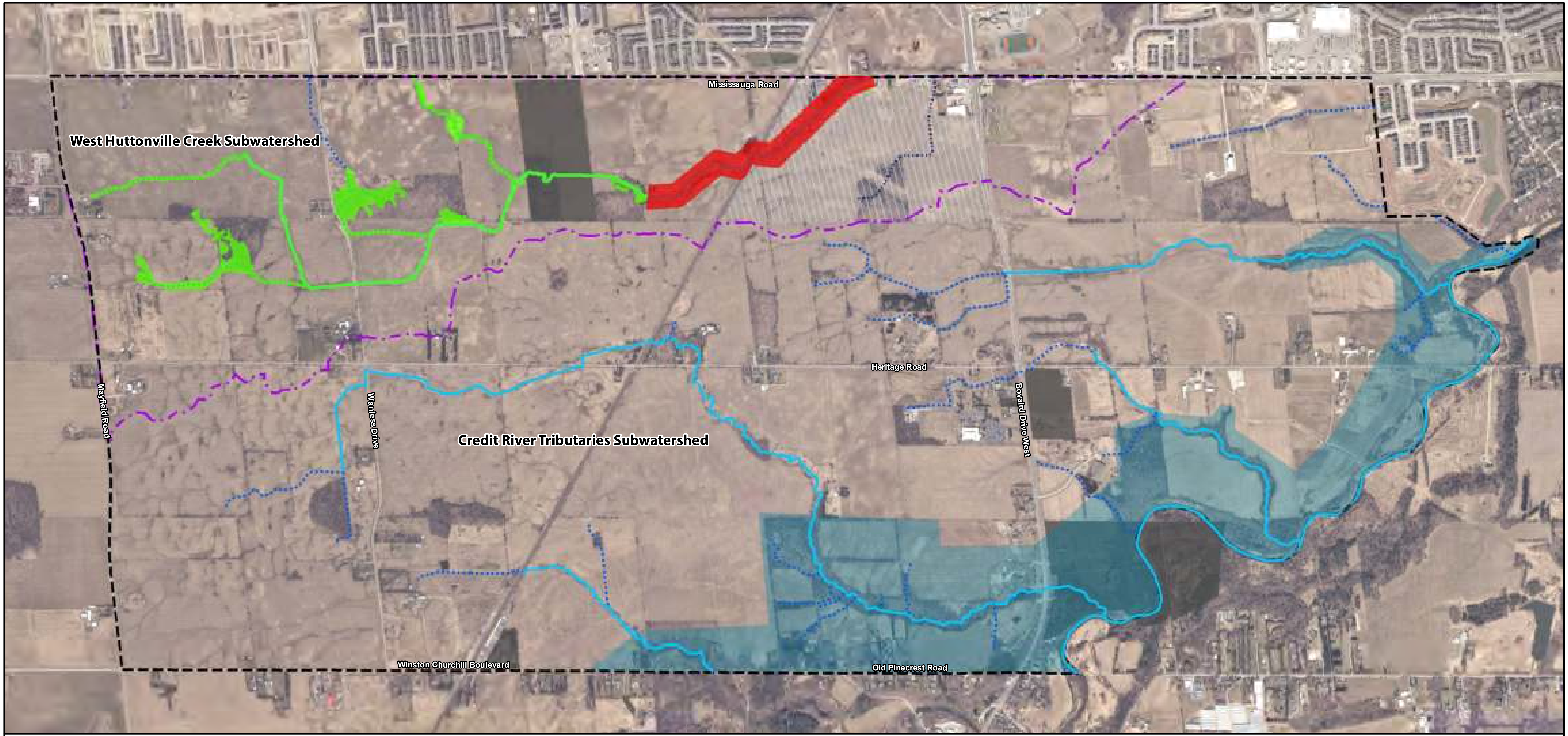

Project 1901516

Heritage Heights Subwatershed Study

Figure F4a
Redside Dace Habitat

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Legend

- Study Area
- ▨ Mount Pleasant Heights Lands
- Greenbelt Plan Area
- Land Access Unavailable
- Huttonville Creek Watershed Boundary
- Headwater Drainage Feature
- Headwater Drainage Feature Under Study
- Watercourse
- 🟥 Existing Redside Dace Habitat as interpreted from Ont Reg 242/08, 29.1(1) v (Formerly "Occupied" Habitat)
- 🟩 Contributing Redside Dace Habitat as interpreted from Ont Reg 242/08, 29.1(1) v (Formerly "Contributing" Habitat)

0 300 m

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GEI Consultants
Savanta Division

Lands within the Provincial Greenbelt Area are located within the SWS Study Area but are not part of the City of Brampton Urban Area.

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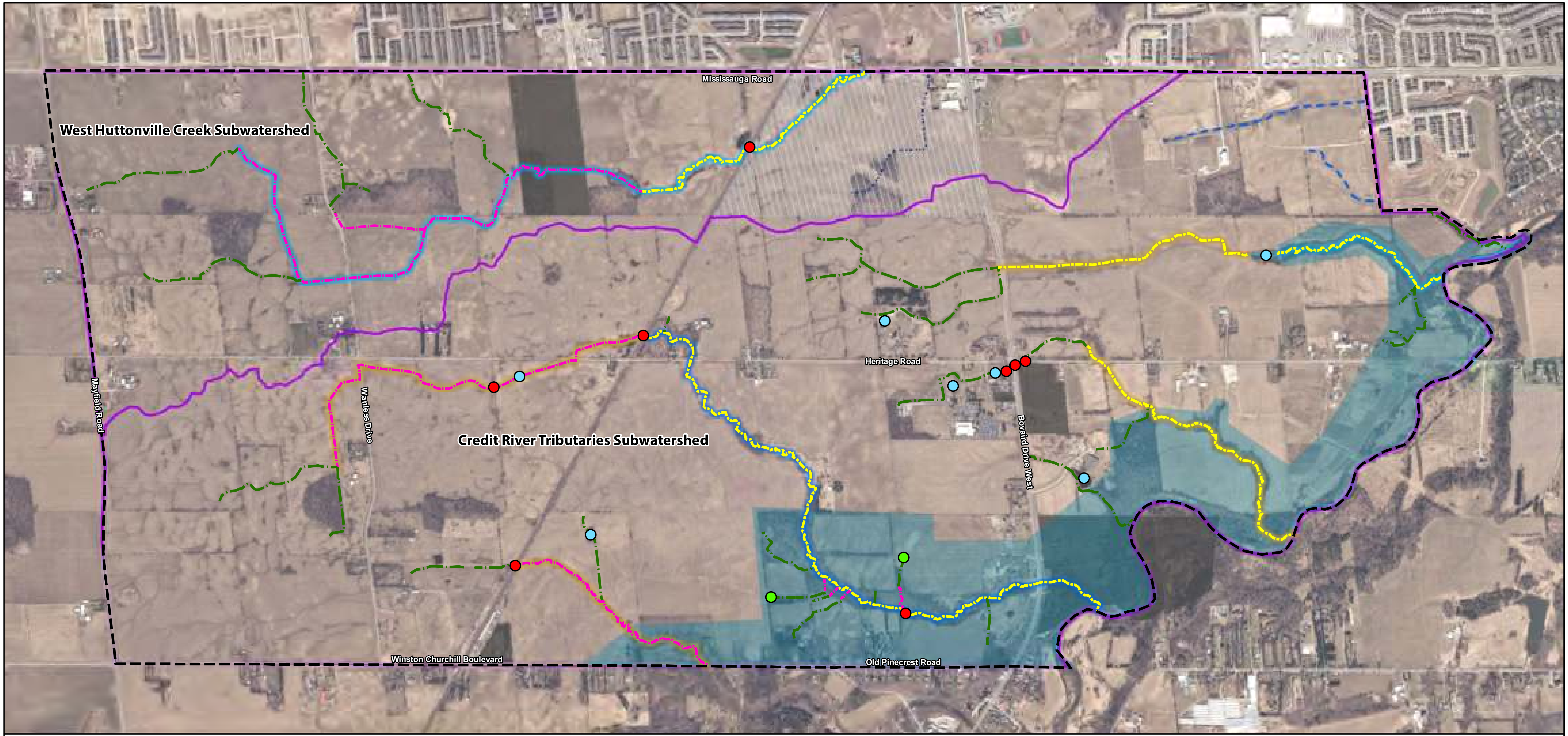

