Stoney Creek Urban Boundary Expansion (SCUBE) West Subwatershed Study

Phase 1 and Phase 2 Final Report

May 15, 2013

Prepared for:

The City of Hamilton

Hamilton

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EXECUTIVE SUMMARY

The City of Hamilton is in the process of preparing the Fruitland-Winona Secondary Plan in support of future urban development within the Stoney Creek Urban Boundary Expansion (SCUBE) area. This study, termed the SCUBE West Subwatershed Study, is one of two subwatershed studies undertaken in support of the development of the Fruitland-Winona Secondary Plan. The study area of the SCUBE West Subwatershed Study is located within the community of Stoney Creek and is bound by Lake Ontario to the north, the Niagara Escarpment to the south, Fruitland Road to the west and McNeilly Road to the east.

The purpose of this Phase 1 Subwatershed Study Report is to investigate and inventory the natural resources which could potentially be impacted by future urban development within the SCUBE West study area and then to identify constraints and opportunities for urban development while protecting key natural heritage features and functions. A summary of the key environmental features and functions is provided below.

Surface Water Resources

The surface water component of this study reviews the existing stormwater drainage patterns within the study area of the SCUBE West Subwatershed Study and defines flood hazard lands through hydrologic / hydraulic modeling and floodplain mapping. Future urban development is not permitted on lands that convey flood waters during extreme storm events and spring melts. For this study area, Hamilton Conservation Authority defines the Regulatory Flood as the 100-year flood event.

For this study hydrologic modeling was undertaken to define flood flows within Watercourses 5, 6 and 7. For modelling purposes, the study area was divided into approximately 45 subcatchments in order to provide peak flow estimates at key locations. A monitoring program was undertaken to collect precipitation and streamflow data within the study area. The data was subsequently used to calibrate the hydrologic model. A precipitation gauge was installed in the institutional facility at Jones Road and Highway 8. Streamflow monitors were also installed in Watercourse 5 and 6 near the South Service Road. As part of the monitoring program, spot flow measurements were undertaken and correlated to the water level measurements at the two streamflow gauge sites in order to develop rating curves for each location. These rating curves were used to translate the water level monitoring data into hydrographs for use in model calibration. The basic hydrologicmodel setup was refined through calibration to ensure that the model results are representative of the monitoring data.

There is little background information available on the water quality for the watercourses within the study area; however, conditions were estimated, in a general manner, based on typical conditions found in other areas with similar land uses. Watercourses 5, 6 and 7 are typically nutrient rich with nutrients such as total phosphorus occurring at concentrations above the provincial water quality objective (PWQO) of 0.03 mg/l. Levels of the bacteria, *E. coli* are also considered moderately high, in the order of 500 – 1000 cts/100 mls, well above the PWQO of 100 cts/100 ml. Trace metals, such as copper, lead and zinc, are likely close to the PWQO, however it is expected that concentrations of these parameters regularly exceed their respective guidelines in the vicinity of the QEW as a result of road runoff. Chloride concentrations may also be high in the vicinity of the QEW; however, it is unlikely that concentrations would exceed the fisheries guideline of 252 mg/l.

<u>Groundwater Resources</u>

A review of the geology and hydrogeology of the study area was undertaken to gain an understanding of the groundwater resources within the study area, including potential groundwater recharge and discharge locations. Water well records, geology and soils maps were reviewed to characterize the groundwater system. In addition, the logs of several monitoring wells and piezometers on this and the contiguous property were provided by the City of Hamilton.

Based on the 2009 boreholes advanced by Stantec, the SCUBE West area is characterized by a relatively low recharge potential and relatively shallow piezometric surface (<5 m below ground surface). In particular, it is noted that the silt till and several metres of the underlying shale bedrock are noted as being dry in the boreholes logs. This observation suggests that the overall recharge potential across SCUBE West is very low. There is a band of sand at the base of the Escarpment where higher infiltration potential is expected, although this represents a small area of the subwatershed.

To better characterize the existing infiltration rates for the study area, a basic water budget was prepared for the existing land use conditions. The estimated annual groundwater recharge for the silty clay soils over the majority of the study area is approximately 100 mm per year. The remaining 171 mm occurs as overland runoff. The isolated area of sand/gravel deposits near the base of the Niagara Escarpment has a significantly higher annual recharge rate of approximately 200 mm per year. The remaining 85 mm occurs as overland runoff.

In areas of silty clay soils it is recommended that future stormwater management planning should include measures, where feasible, to minimize changes to the existing groundwater recharge rate of approximately 100 mm per year. This will, in turn, help to minimize future increases in runoff rates. The areas with granular soils, situated near the base of the Escarpment represent a zone of high groundwater recharge potential. Given its function as a potential contributor of baseflow to stream reaches to the north, the existing recharge potential of approximately 200 mm per year from this feature should be protected through future source and conveyance control stormwater management measures which promote the infiltration of clean runoff.

A groundwater quality monitoring program involving six monitoring wells and seven streambed drive-point piezometers was completed for the study area. Results from the monitoring program indicate that two of the monitoring wells have elevated concentrations of chloride and sodium (salt), sulphate, hardness and electrical conductivity. The elevated sulphate in the groundwater is attributed to gypsum in the shale bedrock. Metals are present in concentrations below the Ontario Drinking Water Standards, with the exception of iron and manganese which are commonly elevated in shale. Groundwater samples contain only trace levels of nitrate (≤1 mg/L) and variable concentrations of total phosphorus (0.05 – 0.64 mg/L), although dissolved orthophosphate ion was non-detectable (<0.01 mg/L). These data suggest that the shallow groundwater has not been overly impacted by nutrients derived from agriculture or private septic systems.

Fluvial Geomorphology

A summary of geomorphic field investigations from previous studies was completed in order to describe existing conditions and channel characteristics of Watercourses 5, 6, and 7. Surficial geology and watershed characteristics were also reviewed to document the watercourse environment and to evaluate stream reaches.

Surface geology mapping indicates that the study area sediments primarily consist of clayey silt from Halton Till materials at the lower extents of the channels. Generally, this sedimentary environment imparts fine and cohesive characteristics to both valley and upland soils; however channel bed material within the valleys is somewhat variable due to local alluvial accumulations of coarse material and artificial fill/debris. Upstream of the Halton Till is a Queenston Shale formation, typical to the base of the escarpment. It is a soft, red shale with a veneer of clay, silt, sand, gravel, and diamicton.

The study area watercourses were delineated into 16 distinct reaches that display relative homogeneity with respect to channel characteristics, functions and processes. For each reach the geomorphic conditions i.e., stable/unstable, the presence of erosion sites and management objectives and restoration opportunities have been defined.

One of the objectives of the sub-watershed study is to minimize erosion and ensure stability and health of the streams as future development occurs. Within the study area, existing erosion hazards were identified where mitigation should be considered, primarily along Watercourse 5 and 6. Because of the proximity of private structures at risk due to erosion, an engineered channel design will likely be necessary, as opposed to a natural approach.

Generally, for the entire study area, it is recommended that future stormwater management planning should include erosion control facilities to prevent impacts from future developments. Where possible, the corridor width should be increased with extended boundaries where structures stand. This will negate the need for hardened channel linings which are currently found in disrepair through the study area. Areas littered with organic and artificial debris should be addressed to improve aquatic habitat, locally reduce potential erosion impacts, and improve conveyance.

At the downstream ends of the primary watercourses (typically upstream of the QEW) the channels have become entrenched with minimal floodplain relief. In these locations, flood flows are completely contained within the channel, resulting in increased depths which induce erosive stresses. It is recommended that where possible these channels should be reconnected to their floodplains to reduce this type of erosive stress.

<u>Aquatic Resources</u>

Watercourses draining the study area generally have their headwaters on the Niagara Escarpment and drain northward into Lake Ontario. The primary watercourses are Watercourses 5, 6 and 7. All three are generally small features that have been highly modified for agricultural purposes and in some cases, further modified to facilitate urban development. Both Watercourse 5 and 6 were considered to be permanent watercourses, while Watercourse 7 was assessed as an intermittent feature. Tributaries to these features were also considered to be intermittent. The streams in the study area have been field verified and identified as warmwater.