Project 1901516

Heritage Heights Subwatershed Study

Figure F4b
Fish Habitat

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Legend

- ▬ ▬ Study Area
- ▨ Mount Pleasant Heights Lands
- ■ Greenbelt Plan Area
- ■ Land Access Unavailable
- ▭ Watershed Boundary
- ● Barrier
- ○ Pond
- ● Tile Drain Outlet
- ▬ ▬ Headwater Drainage Feature
- ⋯ Headwater Drainage Feature Under Study

Fish Habitat

- ▬ · ▬ Direct
- ▬ · ▬ Direct Seasonal
- ▬ · ▬ Indirect

Habitat Thermal Regime

- ▬ Cold
- ▬ Cool/Cold
- ▬ Warm

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GEI Consultants Savanta Division

Lands within the Provincial Greenbelt Area are located within the SWS Study Area but are not part of the City of Brampton Urban Area.

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Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	**Step 1. Hydrology**		**Step 2. Riparian**	**Step 3. Fish Habitat**	**Step 4. Terrestrial Habitat**	**Management Recommendation**	
	Function	**Modifiers**				**2021 (HDFA 2014 Guidelines)**	**Site Specific 2021 Proposed**
CREDIT RIVER TRIBUTARY CRT1							
CRT1-1c	FT – 7 FC – 4 (Round 1) FC – 1 (Round 2) **Limited**	Agricultural	3 – Limited (Cropped)	3 – Contributing	4 – Limited	**No Management**	**No Management**
CRT1-1d	FT – 7 FC – 4 (Round 1) FC – 1 (Round 2) **Limited**	Agricultural	3 – Limited (Cropped)	3 – Contributing	4 – Limited	**No Management**	**No Management**
CRT1-1e	FT – 7 2012 assessment No spring flows. **Limited**	Agricultural	3 – Limited (Cropped)	3 – Contributing	4 – Limited	**No Management**	**No Management**
CRT1-2a	FT – 6 FC – 4 (Round 1) FC – 3 (Round 2) FC – 1 (Round 3) **Valued** – MAM and SAM ELC in reach	Agricultural	6 – Important (Wetland)	3 – Contributing	6 – Valued (wetland with no breeding amphibians)	**Conservation**	**Mitigation (replicable riparian wetland habitat)**
CRT1-2b	FT – 7 FC – 5 (Round 1) FC – 1 (Round 2) **Limited**	Agricultural	3 – Limited (Cropped)	3 – Contributing	4 – Limited	**No Management**	**No Management**
CRT1-2c	FT – 7 FC – 5 (Round 1) FC – 1 (Round 2) **Limited**	Agricultural	3 – Limited (Cropped)	3 – Contributing	4 – Limited	**No Management**	**No Management**
					4 – Limited	**No Management**	**No Management**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	Step 1. Hydrology		Step 2. Riparian	Step 3. Fish Habitat	Step 4. Terrestrial Habitat	Management Recommendation	
	Function	Modifiers				2021 (HDFA 2014 Guidelines)	Site Specific 2021 Proposed
			3 – Limited (Cropped)	3 – Contributing			
CRT1-2d	FT – 7 FC – 2 (Round 1) FC – 1 (Round 2) **Limited**	Agricultural	3 – Limited (Cropped)	3 – Contributing	4 – Limited	**No management**	**No management**
CRT1-2e	FT – 7 FC – 5 (Round 1) FC – 1 (Round 2) **Limited**	PSW not connected Agricultural	3 – Limited (Cropped)	3 – Contributing	4 – Limited	**No management**	**No management**
CRT1-3	FT -7 FC – 4 (Round 1) FC – 1 (Round 2)	Agricultural	3 – Limited (Cropped)	3 – Contributing	4 – Limited	**No management**	**No management**
CRT1-3a	FT – 7 FC – 5 (Round 1)	Valleylands Agricultural	6 – Important (Forest)	3 – Contributing	6 – Contributing	**Mitigation**	**Mitigation**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	Step 1. Hydrology		Step 2. Riparian	Step 3. Fish Habitat	Step 4. Terrestrial Habitat	Management Recommendation	
	Function	**Modifiers**				**2021 (HDFA 2014 Guidelines)**	**Site Specific 2021 Proposed**
	FC – 1 (Round 2) **Limited**					🟩	🟩
CRT1-3a1	FT – 2 FC – 5 (Round 1) FC – 1 (Round 2) **Limited**	Agricultural	4 – Valued (Meadow)	3 – Contributing	4 – Limited	**No Management**	**No Management**
CRT1-3b	FT – 7 FC – 5 (Round 1) FC – 1 (Round 2) **Limited**	Agricultural	3 – Limited (Cropped)	3 – Contributing	4 – Limited	**No Management**	**No Management**
CRT1-3c	FT – 7 FC – 5 (Round 1) FC – 1 (Round 2)	Agricultural	3 – Limited (Cropped)	3 – Contributing	4 – Limited	**No Management**	**No Management**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	**Step 1. Hydrology**		**Step 2. Riparian**	**Step 3. Fish Habitat**	**Step 4. Terrestrial Habitat**	**Management Recommendation**	
	Function	**Modifiers**				**2021 (HDFA 2014 Guidelines)**	**Site Specific 2021 Proposed**
	Limited						
CRT1-3d	FT – 7 FC – 5 (Round 1) FC – 1 (Round 2) **Limited**	Agricultural	3 – Limited (Cropped)	3 – Contributing	4 – Limited	**No Management**	**No Management**
CRT1-3e	FT – 7 FC – 4 (Round 1) FC – 1 (Round 2) **Limited**	Agricultural	3 – Limited (Cropped)	3 – Contributing	4 – Limited	**No Management**	**No Management**
CRT1-3f	FT – 7 FC – 4 (Round 1) FC – 1 (Round 2) **Limited**	Agricultural	3 – Limited (Cropped)	3 – Contributing	4 – Limited	**No Management**	**No Management**
CRT1-3g	FT – 7	Agricultural			4 – Limited	**No Management**	**No Management**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	Step 1. Hydrology		Step 2. Riparian	Step 3. Fish Habitat	Step 4. Terrestrial Habitat	Management Recommendation	
	Function	Modifiers				2021 (HDFA 2014 Guidelines)	Site Specific 2021 Proposed
	FC – 4 (Round 1) FC – 1 (Round 2) **Limited**		3 – Limited (Cropped)	3 – Contributing			