Detailed aquatic habitat inventories were completed on Watercourses 5 and 6 and their tributaries within the study area and downstream to Lake Ontario and some fish inventory work has also been completed. It was noted that downstream of the study area, both watercourses have been significantly altered and include barriers that limit fish movement to and from the Lake.

Based on the habitat classification descriptions Watercourse 5 is classified as permanent fish habitat in the study area. Based on a review of the Interim Guidelines (CVC and TRCA, 2009) combined with the findings of this study, it is recommended that this feature be given a Protection 2 management recommendation. Watercourses 5 and 6 should be protected with a minimum Vegetation Protection Zone of 15 m from each bank, consistent with Natural Heritage Reference Manual (2010) guidelines for warmwater watercourses. It is recommended that tributaries to Watercourses 5 and 6 receive a mitigation 2 management recommendation.

<u>Terrestrial Resources</u>

Terrestrial features in the study area of the SCUBE West Subwatershed Study include agricultural areas comprised primarily of orchards and vineyards and also natural and cultural vegetation communities ranging from deciduous forests to meadow marsh and mixed meadows. There are a number of terrestrial features identified for protection within the study area of the SCUBE West Subwatershed Study. These include a number of Class 2 and Class 3 features as defined by the Stoney Creek Open Spaces and Natural Environment System (SCONES).

Field work was performed to characterize vegetation communities using the MNR's Ecological Land Classification System for Southern Ontario (Lee *et al.* 1998). Eleven distinct ELC communities within the Study Area limits were identified to the vegetation level. Botanical surveys were completed within these ELC communities. In total, 194 flora species were identified. Of these, 80 (41.2%) are listed as exotic or non-native species (Dillon Consulting Limited 2009). No plants observed are listed species under the federal *Species at Risk Act* or the provincial *Endangered Species Act.*

Information from the Atlas of the Mammals of Ontario (Dobbyn 1994) indicates that 22 mammal species have been observed in the vicinity of the Study Area, all of which are considered secure in Ontario. Of these, six were observed during field work (Dillon Consulting Limited 2009).

Breeding bird surveys identified a total of 58 bird species observed in the study area. Data from the Second Ontario Breeding Bird Atlas (BBA) indicates that a total of 103 bird species were found as possible, probable or confirmed breeders in the study area. Fifteen of the bird species observed within the study area are considered area sensitive, while 23 are considered conservation priority species, five bird species at risk were found and two individuals observed are federally and provincially listed as Threatened.

The Ontario Herpetofaunal Atlas information (Oldham and Weller 2000) indicates that 15 species of amphibian and 13 reptile species have been observed in the vicinity of the Study Area, including seven species at risk. Only one species of reptile was observed during field work, the eastern garter snake (*Thamnophis sirtalis sirtalis*). This is a common species and considered secure in Ontario (Dillon Consulting Limited 2009).

Amphibian monitoring was conducted following the Marsh Monitoring Program protocol (Bird Studies Canada 1994). Four amphibian species, all frogs, were observed during fieldwork. All four species are considered common to very common in the Province of Ontario and not evaluated as at risk. Background review suggests the potential presence of species at risk herpetofauna in the Study Area.

Incidental observations of invertebrates, including Lepidoptera and Odonata were recorded in the course of fieldwork. No records for rare invertebrate species in or near the Study Area were indicated by NHIC Database information. All of the invertebrates observed are considered secure in Ontario with the exception of the monarch butterfly, which is listed federally and provincially as Special Concern.

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1.1 Background

On October 23, 2003, Hamilton City Council adopted Regional Official Plan Amendment (ROPA) 14 and Stoney Creek Official Plan Amendment (OPA) 99 to permit future urban development in the Stoney Creek Urban Boundary Expansion (SCUBE) area (Figure 1.1). These amendments were appealed to the Ontario Municipal Board (OMB) by the Ministry of Municipal Affairs and Housing (MMAH) and Hamilton General Homes (City of Hamilton 2010a).

Before the OMB could rule on the MMAH appeal, the Province introduced a draft Greenbelt Plan which identified the City's proposed urban expansion area as "Protected Countryside" and "tender fruit and grape lands". The Province revised the proposed boundaries of these designations. The final version of the Greenbelt Plan, released in February, 2005, includes approximately one third of the urban expansion lands proposed by ROPA 14 and OPA 99 within its "Protected Countryside" and "tender fruit and grape lands" designations (City of Hamilton 2007a).

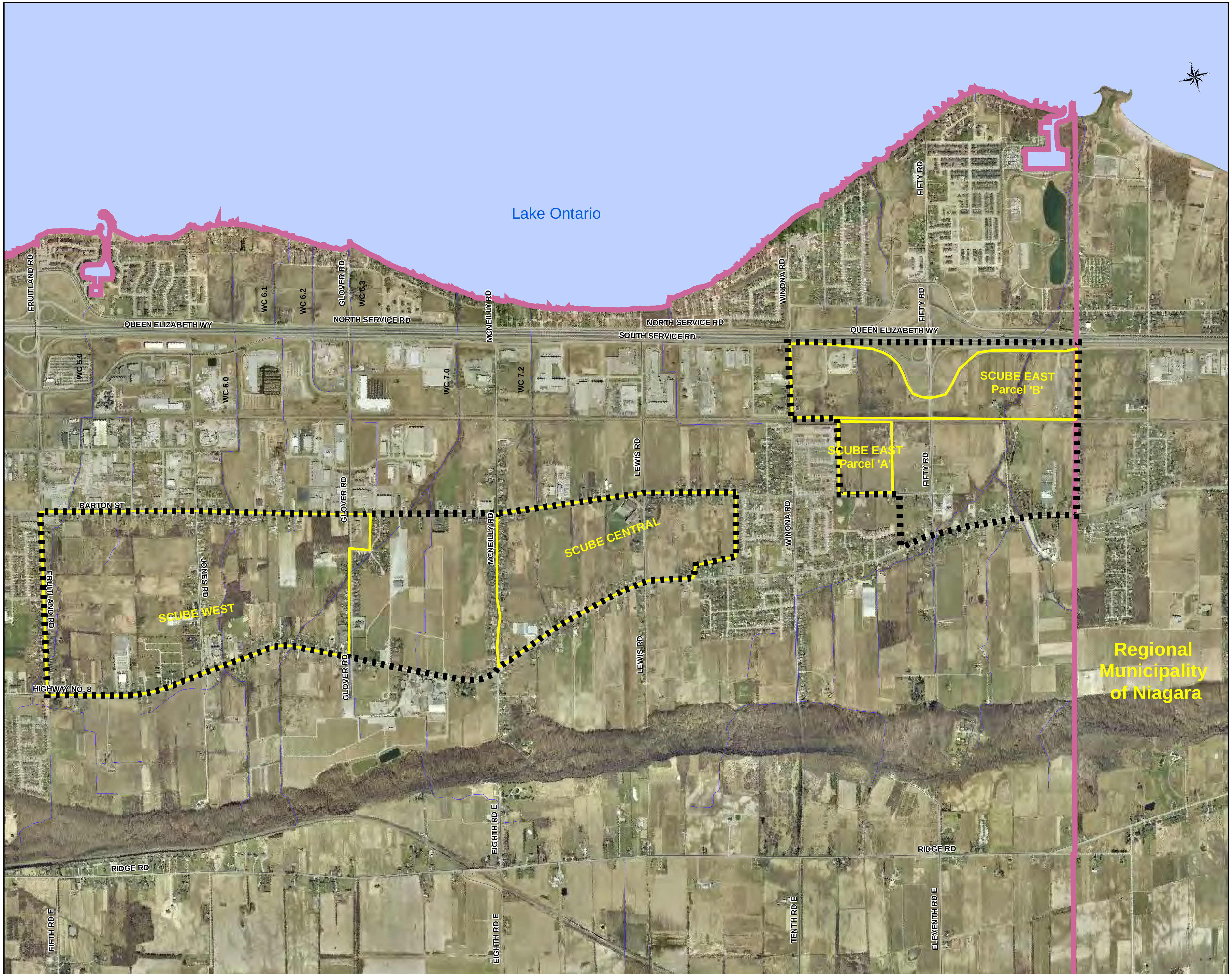
On November 22, 2005, the OMB held a pre-hearing conference to address ROPA 14 and OPA 99. After testimony and comments, the OMB directed the City, Province and other parties to the hearing to bring forward a modified plan for the proposed urban expansion that would be acceptable to all parties. The City of Hamilton submitted a modified plan for the urban expansion that recognized the Greenbelt Plan designations and included the remaining two-thirds of the original SCUBE area lands as Urban (City of Hamilton 2007a, City of Hamilton 2010a).