CRT1-3h	FT – 7 FC – 4 (Round 1) FC – 1 (Round 2) **Limited**	Agricultural	3 – Limited (Cropped)	3 – Contributing	4 – Limited	**No Management**	**No Management**
CRT1-3i	FT – 7 FC – 4 (Round 1) FC – 1 (Round 2) **Limited**	Agricultural	3 – Limited (Cropped)	3 – Contributing	4 – Limited	**No Management**	**No Management**
CRT1-3j	FT – 7 2012 assessment No spring flows. **Limited**	Agricultural	3 – Limited (Cropped)	3 – Contributing	4 – Limited	**No Management**	**No Management**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	**Step 1. Hydrology**		**Step 2. Riparian**	**Step 3. Fish Habitat**	**Step 4. Terrestrial Habitat**	**Management Recommendation**	
	Function	**Modifiers**				**2021 (HDFA 2014 Guidelines)**	**Site Specific 2021 Proposed**
CRT1-3k	FT – 7 FC – 4 (Round 1) FC – 1 (Round 2) **Limited**	Agricultural	3 – Limited (Cropped)	3 – Contributing	4 – Limited	**No Management**	**No Management**
CRT1-3l	FT – 7 FC – 4 (Round 1) FC – 1 (Round 2) **Limited**	Agricultural	3 – Limited (Cropped)	3 – Contributing	4 – Limited	**No Management**	**No Management**
CRT1-4	FT – 7 2012 assessment Flowing early spring. **Limited**	Agricultural	3 – Limited (Cropped)	3 – Contributing	4 – Limited	**No Management**	**No Management**
CREDIT RIVER TRIBUTARY CRT2							
CRT2-2a	FT – 2 FC – 3 (Round 1) FC – 4 (Round 2) FC – 1 (Round 3) **Valued** – Water present during first two assessments and	Agricultura	6 – Important (Wetland)	3 – Contributing	6 - Valued Wetland	**Conservation**	**Conservation**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	**Step 1. Hydrology**		**Step 2. Riparian**	**Step 3. Fish Habitat**	**Step 4. Terrestrial Habitat**	**Management Recommendation**	
	Function	**Modifiers**				**2021 (HDFA 2014 Guidelines)**	**Site Specific 2021 Proposed**
	then dry during final round site visit						
CRT2-3a	FT – 1 FC – 4 (Round 1) FC – 3 (Round 2) FC – 1 (Round 3) **Valued** – flowing during first two assessments and then dry during final round site visit	Valleylands Agricultural Greenland	6 – Important (Forest)	2 - Valued	2 – Valued Terrestrial habitat is valued due to the woodland unit that provides a movement corridor for wildlife and general amphibian habitat.	**Conservation**	**Conservation**
CRT2-3a1	FT – 2 FC – 4 (Round 1) FC – 1 (Round 2) **Contributing** – feature was dry during second round assessment.	Agricultural	**4** – Valued (Meadow)	**3** – Contributing	**4** - Limited	**Mitigation**	**Mitigation**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	**Step 1. Hydrology**		**Step 2. Riparian**	**Step 3. Fish Habitat**	**Step 4. Terrestrial Habitat**	**Management Recommendation**	
	Function	**Modifiers**				**2021 (HDFA 2014 Guidelines)**	**Site Specific 2021 Proposed**
CRT2-3b	FT – 7 FC – 4 (Round 1) FC – 1 (Round 2) **Limited**	Agricultural	**3 –** Limited (Cropped)	**3 –** Contributing	**4 –** Limited	**No Management Required**	**No Management Required**
CRT2-3c1	FT – 7 FC – 5 (Round 1) FC – 1 (Round 2) **Limited**	Agricultural	**4 –** Valued (CUM)	**3 –** Contributing	**4 –** Limited	**No Management Required**	**No Management Required**
CRT2-3c2			**3 –** Limited (Cropped)	**3 –** Contributing	**4 –** Limited	**No Management Required**	**No Management Required**
CRT2-3d	FT – 7 FC – 4 (Round 1) FC – 1 (Round 2)	Agricultural	**4 –** Valued (CUM)	**3 –** Contributing	**4 –** Limited	**No Management Required**	**No Management Required**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	**Step 1. Hydrology**		**Step 2. Riparian**	**Step 3. Fish Habitat**	**Step 4. Terrestrial Habitat**	**Management Recommendation**	
	Function	**Modifiers**				**2021 (HDFA 2014 Guidelines)**	**Site Specific 2021 Proposed**
	Limited						
CRT2-3e	FT – 7 FC – 5 (Round 1) FC – 1 (Round 2) **Limited** – feature was dry upon second round assessments.	Agricultural	**3 –** Limited (Cropped)	3 – Contributing	**4** – Limited	**No Management Required**	**No Management Required**
CRT2-3f	FT – 7 FC – 4 (Round 1) FC – 1 (Round 2) **Limited**	Agricultural	**3 –** Limited (Cropped)	3 – Contributing	**4** – Limited	**No Management Required**	**No Management Required**
CRT2-3g	FT – 7 FC – 4 (Round 1) FC – 1 (Round 2)	Agricultural	**3 –** Limited (Cropped)	3 – Contributing	**4** – Limited	**No Management Required**	**No Management Required**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	**Step 1. Hydrology**		**Step 2. Riparian**	**Step 3. Fish Habitat**	**Step 4. Terrestrial Habitat**	**Management Recommendation**	
	Function	**Modifiers**				**2021 (HDFA 2014 Guidelines)**	**Site Specific 2021 Proposed**
	Limited						
CRT2-3h	FT – 2 FC – 4 (Round 1) FC – 2 (Round 2) FC – 1 (Round 3) **Valued**	Agricultural	**3** – Limited (Cropped)	**3** – Contributing	**4** – Limited	**Mitigation**	**Mitigation**
CRT2-3h2	FT – 1 FC – 4 (Round 1) FC – 1 (Round 2) **Contributing**	Valleylands Agricultural	**6** – Important (Forest)	2 - Valued	**4** – Limited Hedgerow feature that connects to larger woodlot. Provides minimal terrestrial habitat.	**Conservation**	**Conservation**
CRT2-3i	FT – 7	Agricultural			**4** – Limited		