OMB Decision/Order 1202, issued on April 30, 2007, approved in part the modified urban boundary expansion but also provided for a future OMB hearing to address the land use designations of four areas that were identified at the November 22, 2005 pre-hearing conference. Before a hearing on these areas could be held, the MMAH withdrew its appeals. Subsequently, the owners of the largest of these four areas, referred to as the "Glover McDonald Place" entered into an agreement with the City of Hamilton to have these lands included within the Urban Area of the City of Hamilton under ROPA 14 and OPA 99. This agreement was approved by the OMB on April 20, 2009 (City of Hamilton 2007a, City of Hamilton 2010a, OMB 2009).

ROPA 14 and OPA 99, as amended by the OMB, add four blocks of land to the Urban Area of the City of Hamilton in the former Town of Stoney Creek (Figure 1.1). These four blocks include the following:

(1) **SCUBE West –** is bound by Barton Street to the north, Highway 8 to the south, Fruitland Road to the west and Glover Road to the east;

(2) **SCUBE Central –** is bound by Barton Street to the north, Highway 8 to the south, McNeilly Road to the west and the existing residential community west of Winona Road to the east;



KEY MAP

LEGEND:

- SCUBE Area as Orginally Proposed
- SCUBE Area as Revised
- City of Hamilton Boundary

NOTES:

0 250 500 1,000 1,500

Meters

Hamilton

Aquafor Beech Limited

SCUBE WEST SUBWATERSHED STUDY

Stoney Creek Urban Boundary Expansion (SCUBE) Area as Originally Proposed and as Revised

FIGURE No. 1.1

DATE: June 7, 2010

(3) **SCUBE East (Parcel A)** is bound by the CN railway to the north, Barton Street to the south, and located immediately east of the Winona Urban Community; and

(4) **SCUBE East (Parcel B)** is bound by South Service Road to the north, the CN railway to the south, Winona Road to the west, and the municipal boundary between the City of Hamilton and the Regional Municipality of Niagara to the east.

Together, these four blocks comprise approximately 254 ha (628 acres) of land that are now available for a variety of residential, industrial, commercial, institutional and open space uses (City of Hamilton 2007a, OMB 2009).

OMB Decision/Order 1202 requires the City of Hamilton to prepare a Secondary Plan for the urban expansion lands before any development can take place (City of Hamilton 2010a). A Secondary Plan establishes land use designations, a transportation network, infrastructure requirements and the location of community facilities. A Secondary Plan also provides written policies to implement land uses, such as urban design standards. The land use plan and associated policies are adopted into the Official Plan to ensure that their intent is legally binding (City of Hamilton 2007b).

As required by the OMB, the City of Hamilton has undertaken a planning study to prepare a Secondary Plan (referred to as the Fruitland-Winona Secondary Plan) for the lands included within the Urban Area of the City of Hamilton under ROPA 14 and OPA 99. The study area consists of the lands east of Fruitland Road, north of Highway 8 and south of Barton Street, including Winona; and the lands east of Winona, north of Highway 8, south of the Queen Elizabeth Way (QEW) and west of the City limits (Figure 1.2). The study area consists of approximately 504 hectares (1245 acres) of land, including SCUBE West, SCUBE Central, SCUBE East (Parcel A) and SCUBE East (Parcel B). The study area also incorporates several parcels of adjacent land not subject to the Fruitland-Winona Secondary Plan, including approximately 124 ha (306 acres) subject to the Greenbelt Plan (City of Hamilton 2010b).

The City of Hamilton is completing a number of studies in support of the preparation of the Fruitland-Winona Secondary Plan, including two subwatershed studies. The SCUBE East Subwatershed Study addresses three of the four blocks of land subject to the Fruitland-Winona Secondary Plan, including SCUBE Central, SCUBE East (Parcel A) and SCUBE East (Parcel B). **The present study, termed the SCUBE West Subwatershed Study, addresses the remaining block of land subject to the Fruitland-Winona Secondary Plan (SCUBE West).** The process of Subwatershed Planning is described in Section 1.2. The goals and objectives of the SCUBE West Subwatershed Study are outlined in Section 1.3.

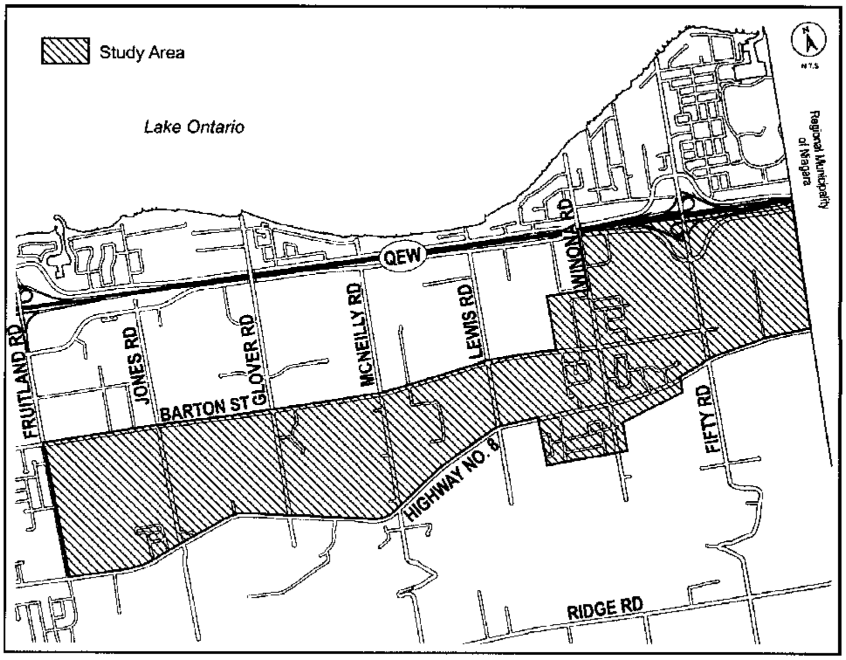


Figure 1.2: Fruitland-Winona Secondary Plan Study Area. From City of Hamilton (2007b).

1.2 Subwatershed Planning

The process of Subwatershed Planning has evolved over the last 20 years. The typical Subwatershed Study of the 1980's was conducted to prepare a "Master Drainage Plan" and was primarily concerned with flooding and erosion. In the latter part of the 1980's such studies evolved and typically also dealt with water quality and occasionally aquatic resources.

Presently, subwatershed studies address a number of issues including the following:

- flooding
- erosion
- water quality
- the water budget (i.e., groundwater, baseflow and peak flows)
- terrestrial and aquatic habitat
- woodlands, including woodlots and forests
- wetlands
- Areas of Natural and Scientific Interest;
- Environmentally Significant Areas
- aesthetics
- recreation

Furthermore, current subwatershed studies are ecosystem based, with the potential interaction between each of the environmental features being strongly considered.
The integration of land use planning with water resource management planning has also evolved over the last 20 years. Whereas the common practice in the mid-1980's involved the development of Official, Secondary and Draft Plans with nominal consideration of environmental consequences; present practices consider the two planning processes in unison. In this manner, the resulting Subwatershed Plan becomes an integral part of the overall planning process, and if successfully completed should provide:

- a solid foundation such that the environmental features will be protected, enhanced or restored under present conditions, and as land use changes occur; and

- an environmentally sound framework within which those involved in planning and decision-making can evaluate the consequences of current and post-development scenarios in the context of the entire subwatershed.