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	**Step 1. Hydrology**		**Step 2. Riparian**	**Step 3. Fish Habitat**	**Step 4. Terrestrial Habitat**	**Management Recommendation**	
	Function	**Modifiers**				**2021 (HDFA 2014 Guidelines)**	**Site Specific 2021 Proposed**
	FC – 4 (Round 1) FC – 1 (Round 2) **Limited**		**3 –** Limited (Cropped)	**3 –** Contributing		**No Management Required**	**No Management Required**
CRT2-3j	FT – 1 FC – 5 (Round 1) FC – 5 (Round 2) FC – 4 (Round 3) **Contributing** – flowing during all assessments due to tile drain discharge	Agricultural Tile drain input	**3** – Limited (Cropped)	**3** – Contributing	**4** – Limited	**Mitigation**	**Mitigation**
CRT2-3j1	FT – 1 FC – 5 (Round 1) FC – 5 (Round 2) FC – 4 (Round 3)	Valleylands Agricultural Tile drain input	6 – Important (Forest)	2 - Valued	3 - Contributing	**Conservation**	**Conservation**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	**Step 1. Hydrology**		**Step 2. Riparian**	**Step 3. Fish Habitat**	**Step 4. Terrestrial Habitat**	**Management Recommendation**	
	Function	**Modifiers**				**2021 (HDFA 2014 Guidelines)**	**Site Specific 2021 Proposed**
	Contributing – flowing during all assessments due to tile drain discharge						
CRT2-3j2	FT – 2 FC – 5 (Round 1) FC – 5 (Round 2) FC – 4 (Round 3) **Contributing** – flowing during all assessments due to tile drain discharge	Agricultural - Tile drain	**3** – Limited (Cropped)	**3** – Contributing	**4** – Limited	**Mitigation**	**Mitigation**
CRT2-3j3	FT – 5 FC – 3 (Round 1) FC – 1 (Round 2)	Agricultural - Tile drain	**3 –** Limited (Cropped)	**3** – Contributing	**4** – Limited	**No Management Required**	**No Management Required**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	**Step 1. Hydrology**		**Step 2. Riparian**	**Step 3. Fish Habitat**	**Step 4. Terrestrial Habitat**	**Management Recommendation**	
	Function	**Modifiers**				**2021 (HDFA 2014 Guidelines)**	**Site Specific 2021 Proposed**
	Limited – feature was dry upon second round assessment. Flow in round 1 from broken tile drain discharge.						
CRT2-3k	FT – 6 Important – No data assumed important hydrology due to PSW designation.	PSW	**6** – Important (Forest)	**3** – Contributing	**2** – Valued	**Protection**	**Protection**
CRT2-3l	FT – 1 FC – 4 (Round 1) FC – 4 (Round 2)	Agricultural Valleylands	6 – Important (Forest)	**3** – Contributing	**6 -** Contributing	**Conservation**	**Conservation**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	**Step 1. Hydrology**		**Step 2. Riparian**	**Step 3. Fish Habitat**	**Step 4. Terrestrial Habitat**	**Management Recommendation**	
	Function	**Modifiers**				**2021 (HDFA 2014 Guidelines)**	**Site Specific 2021 Proposed**
	FC – 1 (Round 3) **Valued** – dry during third round assessment						
CRT2-3m	FT – 2 FC – 4 (Round 1) FC – 1 (Round 2) **Valued** – feature was dry upon second round assessments.	Agricultural	3 – Limited (Cropped)	3 – Contributing	3 - Limited	**Mitigation**	**Mitigation**
CRT2-3m1	FT – 1 FC – 4 (Round 1) FC – 1 (Round 2)	Valleylands Agricultural	6 – Important (Forest)	2 - Valued	6 - Contributing	**Conservation**	**Conservation**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	Step 1. Hydrology		Step 2. Riparian	Step 3. Fish Habitat	Step 4. Terrestrial Habitat	Management Recommendation	
	Function	Modifiers				2021 (HDFA 2014 Guidelines)	Site Specific 2021 Proposed
	Valued – feature was dry upon second round.					🟨	🟨
CRT2-4a	FT -7 FC – 4 (Round 1) FC – 1 (Round 2) **Limited**	Agricultural	3 – Limited (Cropped)	3 – Contributing	3 - Limited	**No Management**	**No Management**
CRT2-4b	FT -7 FC – 4 (Round 1) FC – 1 (Round 2) **Limited**	Agricultural	3 – Limited (Cropped)	3 – Contributing	3 - Limited	**No Management**	**No Management**
CRT2-5a	FT – 7 FC – 5 (Round 1) FC – 4 (Round 2) FC – 1 (Round 3) **Important**	PSW Agricultural	6 – Important (Forest)	3 – Contributing	2 – Valued	**Protection (PSW connection)**	**Protection (PSW connection)**
CRT2-6a	FT – 7 2012 assessment Early spring flow.	Agricultural	**3 –** Limited (Cropped)	**3** – Contributing	**4** – Limited	**No Management**	**No Management**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	**Step 1. Hydrology**		**Step 2. Riparian**	**Step 3. Fish Habitat**	**Step 4. Terrestrial Habitat**	**Management Recommendation**	
	Function	**Modifiers**				**2021 (HDFA 2014 Guidelines)**	**Site Specific 2021 Proposed**
	Limited						
CRT2-6b	FT – 7 2012 assessment Early spring flow. **Limited**	Agricultural	**3 –** Limited (Cropped)	**3** – Contributing	**4** – Limited	**No Management**	**No Management**
CRT2-8a	FT – 7 2012 assessment Early spring flow. **Limited**	Agricultural	**3 –** Limited (Cropped)	**3** – Contributing	**4** – Limited	**No Management**	**No Management**
CRT2-8b	FT – 7 2012 assessment **Limited**	Agricultural	**3 –** Limited (Cropped)	**3** – Contributing	**4** – Limited	**No Management**	**No Management**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	**Step 1. Hydrology**		**Step 2. Riparian**	**Step 3. Fish Habitat**	**Step 4. Terrestrial Habitat**	**Management Recommendation**	
	Function	**Modifiers**				**2021 (HDFA 2014 Guidelines)**	**Site Specific 2021 Proposed**
CRT2-8c	FT – 7 2012 assessment Early spring flow. **Limited**	Agricultural	**3 –** Limited (Cropped)	3 – Contributing	**4** – Limited	**No Management**	**No Management**
CRT2-8d	FT – 7 FC – 5 (Round 1) FC – 2 (Round 2) FC – 1 (Round 3) **Valued** – dry during third round assessment.	PSW Agricultural	**6 –** Important (Wetland)	3 – Contributing	**4** – Limited	**Protection (PSW)**	**Protection (PSW)**
CRT2-9	FT – 7 FC – 4 (Round 1) FC – 2 (Round 2) FC – 1 (Round 3) **Valued**	Agricultural	**3 –** Limited (Cropped)	3 - Contributing Small bodied fish noted in first round	**4** – Limited	**Mitigation**	**Mitigation**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	Step 1. Hydrology		Step 2. Riparian	Step 3. Fish Habitat	Step 4. Terrestrial Habitat	Management Recommendation	
	Function	Modifiers				2021 (HDFA 2014 Guidelines)	Site Specific 2021 Proposed
				2018 just above confluence with CRT2-8d			
CRT2-9a	FT –7 2012 assessment Early spring flow. **Limited**	Agricultural	**3 –** Limited (Cropped)	**3 –** Contributing	**4** – Limited	**No Management**	**No Management**
CRT2-9b	FT – 7 2012 assessment No spring flow. **Limited**	Agricultural	**3 –** Limited (Cropped)	**3 –** Contributing	**4** – Limited	**No Management**	**No Management**
CRT2-10	FT – 7 FC – 4 (Round 1) FC – 1 (Round 2)	Agricultural	**3 –** Limited (Cropped)	**3 –** Contributing	**4** – Limited	**No Management**	**No Management**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	**Step 1.** **Hydrology**		**Step 2.** **Riparian**	**Step 3.** **Fish Habitat**	**Step 4.** **Terrestrial Habitat**	**Management Recommendation**	
	Function	**Modifiers**				**2021 (HDFA 2014 Guidelines)**	**Site Specific 2021 Proposed**
	Limited						
CRT2-11	FT – 7 FC – 4 (Round 1) FC – 1 (Round 2) **Limited**	Agricultural	**3 –** Limited (Cropped)	**3 –** Contributing	**4 –** Limited	**No Management**	**No Management**
CREDIT RIVER TRIBUTARY CRT2A							
CRT2A-1	FT – 1 2012 Assessment **Important** – PSW upstream	Agricultural	6 – Important (Forest)	3 – Contributing	6 – Valued	**Protection**	**Protection**
CRT2A-2	FT – 7 2012 Assessment **Important** No data Hydrology assumed important due to upstream PSW.	Agricultural	2 – Limited (Cropped)	3 – Contributing	6 – Valued	**Protection (Protected reach upstream)**	**Conservation (replicable riparian wetland habitat)**
CRT2A-2a	FT – 9	Agricultural			3 – Limited	**No Management**	**No Management**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	**Step 1. Hydrology**		**Step 2. Riparian**	**Step 3. Fish Habitat**	**Step 4. Terrestrial Habitat**	**Management Recommendation**	
	Function	**Modifiers**				**2021 (HDFA 2014 Guidelines)**	**Site Specific 2021 Proposed**
	2012 Assessment Limited		2 – Limited (Pond)	3 – Contributing			
CRT2A-3	FT – 6 2012 Assessment Important No data Hydrology assumed important due to upstream PSW.	PSW Agricultural	6 – Important (Wetland)	3 – Contributing	6 – Valued	**Protection (PSW)**	**Protection (PSW)**
CREDIT RIVER TRIBUTARY CRT3							
CRT3-3b2	FT – 7 2012 Assessment	Agricultural	3 – Limited (Cropped)	3 – Contributing	4 – Limited	**No Management**	**No Management**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	**Step 1. Hydrology**		**Step 2. Riparian**	**Step 3. Fish Habitat**	**Step 4. Terrestrial Habitat**	**Management Recommendation**	
	Function	**Modifiers**				**2021 (HDFA 2014 Guidelines)**	**Site Specific 2021 Proposed**
	Limited						
CRT3-3b1	FT – 7 2012 Assessment **Limited**	Valleylands Agricultural Greenbelt	6 – Important (Forest)	3 – Valued	4 – Limited	**No Management**	**No Management**
CRT3-4a	FT – 7 2012 Assessment **Limited**	Agricultural Greenbelt	**3 –** Contributing (CUT)	**3** – Contributing	**3** – Contributing	**Conservation**	**Conservation**
CRT3-4a1	FT – 7 2012 Assessment **Limited**	Agricultural	3 – Contributing (CUM)	3 – Contributing	3 – Contributing	**Mitigation**	**Mitigation**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	**Step 1. Hydrology**		**Step 2. Riparian**	**Step 3. Fish Habitat**	**Step 4. Terrestrial Habitat**	**Management Recommendation**	
	Function	**Modifiers**				**2021 (HDFA 2014 Guidelines)**	**Site Specific 2021 Proposed**
CRT3-6	FT – 6 FC – 5 (Round 1) FC – 4 (Round 2) FC – 2 (Round 3) **Important**	PSW Agricultural	6 – Important (Wetland)	3 – Contributing	6 – Important (Wetland)	**Protection**	**Protection**
CRT3-7	FT – 2 FC – 5 (Round 1) FC – 2 (Round 2) FC – 2 (Round 3) **Valued** – pools of standing water during second and third round assessment caused by blocked culvert.	Agricultural Blocked culvert at HWY7 causing standing water in feature that would not be expected if culvert was not blocked	2 – Contributing (Lawn)	3 – Contributing	4 – Limited	**Conservation (conservation reach upstream)**	**Conservation (conservation reach upstream)**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	**Step 1. Hydrology**		**Step 2. Riparian**	**Step 3. Fish Habitat**	**Step 4. Terrestrial Habitat**	**Management Recommendation**	
	Function	**Modifiers**				**2021 (HDFA 2014 Guidelines)**	**Site Specific 2021 Proposed**
CRT3-7a	FT – 7 FC – 3 (Round 1) FC – 1 (Round 2) FC – 1 (Round 3) **Limited**	Agricultural	**2** – Contributing (Lawn)	**3** – Contributing	**4** – Limited	**No Management Required**	**No Management Required**
CRT3-7	FT – 2 FC – 5 (Round 1) FC – 2 (Round 2) FC – 2 (Round 3) **Valued** – pools of standing water during second and third round assessment caused by blocked culvert.	Agricultural Blocked culvert at HWY7 causing standing water in feature that would not be expected if culvert was not blocked	2 – Contributing (Lawn)	3 – Contributing	4 – Limited	**Conservation (conservation reach upstream)**	**Conservation (conservation reach upstream)**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	**Step 1. Hydrology**		**Step 2. Riparian**	**Step 3. Fish Habitat**	**Step 4. Terrestrial Habitat**	**Management Recommendation**	
	Function	**Modifiers**				**2021 (HDFA 2014 Guidelines)**	**Site Specific 2021 Proposed**
CRT3-7a	FT – 7 FC – 3 (Round 1) FC – 1 (Round 2) FC – 1 (Round 3) **Limited**	Agricultural	**2** – Contributing (Lawn)	**3** – Contributing	**4** – Limited	**No Management Required**	**No Management Required**
CRT3-7b	FT – 7 FC – 3 (Round 1) FC – 2 (Round 2) FC – 1 (Round 3) **Limited**	Agricultural	**2** – Contributing (Lawn)	**3** – Contributing	**4** – Limited	**No Management Required**	**No Management Required**
CRT3-7c	FT – 7 FC – 3 (Round 1) FC – 2 (Round 2) FC – 1 (Round 3)	Agricultural	**2** – Contributing (Lawn)	**3** – Contributing	**4** – Limited	**No Management Required**	**No Management Required**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	**Step 1. Hydrology**		**Step 2. Riparian**	**Step 3. Fish Habitat**	**Step 4. Terrestrial Habitat**	**Management Recommendation**	
	Function	**Modifiers**				**2021 (HDFA 2014 Guidelines)**	**Site Specific 2021 Proposed**
	Limited – standing water during second round visit; dry during third round assessment.						
CRT3-7d	FT – 7 FC – 1 (Round 1) **Limited** – feature was dry during first round assessments	Agricultural	**4** – Valued (Meadow)	**3** – Contributing	**4** – Limited	**No Management Required**	**No Management Required**
CRT3-7e	FT – 7 FC – 4 (Round 1) FC – 2 (Round 2) FC – 1 (Round 3)	Agricultural	**2** – Contributing (Lawn)	**3** – Contributing	**4** – Limited	**No Management Required**	**No Management Required**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	Step 1. Hydrology		Step 2. Riparian	Step 3. Fish Habitat	Step 4. Terrestrial Habitat	Management Recommendation	
	Function	Modifiers				2021 (HDFA 2014 Guidelines)	Site Specific 2021 Proposed
	Limited – pockets of standing water during first and second round assessments; dry during final site visit.						
CRT3-7f	FT – 7 FC – 3 (Round 1) FC – 2 (Round 2) FC – 1 (Round 3) **Valued** – standing water during second round site visit; dry during third round assessment.	Agricultural	**2** – Contributing (Lawn)	**3** – Contributing	**4** – Limited	**No Management Required**	**No Management Required**
CRT3-8	FT – 7 FC – 3 (Round 1)	Agricultural	6 – Important (Forest)	**3** – Contributing	**4** – Limited	**Conservation**	**Conservation**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	**Step 1. Hydrology**		**Step 2. Riparian**	**Step 3. Fish Habitat**	**Step 4. Terrestrial Habitat**	**Management Recommendation**	
	Function	**Modifiers**				**2021 (HDFA 2014 Guidelines)**	**Site Specific 2021 Proposed**
	FC – 2 (Round 2) FC – 2 (Round 3) **Valued** – standing water during second and third round assessment.						
CRT3-8a	FT – 7 FC – 2 (Round 1) FC – 2 (Round 2) FC – 1 (Round 3) **Limited** – pockets of standing water during first and second round assessments; dry during final site visit.	Agricultural	2 – Contributing (Lawn)	**3** – Contributing	**4** – Limited	**No Management Required**	**No Management Required**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	**Step 1. Hydrology**		**Step 2. Riparian**	**Step 3. Fish Habitat**	**Step 4. Terrestrial Habitat**	**Management Recommendation**	
	Function	**Modifiers**				**2021 (HDFA 2014 Guidelines)**	**Site Specific 2021 Proposed**
CREDIT RIVER TRIBUTARY CRT4							
CRT4-a	FT – 7 **Valued** Assumed important due to Greenbelt designation	Agricultural Greenbelt	**6** – Important (Forest)	**3** – Contributing	6 – Valued	**Conservation**	**Conservation**
CRT4-b	FT – 7 **Valued** Assumed important due to wetland feature type up stream and Greenbelt designation	Agricultural Greenbelt	**6** – Important (Forest)	**3** – Contributing	6 – Valued	**Conservation**	**Conservation**
CRT4-c	FT – 7 **Valued** Assumed important due to wetland feature type up stream and Greenbelt designation	Agricultural Greenbelt	**6** – Important (Forest)	**3** – Contributing	6 – Valued	**Conservation**	**Conservation**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	**Step 1. Hydrology**		**Step 2. Riparian**	**Step 3. Fish Habitat**	**Step 4. Terrestrial Habitat**	**Management Recommendation**	