1.3 Study Overview

1.3.1 Study Goal

The goal of the SCUBE West Subwatershed Study is to protect, maintain and enhance the ecological processes, functions and significant natural features of the subject area, by providing a framework through which future growth may be established and undertaken in a manner which is environmentally sound and socially and economically sustainable (City of Hamilton 2009a).

1.3.2 Study Objectives

The objective of the SCUBE West Subwatershed Study is to provide for the protection, maintenance and enhancement of surface water and groundwater quality and quantity by supporting the development of environmentally sound and responsive policies for the Fruitland-Winona Secondary Plan. Specifically, the Study will provide recommendations as to where and how future development activity can safely occur in the Fruitland-Winona Secondary Plan area so as to minimize flood risks, stream erosion, degradation of water quality and negative impacts on natural systems, including groundwater. Recommendations may also identify opportunities for ecological enhancement where deemed integral to the function of the plan (City of Hamilton 2009a).

To achieve its objectives, the SCUBE West Subwatershed Study is to:

- Review and evaluate the study area's existing hydrologic, hydrogeologic, geotechnical, environmental, land use and natural heritage conditions;
- Determine appropriate methods of accommodating the pre- and post- development stormwater discharge and stormwater quality control from the areas of future growth located within the study area;
- Develop an appropriate storm water management control and natural heritage strategy, block limits and footprint, drainage assessment, post development target flows, including identification of general locations and preliminary design for any required stormwater management facilities;
- Recommend Best Management Practices;
- Assess the feasibility of Low Impact Development in the study area and incorporate into overall Storm Water Management strategy; and
- Assess and review the impacts of storm runoff from development within the study area, watercourses and hydraulic structures.

1.3.3 Study Process

In November, 2009 the City of Hamilton retained Aquafor Beech Limited to complete the SCUBE West Subwatershed Study. The Study is to be completed in the three stages of a typical subwatershed study. During Phase 1, the Study will characterize the subwatershed through a review of background literature, previous and ongoing projects/assignments and by conducting studies to address gaps in existing data. During Phase 2, the Study will provide a detailed analysis of the potential impacts of future land uses and develop a management strategy to ensure that the critical elements of the subwatershed are protected. During Phase 3, the Study will develop implementation and monitoring plans (City of Hamilton 2009a).

This report presents the results of Phase 1 and 2 of the SCUBE West Subwatershed Study.

To characterize the existing conditions of the SCUBE West Subwatershed, Aquafor Beech Limited largely summarized the results of a number of previous and ongoing studies undertaken by other consulting firms. Aquafor Beech Limited also completed additional fieldwork/analysis as required to address gaps in existing data. Sections 2.3 and 3.2 describe in greater detail the previous/ongoing studies reviewed and the additional fieldwork/analyses completed by Aquafor Beech Limited in the preparation of this Report.

2 STUDY AREA AND BACKGROUND

2.1 Study Area

The study area of the SCUBE West Subwatershed Study is located within the community of Stoney Creek, in the northeast portion of the City of Hamilton. As shown by Figure 2.1, the study area is bound by Lake Ontario to the north, the Niagara Escarpment to the south, Fruitland Road to the west and McNeilly Road to the east (City of Hamilton 2009a). Altogether, the study area encompasses approximately 1130 ha (11.3 km^2).

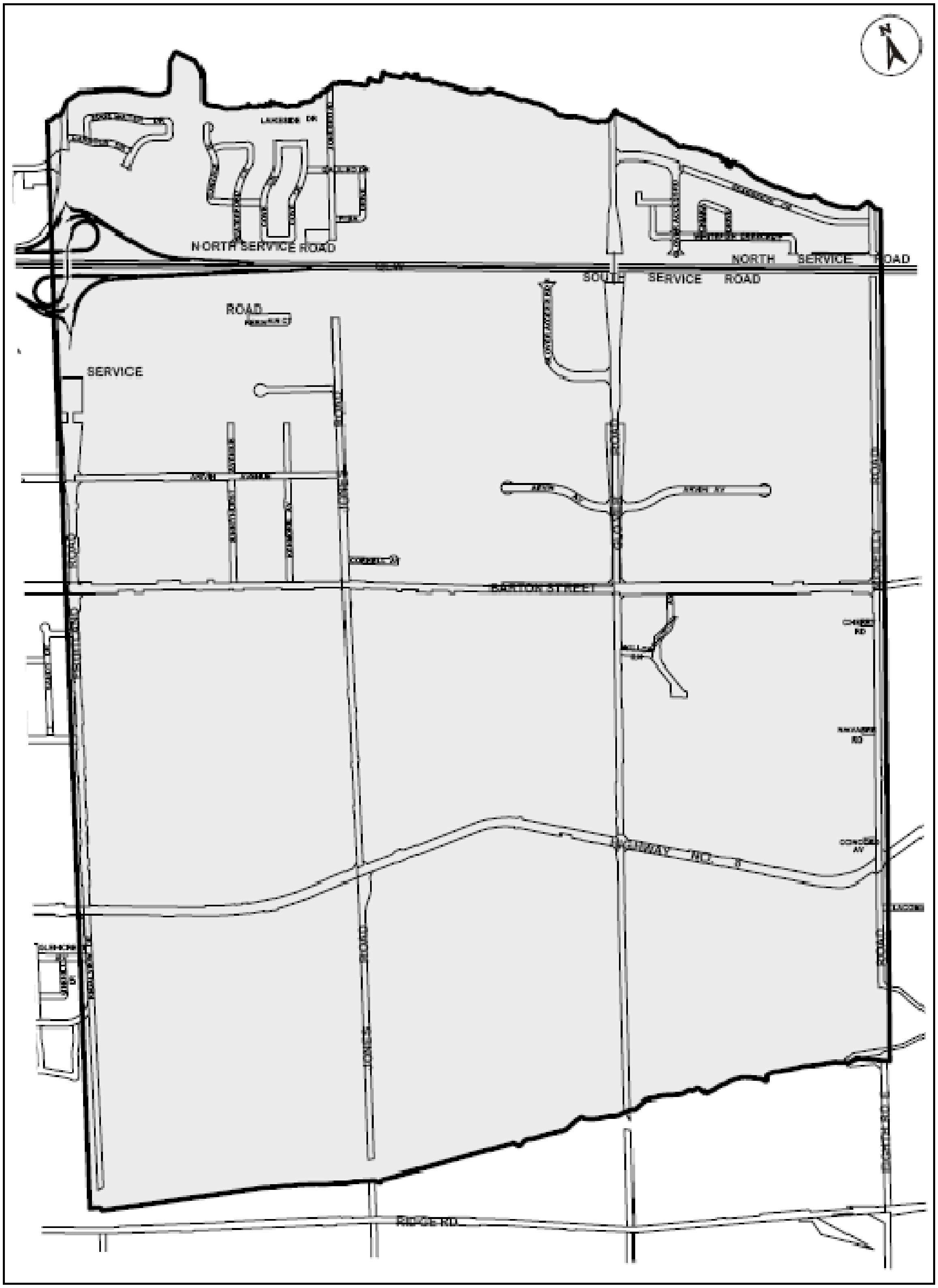


Figure 2.1: Study area of SCUBE West Subwatershed Study. From City of Hamilton (2009a).

The study area of the SCUBE West Subwatershed Study is drained by three main watercourses. These include Watercourses 5, 6 and 7. Further detailed descriptions of the main reaches of these watercourses are provided in Sections 3.2.2 and 3.2.4.

Consistent with its goals and objectives, the SCUBE West Subwatershed Study focuses on the block of land west of McNeilly Road that is subject to the Fruitland-Winona Secondary Plan (SCUBE West). As previously noted, the SCUBE West lands are bound by Barton Street to the north, Highway 8 to the south, Fruitland Road to the west and Glover Road to the east.

2.2 Existing Land Use

Existing land use varies across the study area of the SCUBE West Subwatershed Study. Lands north of the QEW are dedicated primarily to residential housing. The area between QEW and Barton Street is the Stoney Creek Business Park predominated by industrial land. Lands between Highway 8 and the Niagara Escarpment are largely dedicated to agriculture (Figure 2.2).

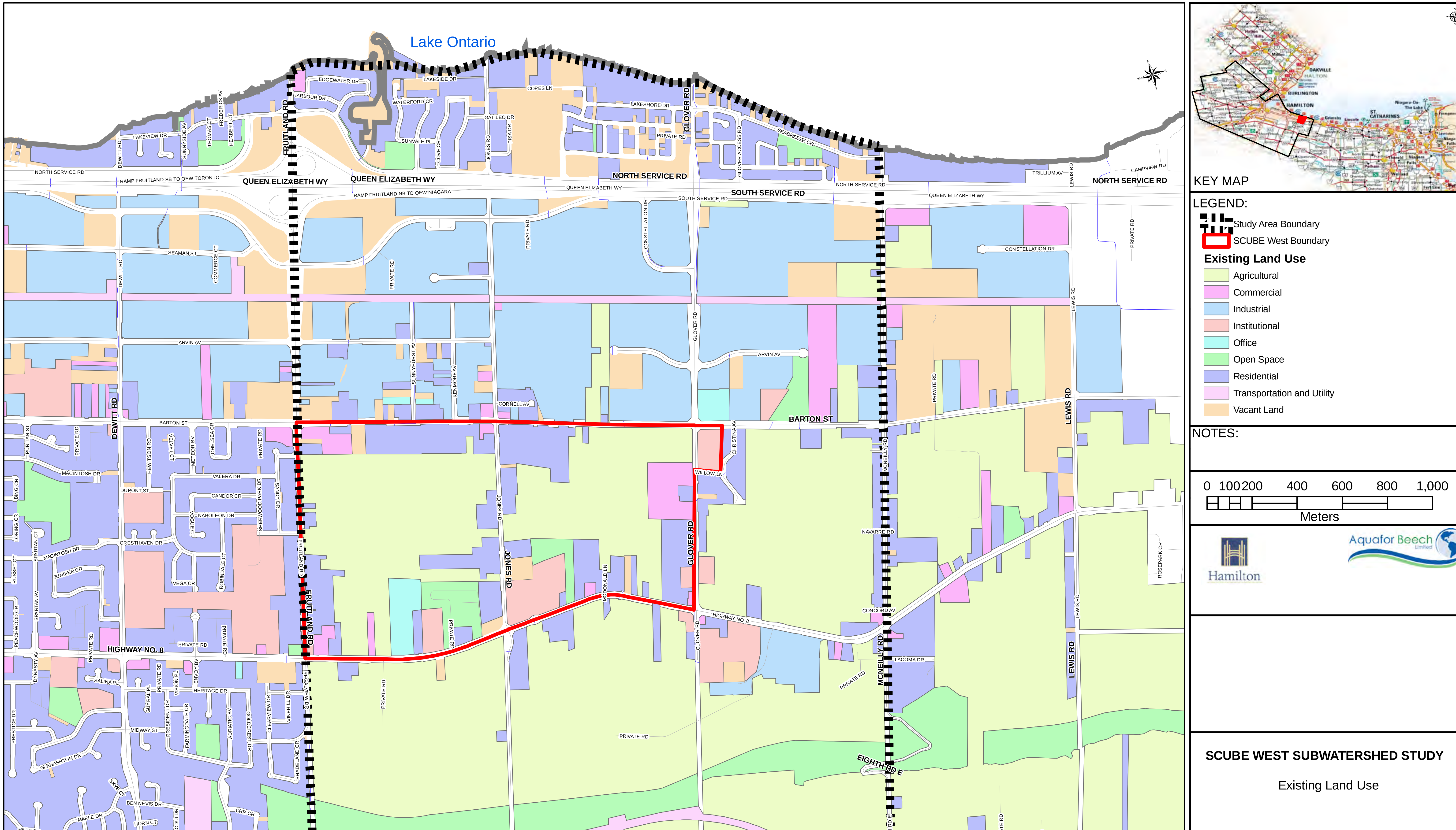
Existing land use between Barton Street and Highway 8 varies considerably. Roads are generally fronted by a mix of residential, commercial and institutional land uses. Notable among the latter are the Mountainview Gardens Cemetery, which fronts Highway 8 east of Fruitland Road and the Stoney Creek Municipal Centre, located at the intersection of Highway 8 and Jones Road. Away from the roads, the majority of land is zoned for agricultural uses. A number of orchards, vineyards and fields of row crops are present; however a mixture of natural and cultural vegetation communities also exists, ranging from deciduous forest and meadow marsh to hedgerows and mixed meadows (Dillon Consulting Limited 2009)

2.3 Proposed Land Uses

The City of Hamilton has prepared a draft preferred land use plan for the area subject to the Fruitland-Winona Secondary Plan. The SCUBE West lands are proposed to be developed primarily as low and medium density residential housing, with smaller areas dedicated to commercial and institutional uses. Several parks are also proposed. Maps could be found in the Secondary Plan.

2.4 Background Reports

To characterize the existing conditions of the SCUBE West Subwatershed, Aquafor Beech Limited summarized the results of a number of previously completed and ongoing studies undertaken by other firms. Each of these studies is summarized briefly below (Figure 2.3).



SCUBE WEST SUBWATERSHED STUDY

Existing Land Use

FIGURE No. 2.2

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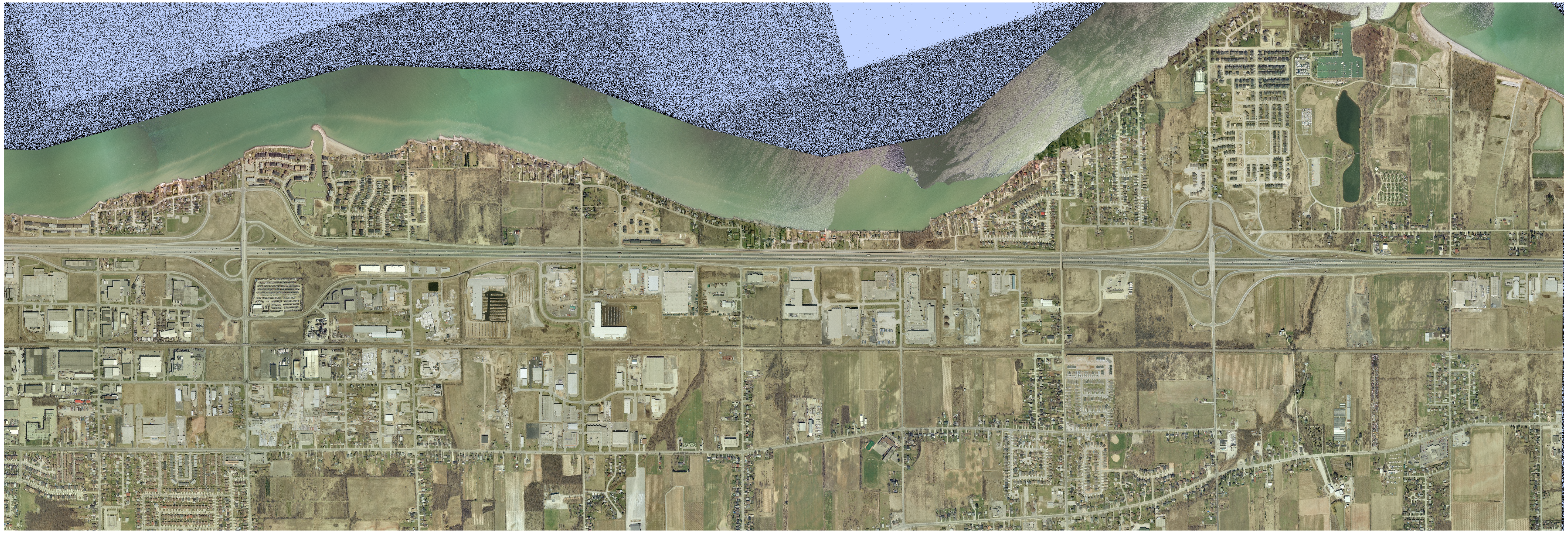


Halton Hills
Milton
OAKVILLE
HALTON
BURLINGTON
HAMILTON
Grimsby
Lincoln
ST. CATHARINES
Niagara-On-The Lake
Lewiston
Niagara Falls
Thorold
Pelham
Welland
Fort Erie
Buffalo

2.4.1 Watercourse 7 Creek System Improvements Class EA

The primary purpose of this study was to determine a preferred watercourse system improvement solution for Watercourse 7, between Barton Street and Lake Ontario, to address flooding, erosion, terrestrial and aquatic habitat issues. The study was completed in September, 2003. The preferred solution was a combination of watercourse improvements through natural channel design, together with a stormwater management facility for flood and erosion control storage (Philips Engineering Limited 2003).