	Function	**Modifiers**				**2021 (HDFA 2014 Guidelines)**	**Site Specific 2021 Proposed**
CRT4-c1	FT – 6 **Important** – Assumed important due to wetland feature type and Greenbelt designation	PSW Agricultural Greenbelt	**6** – Important (Forest)	**3** – Contributing	6 – Valued	**Protection**	**Protection**
CRT4-d	FT – 6 **Important** – Assumed important due to wetland feature type and Greenbelt designation	Agricultural Greenbelt	**6** – Important (Wetland)	**3** – Contributing	6 – Important	**Protection**	**Protection**
CRT4-e	FT – 6 **Important** – Assumed important due to wetland feature type and Greenbelt designation	Agricultural Greenbelt	**6** – Important (Wetland)	**3** – Contributing	6 – Important	**Protection**	**Protection**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	**Step 1. Hydrology**		**Step 2. Riparian**	**Step 3. Fish Habitat**	**Step 4. Terrestrial Habitat**	**Management Recommendation**	
	Function	**Modifiers**				**2021 (HDFA 2014 Guidelines)**	**Site Specific 2021 Proposed**
						🟥	🟥
CRT4-7	FT – 2 FC – 5 (Round 1) FC – 2 (Round 2) FC – 1 (Round 3) **Valued** – flowing during first round, standing water during second round and dry during the final round assessments	Agricultural	**3 –** Limited (Cropped)	**3** – Contributing	**4** – Limited	**Conservation (due to up upstream conservation reach)**	**Mitigation (due to upstream mitigation reach)**
CRT4-7a	FT – 7 FC – 3 (Round 1) FC – 2 (Round 2) FC – 1 (Round 3)	Agricultural	**4 –** Valued (Meadow)	**3** – Contributing	**4** – Limited	**Conservation (due to up upstream conservation reach)**	**Mitigation (Due to upstream mitigation reach)**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	Step 1. Hydrology		Step 2. Riparian	Step 3. Fish Habitat	Step 4. Terrestrial Habitat	Management Recommendation	
	Function	Modifiers				2021 (HDFA 2014 Guidelines)	Site Specific 2021 Proposed
	Valued – standing water during second round and dry upon final assessments						
CRT4-7b	FT – 6 FC - 4 (Round 1) FC – 2 (Round 2) FC – 1 (Round 3) **Valued** – standing water during second round and dry during final assessment	Agricultural	**6 –** Important (Wetland)	**3** – Contributing	6 – Valued	**Conservation (Due to presence of riparian wetland)**	**Mitigation (Riparian wetland habitat replicated with in CRT4)**
CRT4-7c	FT – 7 FC - 4 (Round 1) FC – 1 (Round 2)	Agricultural	**3 –** Limited (Cropped)	**3** – Contributing	**4** – Limited	**No Management**	**No Management**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	**Step 1. Hydrology**		**Step 2. Riparian**	**Step 3. Fish Habitat**	**Step 4. Terrestrial Habitat**	**Management Recommendation**	
	Function	**Modifiers**				**2021 (HDFA 2014 Guidelines)**	**Site Specific 2021 Proposed**
	Limited						
CRT4-7d	FT – 7 FC - 4 (Round 1) FC – 1 (Round 2) **Limited**	Agricultural	**3 –** Limited (Cropped)	3 – Contributing	**4 –** Limited	**No Management**	**No Management**
CRT4-8	FT – 6 FC – 3 (Round 1) FC – 2 (Round 2) FC – 1 (Round 3) **Valued** – standing water during second round and dry during final assessment	Agricultural	**6 –** Important (Wetland)	3 – Contributing	6 – Valued	**Conservation (Due to presence of riparian wetland)**	**Mitigation (Riparian wetland habitat replicated with in CRT4)**
CRT4-8a	FT – 2	Agricultural			**4 –** Limited	**Mitigation**	**Mitigation**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	**Step 1. Hydrology**		**Step 2. Riparian**	**Step 3. Fish Habitat**	**Step 4. Terrestrial Habitat**	**Management Recommendation**	
	Function	**Modifiers**				**2021 (HDFA 2014 Guidelines)**	**Site Specific 2021 Proposed**
	FC – 5 (Round 1) FC – 2 (Round 2) FC – 1 (Round 3) **Valued** – flowing during first round, standing water during second round and dry during the final round assessments		**3 –** Limited (Cropped)	**3** – Contributing		🟩	🟩
CREDIT RIVER TRIBUTARY CRT4A							
CRT4A-1	FT – 1 FC – 5 (Round 1) FC – 5 (Round 2) FC – 1 (Round 3)	Agricultural	6 – Important (Forest)	**3** – Contributing	6 – Important	**Protection**	**Protection**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	Step 1. Hydrology		Step 2. Riparian	Step 3. Fish Habitat	Step 4. Terrestrial Habitat	Management Recommendation	
	Function	Modifiers				2021 (HDFA 2014 Guidelines)	Site Specific 2021 Proposed
	Valued – flowing during first round, standing water during second round and dry during the final round assessments					🟥	🟥
CRT4A-2	FT – 7 FC – 5 (Round 1) FC – 2 (Round 2) FC – 1 (Round 3) **Valued** – flowing during first round, standing water during second round and dry during the final round assessments	Agricultural	**3 –** Limited (Cropped)	**3** – Contributing	**4** – Limited	**Mitigation**	**Mitigation**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	**Step 1. Hydrology**		**Step 2. Riparian**	**Step 3. Fish Habitat**	**Step 4. Terrestrial Habitat**	**Management Recommendation**	
	Function	**Modifiers**				**2021 (HDFA 2014 Guidelines)**	**Site Specific 2021 Proposed**
CRT4A-3	FT – 7 FC – 5 (Round 1) FC – 2 (Round 2) FC – 1 (Round 3) **Valued** – flowing during first round, standing water during second round and dry during the final round assessments	Agricultural	**3 –** Limited (Cropped)	**3** – Contributing	**4** – Limited	**Mitigation**	**Mitigation**
CREDIT RIVER TRIBUTARY CRT5							
CRT5-6	FT – 7 FC – 5 (Round 1) FC – 2 (Round 2) FC – 1 (Round 3)	Agricultural	**3 –** Limited (Cropped)	**3** – Contributing	**4** – Limited	**Mitigation**	**Mitigation**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	Step 1. Hydrology		Step 2. Riparian	Step 3. Fish Habitat	Step 4. Terrestrial Habitat	Management Recommendation	
	Function	Modifiers				2021 (HDFA 2014 Guidelines)	Site Specific 2021 Proposed
	Valued – flowing during first round, standing water during second round and dry during the final round assessments						
CRT5-7	FT – 7 FC – 5 (Round 1) FC – 2 (Round 2) FC – 1 (Round 3) **Valued** – flowing during first round, standing water during second round and dry during the final round assessments	Agricultural	**3 –** Limited (Cropped)	**3** – Contributing	**4** – Limited	**Mitigation**	**Mitigation**
HUTTONVILLE CREEK							
HV6a	FT – 7 FC – 4 (Round 1) FC – 1 (Round 2) **Limited** – feature was dry during second round assessment	Agricultural	4 – Valued (Meadow)	2 – Valued	4 – Valued	**Protection (Due to protected reach upstream)**	**Conservation (The ecological value of the reach can be maintained as well as allow flexibility for development)**
HV6b	FT – 6 FC – 4 (Round 1)	Agricultural PSW		2 – Valued	6 – Valued	**Protection**	**Protection**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	Step 1. Hydrology		Step 2. Riparian	Step 3. Fish Habitat	Step 4. Terrestrial Habitat	Management Recommendation	
	Function	Modifiers				2021 (HDFA 2014 Guidelines)	Site Specific 2021 Proposed
	FC – 1 (Round 2) **Valued**		6 – Important (wetland)				
HV6c	FT – 6 FC – 4 (Round 1) FC – 1 (Round 2) **Valued** – feature was dry during second round assessments	Agricultural Road widening planned	6 – Important (wetland)	2 – Valued	4 – Limited	**Conservation**	**Mitigation (Ecological functions replicable)**
HV9a	FT – 7 FC – 4 (Round 1) FC – 1 (Round 2) **Limited** – feature was dry upon second round assessment.	Agricultural	3 – Limited (Cropped)	3 – Contributing	4 – Limited	**No Management Required**	**No Management Required**
HV9b	FT – 7 FC – 4 (Round 1) FC – 1 (Round 2) **Limited** – feature was dry upon second round assessment.	Agricultural	3 – Limited (Cropped)	3 – Contributing	4 – Limited	**No Management Required**	**No Management Required**
HV9c	FT – 7	Agricultural			4 – Limited		