2.4.2 Draft Natural Heritage Assessment

Dillon Consulting Limited (Dillon) was retained by the City of Hamilton to undertake an assessment of the natural heritage features for the lands between Fruitland Road to the west, Glover Road to the East, Barton Street to the North and Highway 8 to the South in support of the Fruitland-Winona Secondary Plan Study and the Fruitland Road Class EA (Dillon Consulting Limited 2009). The Study is currently ongoing. Preliminary study results are described in greater detail in Section 3.2.6.

2.4.3 Watercourses 5 and 6 Class EA Study

A Class Environmental Assessment Study was procured for subwatersheds 5 & 6 within the City of Hamilton. The impetus of the study is the expected urban and commercial development within the subwatersheds. Dillon Consulting Limited was contracted to perform the study and submitted a draft report in November 2007. Dillon assessed each of the primary and secondary watercourses within the study area, providing alternatives to address existing deficiencies with respect to future development. Their study defined each watercourse in terms of technical environment components such as hydraulic capacities, fluvial geomorphology, aquatic and terrestrial resources, and socio-economic conditions (Dillon Consulting Limited 2007).

2.4.4 Final SWM Report for Existing SWM Facility Retrofit – Fruitland Meadows Subdivision

The primary purpose of this study was to retrofit the existing stormwater management facility that serving Fruitland Meadows Subdivision, in order to accommodate the future development for five single residential lots, a total of 0.3 ha. Due to the fact that the proposed lots are within the limits of the existing SWM facility, the existing headwall outlet will be relocated and the footprint of the existing SWM facility will be reduced. The study shown the future development has negligible effect on the storage volumes, peak flows and sufficient ponding area for future stormwater management retrofits (S. Llewellyn & Associated Limited 2003).

2.4.5 Arvin Avenue Extension Schedule C Class EA

Arvin Avenue presently exists in segments that extend through the study area of the SCUBE West Subwatershed Study between Barton Street and the CN Railway. This Class EA study was conducted to assess the potential extension of Arvin Avenue to provide improved access to lands in the Stoney Creek Industrial Park. The study, completed in December, 2008 assessed several alternatives for each of three potential extensions of Arvin Avenue and identified the preferred alternative for each segment. The study included an assessment of existing environmental conditions based on a review of background information and one day of fieldwork. The study also included a review of drainage and traffic conditions that would be affected by the proposed extensions (AECOM 2008).

2.4.6 Master Drainage Plan Industrial Corridor – Area 5, 6 and 7 Final Report

The primary purpose of this study was to identify the drainage constraints for Watercourses 5, 6 and 7, between Barton Street and Lake Ontario, using updated hydrologic data and expected future land use and property ownership. The drainage constraints included flat topography, undersized culverts and inadequate outlets to Lake Ontario. The preferred solution was a combination of culvert replacement, outlet improvement, diversion, detention storage and channelization (Philips Planning and Engineering Limited 1990).

Specific issues noted during the background review that are relevant to the current SCUBE West Subwatershed Study include the following:

- Recommendation was made to divert Watercourses 6 and 5.1 to Watercourse 5 along the QEW.

- Stormwater management (SWM) storage upstream of Barton Street to attenuate post development peak flows to pre development levels for all lands south of Barton Street on Watercourse 5, 6 and 7.

Specific issues noted during the background review that are relevant to the current SCUBE Subwatershed Study include the following:

- Watercourse 7.2 have been diverted to the west of McNeilly Road, upstream of the QEW/South Service Road to a new culvert at Watercourse 7; and
- The eastern branch of Watercourse 7, west of McNeilly Road, was classified as a perennial stream. This is consistent with findings from the groundwater assessment undertaken in this Subwatershed Study (refer to Section 3.4), which indicates a potential groundwater linkage between sand/gravel deposits near Highway 8 and the streams to the north.

2.4.7 SCUBE Area Transportation Master Plan (Phases 1 & 2) Study Report

The City of Hamilton initiated the SCUBE Transportation Master Plan study to assess transportation needs to accommodate planned growth in the Stoney Creek Urban Boundary Expansion (SCUBE) area by 2021. The study area is bound by the South Service Road to the north, the City of Hamilton-Regional Municipality of Niagara boundary to the east, Highway 8 to the south and Fruitland Road to the west (Dillon Consulting Limited 2008).

The study, completed in November, 2008, involved the following major tasks:

- Assessment of the existing transportation network and required transportation infrastructure;

- Development of a Transportation Master Plan for the SCUBE area;
- Identification of key road links, required transit routes, cycling routes and other infrastructure requirements;
- Review of the proposed widening of Highway 8 from DeWitt Road to Fruitland Road; and
- Identification of opportunities for operational improvements.

3 EXISTING SUBWATERSHED CONDITIONS

3.1 Land Use Designations

Land use within the study area of the SCUBE West Subwatershed Study is regulated by a combination of provincial plans and municipal official plans. To the extent of any conflict, provincial plans take precedence over municipal official plans. The land use planning designations of the plans that apply to the study area are described below (Figure 3.1).