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	**Step 1. Hydrology**		**Step 2. Riparian**	**Step 3. Fish Habitat**	**Step 4. Terrestrial Habitat**	**Management Recommendation**	
	Function	**Modifiers**				**2021 (HDFA 2014 Guidelines)**	**Site Specific 2021 Proposed**
	FC – 4 (Round 1) FC – 1 (Round 2) **Limited** – feature was dry upon second round assessment.		3 – Limited (Cropped)	3 – Contributing		**No Management Required**	**No Management Required**
HV9d	FT – 7 FC – 4 (Round 1) FC – 1 (Round 2) **Limited** – feature was dry upon second round assessment.	Agricultural	3 – Limited (Cropped)	3 – Contributing	4 – Limited	**No Management Required**	**No Management Required**
HV9e	FT – 7 FC – 4 (Round 1)	Agricultural	3 – Limited (Cropped)	3 – Contributing	4 – Limited	**No Management Required**	**No Management Required**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	Step 1. Hydrology		Step 2. Riparian	Step 3. Fish Habitat	Step 4. Terrestrial Habitat	Management Recommendation	
	Function	Modifiers				2021 (HDFA 2014 Guidelines)	Site Specific 2021 Proposed
	FC – 1 (Round 2) **Limited** – feature was dry upon second round assessment.						
HV9-2	FT – 7 FC – 4 (Round 1) FC – 1 (Round 2) **Limited** – feature was dry upon second round assessment.	Agricultural	3 – Limited (Cropped)	3 – Contributing	4 – Limited	**No Management Required**	**No Management Required**
HV11a	FT – 7 FC – 4 (Round 1) FC – 1 (Round 2)	Agricultural	3 – Limited (Cropped)	3 – Contributing	4 – Limited	**No Management Required**	**No Management Required**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	Step 1. Hydrology		Step 2. Riparian	Step 3. Fish Habitat	Step 4. Terrestrial Habitat	Management Recommendation	
	Function	Modifiers				2021 (HDFA 2014 Guidelines)	Site Specific 2021 Proposed
	Limited – feature was dry upon second round assessment.						
HV12	FT – 7 FC – 4 (Round 1) FC – 1 (Round 2) **Limited** – feature was dry upon second round assessments.	Agricultural	3 – Limited (Cropped)	3 – Contributing	4 – Limited	**No Management Required**	**No Management Required**
HV13	FT – 7 FC – 4 (Round 1) FC – 4 (Round 2) FC – 1 (Round 3)	Agricultural Seep	4 – Valued (Meadow)	2 – Valued	4 – Limited	**Conservation (Due to Redside Dace Contributing Habitat)**	**Mitigation (low quality seasonal fish habitat, Ecological functions replicable)**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	Step 1. Hydrology		Step 2. Riparian	Step 3. Fish Habitat	Step 4. Terrestrial Habitat	Management Recommendation	
	Function	Modifiers				2021 (HDFA 2014 Guidelines)	Site Specific 2021 Proposed
	Valued – feature was flowing during first and second round assessments and was dry upon third round assessments					🟨	🟩
HV13a	FT – 7 FC – 5 (Round 1) FC – 1 (Round 2) **Limited** – feature was dry during first round assessments	Agricultural	3 – Limited (Cropped)	3 – Contributing	4 – Limited	**No Management Required**	**No Management Required**
HV13b	FT – 7 FC – 4 (Round 1) FC – 1 (Round 2)	Agricultural	3 – Limited (Cropped)	3 – Contributing	4 – Limited	**No Management Required**	**No Management Required**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	Step 1. Hydrology		Step 2. Riparian	Step 3. Fish Habitat	Step 4. Terrestrial Habitat	Management Recommendation	
	Function	Modifiers				2021 (HDFA 2014 Guidelines)	Site Specific 2021 Proposed
	Limited – feature was dry during first round assessments						
HV14	FT – 7 FC – 4 (Round 1) FC – 1 (Round 2) **Limited** – feature was dry during first round assessments	Agricultural	4 – Valued (Meadow)	3 – Contributing	4 – Limited	**No Management Required**	**No Management Required**
HV-14a	FT – 7 FC – 5 (Round 1) FC – 1 (Round 2) **Limited** – feature was dry upon second round assessments.	Agricultural	3 – Limited (Cropped)	3 – Contributing	4 – Limited	**No Management Required**	**No Management Required**
HV14-1	FT – 7 FC – 4 (Round 1)	Agricultural	4 – Valued (Meadow)	3 – Contributing	4 – Limited	**No Management Required**	**No Management Required**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	Step 1. Hydrology		Step 2. Riparian	Step 3. Fish Habitat	Step 4. Terrestrial Habitat	Management Recommendation	
	Function	Modifiers				2021 (HDFA 2014 Guidelines)	Site Specific 2021 Proposed
	FC – 1 (Round 2) **Limited** – feature was dry during first round assessments						
HV14-2	FT – 7 FC – 4 (Round 1) FC – 1 (Round 2) **Limited** – feature was dry upon second round assessments.	Agricultural	3 – Limited (Cropped)	3 – Contributing	4 – Limited	**No Management Required**	**No Management Required**
HV15	FT – 7 FC – 4 (Round 1) FC – 1 (Round 2) **Limited**	Agricultural Clean water from Mount Pleasant Community	3 – Limited (Cropped)	3 – Contributing	4 – Limited	**No Management Required**	**No Management Required**
HV15a	FT – 7 FC – 4 (Round 1) FC – 1 (Round 2) **Limited**	Agricultural	3 – Limited (Cropped)	3 – Contributing	4 – Limited	**No Management Required**	**No Management Required**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	**Step 1. Hydrology**		**Step 2. Riparian**	**Step 3. Fish Habitat**	**Step 4. Terrestrial Habitat**	**Management Recommendation**	
	Function	**Modifiers**				**2021 (HDFA 2014 Guidelines)**	**Site Specific 2021 Proposed**
HV16	FT – 7 FC – 5 (Round 1) FC – 5 (Round 2) FC – 1 (Round 3) **Valued**	Agricultural	3 – Limited (Cropped)	2 – Valued	4 – Limited	**Protection (Protected reach upstream)**	**Conservation (The ecological value of the reach can be maintained as well as allow flexibility of development)**
HV17	FT – 6 FC – 5 (Round 1) FC – 5 (Round 2) FC – 1 (Round 3) **Valued**	PSW Agricultural	**6 –** Important (Forest)	2 – Valued	6 – Valued	**Protection**	**Protection**
HV17b	FT – 7 FC – 4 (Round 1) FC – 1 (Round 2)	Agricultural Clean water from Mount Pleasant Community	3 – Limited (Cropped)	3 – Contributing	4 – Limited	**No Management Required**	**Mitigation (Maintain conveyance of offsite clean water to downstream wetland)**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	**Step 1. Hydrology**		**Step 2. Riparian**	**Step 3. Fish Habitat**	**Step 4. Terrestrial Habitat**	**Management Recommendation**	
	Function	**Modifiers**				**2021 (HDFA 2014 Guidelines)**	**Site Specific 2021 Proposed**
	Limited – Swale was dry upon second round assessments.						🟩
HV17c	FT – 6 FC – 5 (Round 1) FC – 5 (Round 2) FC – 1 (Round 3) **Valued**	PSW Agriculture	6 – Important (Forest)	2 – Valued	6 – Contributing	**Protection**	**Protection**
HV31	FT – 7 FC – 1 (Round 1)	Agricultural Roadside ditch	3 – Limited (Cropped)	3 – Contributing	4 – Limited	**No Management Required**	**No Management Required**
HV80a1	FT – 7 FC – 4 (Round 1) FC – 1 (Round 2)	Agricultural	3 – Limited (Cropped)	2 – Valued	4 – Limited	**Protection (Protection reach upstream)**	**Conservation (Protection reach upstream)**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	**Step 1. Hydrology**		**Step 2. Riparian**	**Step 3. Fish Habitat**	**Step 4. Terrestrial Habitat**	**Management Recommendation**	
	Function	**Modifiers**				**2021 (HDFA 2014 Guidelines)**	**Site Specific 2021 Proposed**
	Limited – dry during second round assessment					🟥	🟨
HV80a2	FT – 3 FC – 4 (Round 1) FC – 1 (Round 2) **Valued** – dry during second round assessment	PSW Agricultural	6 – Important (Wetland)	2 – Valued	6 – Contributing	**Protection**	**Protection**
HV80b	FT – 7 FC – 4 (Round 1) FC – 1 (Round 2) **Limited**	Agricultural	**3** – Limited (Cropped)	3 – Contributing	**4** – Limited	**No Management Required**	**No Management Required**
HV80-b1	FT – 7 FC – 4 (Round 1) FC – 1 (Round 2) **Limited**	Agricultural	**3** – Limited (Cropped)	**3** – Contributing	**4** – Limited	**No Management Required**	**No Management Required**
HV80-b2	FT – 7	Agricultural			**4** – Limited		