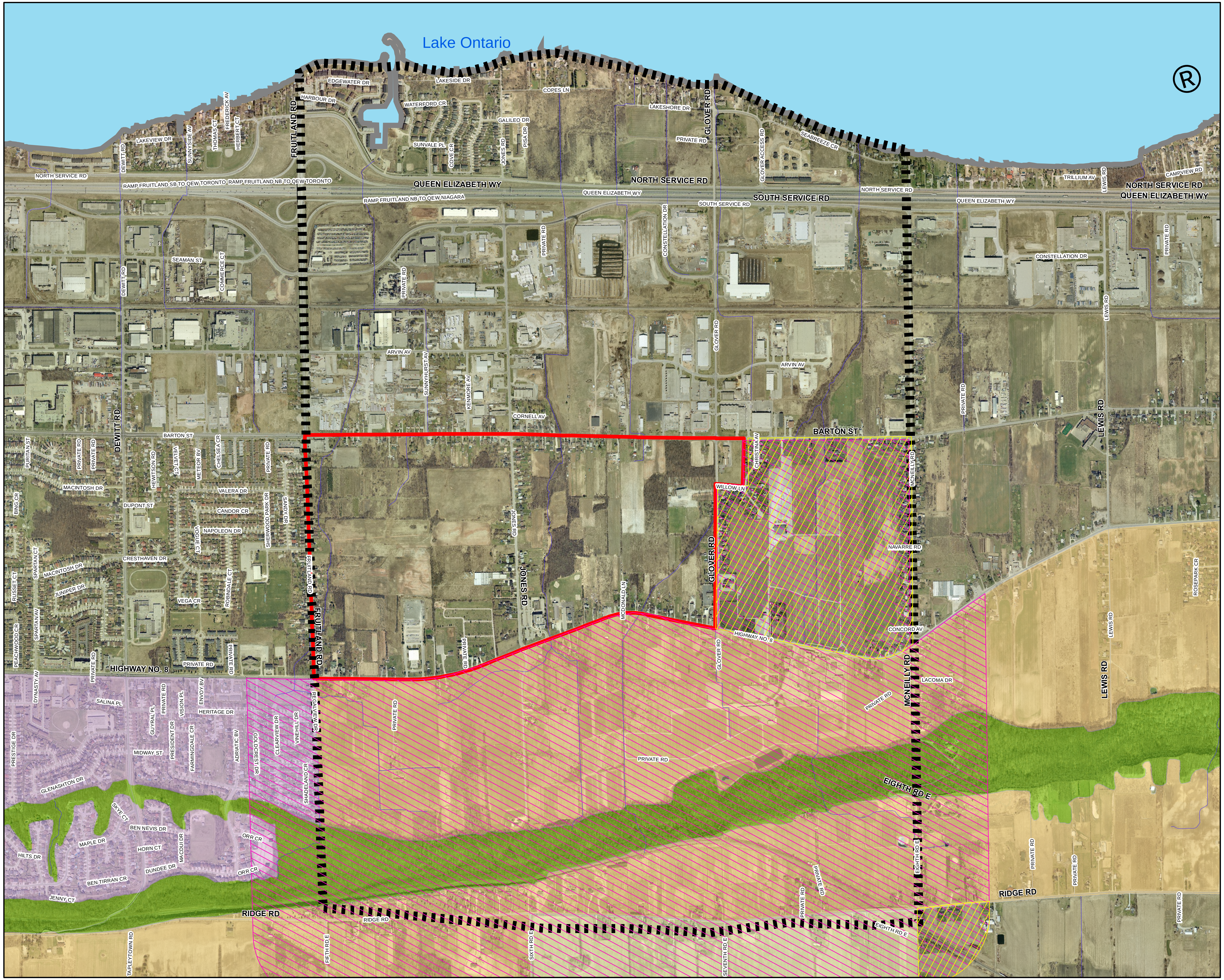
3.1.1 Provincial Land Use Plans

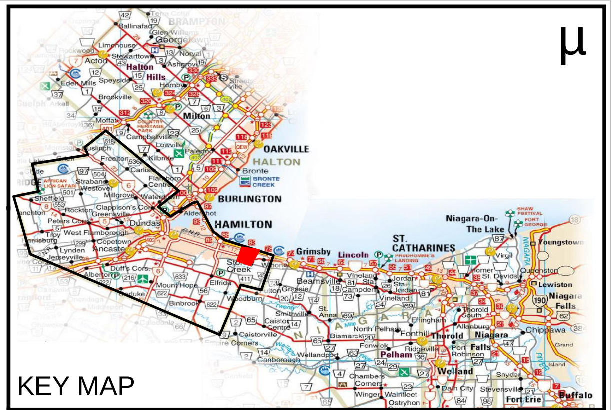
The study area of the SCUBE West Subwatershed Study is subject to two provincial plans: the Niagara Escarpment Plan and the Greenbelt Plan. These two plans are described in greater detail below.

3.1.1.1 Niagara Escarpment Plan

The Niagara Escarpment Planning and Development Act (1990) is intended to "provide for the maintenance of the Niagara Escarpment and land in its vicinity substantially as a continuous natural environment and to ensure only such development occurs as is compatible with that natural environment". The Act established a land use planning process which resulted in the development of the Niagara Escarpment Plan (NEP). The NEP provides a framework of provincial objectives and policies intended to balance the protection and development of the Niagara Escarpment. Lands within the NEP Planning Area are designated (i) Escarpment Natural Area, (ii) Escarpment Protection Area, (iii) Escarpment Rural Area, (iv) Mineral Resource Extraction Area, (v) Escarpment Recreation Area, (vi) Urban Area, or (vii) Minor Urban Centre. Different land use policies are associated with each of these seven designations. The NEP also sets out policies for a Niagara Escarpment Parks and Open Space System, intended to serve a framework for the establishment and coordination of a system of publicly owned lands on the Escarpment. The policies associated with the seven land use designations and the Parks and Open Space System are fully described in the NEP (NEC 2005).

Within the study area of the SCUBE West Subwatershed Study, all lands south of Highway 8 are subject to the Niagara Escarpment Plan. The Niagara Escarpment is designated Escarpment Natural Area; lands between the Highway 8 and the Niagara Escarpment are designated Escarpment Protection Area.





KEY MAP

LEGEND:

Study Area Boundary

SCUBE West Boundary

Niagara Escarpment Plan Designations

- Escarpment Natural Area
- Escarpment Protection Area
- Escarpment Rural Area
- Urban Area
- Protected Niagara Peninsula Tender Fruit and Grape Area
- Protected Countryside

NOTES:

0 100 200 400 600 800 1,000

Meters

Hamilton

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SCUBE WEST SUBWATERSHED STUDY

Land Use Designations of Provincial Plans

FIGURE No. 3.1

DATE: October 2010

3.1.1.2 Greenbelt Plan

The Greenbelt Act (2005) is intended to protect agricultural and environmentally sensitive lands in the Golden Horseshoe from urban development. The Act gives the Ontario Government the authority to establish a Greenbelt Plan to regulate land use planning related matters within a designated Greenbelt Area. As defined by Ontario Regulation 59/05, the Greenbelt Area consists of lands subject to the Oak Ridges Moraine Conservation Plan, the Niagara Escarpment Plan and the Parkway Belt West Plan, as well as lands that the Greenbelt Plan designates as Protected Countryside. Lands within the Protected Countryside are further categorized as Agricultural System, Natural System or Settlement Area. The Agricultural System is made up of (i) Specialty Crop Areas, (ii) Prime Agricultural Areas and (iii) Rural Areas, while the Natural System consists of a Natural Heritage System and a Water Resource System. Specific policies apply to each of these three designations (MMAH 2005).

Approximately one-third of the study area of the SCUBE West Subwatershed Study is subject to the Greenbelt Plan. The majority of the lands bound by Barton Street to the north, Glover Road to the west, McNeilly Road to the east and Highway 8 to the south are designated Specialty Crop Area and comprise part of the Niagara Peninsula Tender Fruit and Grape Area. In addition to the specific policies that apply to lands designated specialty crop areas, these lands are also subject to the General policies and Parkland, Open Space and Trails policies that apply to the Protected Countryside.

The other lands within the study area of the SCUBE West Subwatershed Study that are subject to the Greenbelt Plan are those described in Section 4.1.1.1 that are also subject to the Niagara Escarpment Plan. Only the Parkland, Open Space and Trails policies of the Greenbelt Plan apply to these lands (MMAH 2005).

3.1.2 Municipal Official Plans

The City of Hamilton assumed the planning authority of the former Regional Municipality of Hamilton-Wentworth and its six constituent local municipalities, including the Town of Stoney Creek, on January 1, 2001. In February 2003, the Council of the City of Hamilton authorized staff to develop a new Official Plan for the amalgamated city. The development of a new Official Plan for the City occurred in two Phases. The first phase culminated in the completion of the Rural Hamilton Official Plan in 2006. The Rural Official Plan was approved by the Province in December 2008, but is currently under appeal to the Ontario Municipal Board. The Urban Official Plan was council adopted in July 2009 and is currently awaiting approval from MMAH (City of Hamilton 2010c).

Until these new Plans are approved, the existing Official Plans remains in force. As a result, the study area of the SCUBE West Subwatershed Study remains subject to the policies of the Regional Municipality of Hamilton-Wentworth Official Plan and the Town of Stoney Creek Official Plan, however, the new Official Plan provides planning direction, despite the fact that the existing OP’s are still in effect.

3.1.2.1 Regional Municipality of Hamilton-Wentworth Official Plan

Section C1.1 of the Regional Official Plan identifies a Natural Heritage System (NHS) as the framework for conservation planning and management within the Regional Municipality of Hamilton-Wentworth (now the City of Hamilton). The NHS includes (i) Core Natural Areas (primarily Environmentally Significant Areas), (ii) Linkages and (iii) Restoration Opportunities (Regional Municipality of Hamilton-Wentworth 2005).

There are no Environmentally Significant Areas or other Core Natural Areas with the lands subject to the Fruitland-Winona Secondary Plan. However, the Devil's Punch Bowl Escarpment Environmentally Significant Area (ESA) extends along the southern edge of the study area of the SCUBE West Subwatershed Study. This ESA consists of a 10 km section of the Niagara Escarpment that extends from Highway 20 east to the municipal boundary between the City of Hamilton and the Regional Municipality of Niagara (Dwyer 2003).

The Regional Official Plan defines Linkages as watercourses or naturally vegetated areas that border or connect Core Natural Areas and provide ecological functions such as passage, feeding, shelter, hydrological flow, or buffering from adjacent impacts. The Plan also defines Restoration Opportunities as vacant or available lands or watercourses where natural habitat is altered, degraded or destroyed; and notes that, through habitat restoration and conservation management these areas may function as Linkages (Regional Municipality of Hamilton-Wentworth 2005).