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	**Step 1.** **Hydrology**		**Step 2.** **Riparian**	**Step 3.** **Fish Habitat**	**Step 4.** **Terrestrial Habitat**	**Management Recommendation**	
	Function	**Modifiers**				**2021 (HDFA 2014 Guidelines)**	**Site Specific 2021 Proposed**
	FC – 4 (Round 1) FC – 1 (Round 2) **Limited**		**3** – Limited (Cropped)	**3** – Contributing		**No Management Required**	**No Management Required**
HV80	FT – 6 FC – 4 (Round 1) FC – 1 (Round 2) **Valued** – dry during second round assessment	PSW Agricultural	6 – Important (Wetland)	2 - Valued	**4** – Limited	**Protection**	**Protection**
HV80-2	FT – 7 FC – 4 (Round 1) FC – 1 (Round 2) **Limited** – feature was dry upon second round assessments.	Agricultural	**3** – Limited (Cropped)	**3** – Contributing	**4** – Limited	**Protection (Protected reach upstream)**	**Conservation (The ecological value of the reach can be maintained as well as allow flexibility of development)**
HV81	FT – 7	Agricultural		2 - Valued	4 – Limited		

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	**Step 1. Hydrology**		**Step 2. Riparian**	**Step 3. Fish Habitat**	**Step 4. Terrestrial Habitat**	**Management Recommendation**	
	Function	**Modifiers**				**2021 (HDFA 2014 Guidelines)**	**Site Specific 2021 Proposed**
	FC – 5 (Round 1) FC – 4 (Round 2) FC - 1 (Round 3) **Valued -** Dry in Round 3		3 – Limited (Cropped)			**Protection (Protected reach upstream)**	**Conservation (The ecological value of the reach can be maintained as well as allow flexibility of development)**
HV81a	FT – 6 FC – 5 (Round 1) FC – 5 (Round 2) FC – 1 (Round 3) **Valued -** Dry in Round 3	PSW Agriculture Pipeline Significant Woodland	**6 –** Important (Forest)	2 – Valued	6 – Valued	**Protection**	**Protection**
HV81b	FT – 6 FC – 5 (Round 1) FC – 5 (Round 2) FC – 1 (Round 3)	PSW Agriculture Pipeline Significant Woodland	**6 –** Important (Wetland)	2 – Valued	6 – Valued	**Protection**	**Protection**

Appendix G Table 1: Headwater Drainage Feature Assessment Table

Drainage Feature Segment	**Step 1. Hydrology**		**Step 2. Riparian**	**Step 3. Fish Habitat**	**Step 4. Terrestrial Habitat**	**Management Recommendation**	
	Function	**Modifiers**				**2021 (HDFA 2014 Guidelines)**	**Site Specific 2021 Proposed**
	Valued - Dry in Round 3					🟥	🟥