3.1.2.2 Town of Stoney Creek Official Plan

Amendment 92 to the Official Plan for the former Town of Stoney Creek identifies the Stoney Creek Open Spaces and Natural Environment System (SCONES). This System is intended to achieve the following:

- Implement Provincial and Regional natural areas policy.
- Protect and preserve in their natural state ecologically unique and significant areas and to maintain the biodiversity of flora and fauna species by protecting and connecting natural areas and open spaces.
- Promote sustainable development and to encourage volunteerism a means to achieve sustainable development and land stewardship.
- Improve the quality of watercourses and to protect and enhance the quantity and quality of groundwater.

The System includes the following four designations:

Class 1 (Environmentally Significant Areas)

Class 1 features include Environmentally Significant Areas as defined by the Regional Official Plan as well as other features, including but not limited to, provincially significant wetlands as identified by the Ministry of Natural Resources (MNR), provincially significant Life Science

Areas of Natural and Scientific Interest, habitat with endangered, threatened and rare or varied species of flora and fauna, as well as lands designated Escarpment Natural Area under the Niagara Escarpment Plan.

Class 2 (Core Areas)

Class 2 features include Type 1 streams as defined by the MNR (i.e., significant fish habitat) with an associated 30 m buffer from the top-of-bank, significant woodlots (over 2 ha in size) and areas listed in the Hamilton-Wentworth Natural Areas Inventory but not designated as Environmentally Significant Areas under the Regional Official Plan. Class 2 features also include groundwater recharge and discharge zones identified by subwatershed studies.
Class 3 (Rehabilitation Areas)

Class 3 (Rehabilitation Areas)

Class 3 features include Regional Life Science and all Earth Science Areas of Natural and Scientific Interest not defined in the Regional Official Plan as Environmentally Significant Areas, Type 2 stream corridors as defined by the MNR, including a 30 metre buffer zone on either side of the top-of-bank, regionally significant wetlands (MNR Class 4 to 7), lands designated by the Niagara Escarpment Commission as Protection Areas, woodlots under 2 ha in size, hedgerows, windbreaks, meadows, scrub-thicket, non-evaluated wetlands and storm water quality ponds. All contiguous lands within 50 m of an ESA or Core Area are also considered Class 3 to provide an adequate buffer zone and encourage ecological restoration where appropriate.

Class 4 (Open Space)

Class 4 features include public and private parks, sports fields, publicly-owned open space, privately-owned open space, some storm water management facilities and cemeteries not classified as Class 1 through Class 3 above. Class 4 lands are not specifically regulated; however, the general environmental objectives of the Town’s Official Plan apply.

Schedule B of the Town of Stoney Creek Official Plan illustrates the SCONES lands. Within the study area of the SCUBE West Subwatershed Study, these include a single Class 1 feature (the Regionally-designated Devil’s Punch Bowl Escarpment ESA), four Class 2 features and a number of Class 3 and Class 4 features. The majority of the Class 2 and Class 3 features are located within the portion of the study area that is subject to the Fruitland-Winona Secondary Plan (Figure 3.2).

To protect Class 1 features, Amendment 92 requires that an Environmental Impact Statement (EIS) be completed to address development proposals within or adjacent to ESAs. The EIS must demonstrate that ecological functions will be maintained and that the effects of the proposed development have been identified and will be minimized through mitigation measures.

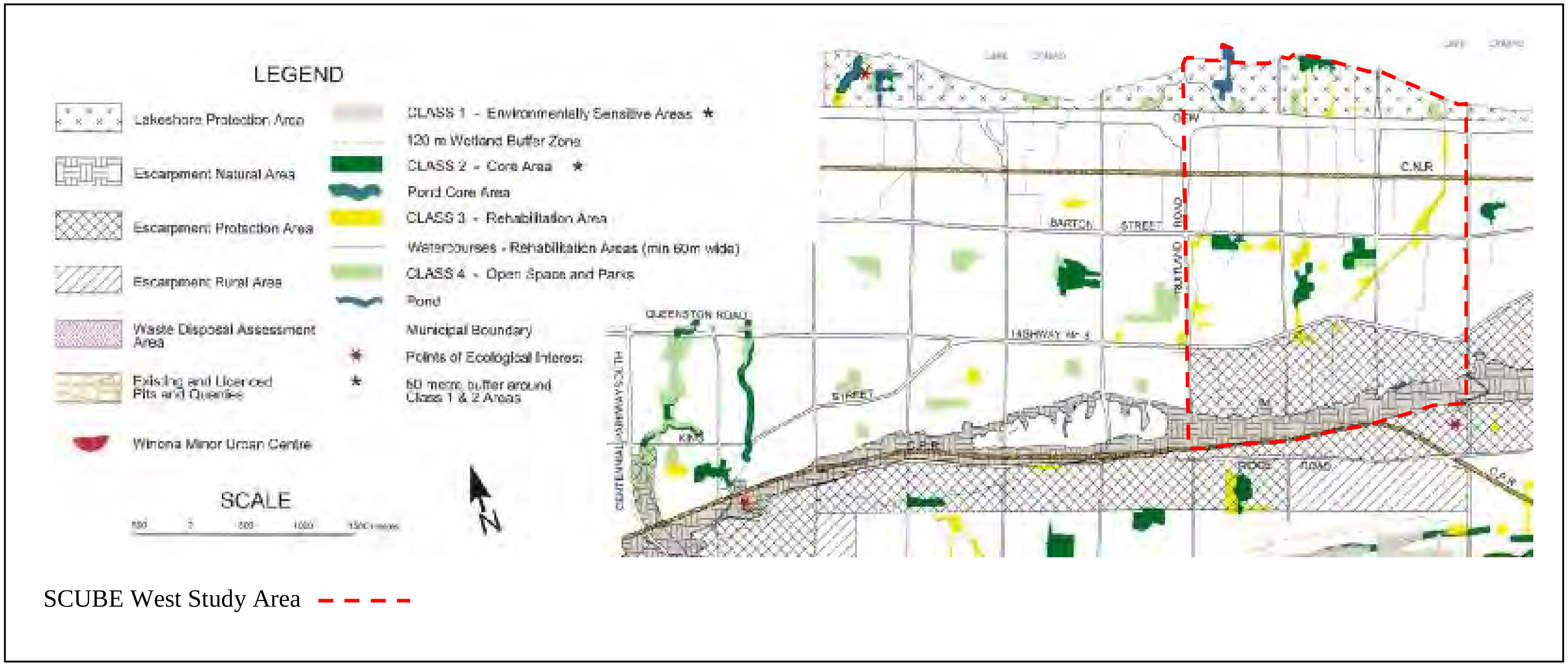


Figure 3.2: Excerpt of Schedule B of Town of Stoney Creek Official Plan showing the study area of the SCUBE West Subwatershed Study.

To protect Class 2 features, Amendment 92 requires that development in Core Areas be accompanied by an Environmental Design Analysis (EDA) to define Core Area boundaries and buffer zones and to integrate the design of the development proposal in a manner that protects or enhances as much as possible the important ecological conditions of the Core Area.

To assist in the protection of streams, Amendment 92 to also requires that a 30 m buffer from the stable top-of-bank on either side of MNR Type 1 and 2 watercourses be established where possible.

3.1.2.3 City of Hamilton Official Plan

Lands subject to the Fruitland-Winona Secondary Plan are located within the planning area of the City of Hamilton's Urban Official Plan. Section C.2 of this Plan defines a Natural Heritage System(NHS) (Figure 3.3). The NHS consists of the Protected Countryside of the Greenbelt Plan, the planning area of the Niagara Escarpment Plan, and Core Areas and Linkages identified by the City, based on the requirements of the Provincial Policy Statement (City of Hamilton 2009b).

The Plan defines Core Areas as Key Natural Heritage Features (KNHF), Key Hydrologic Features (KHF) and Local Natural Areas. In turn, the Plan defines these elements as follows:

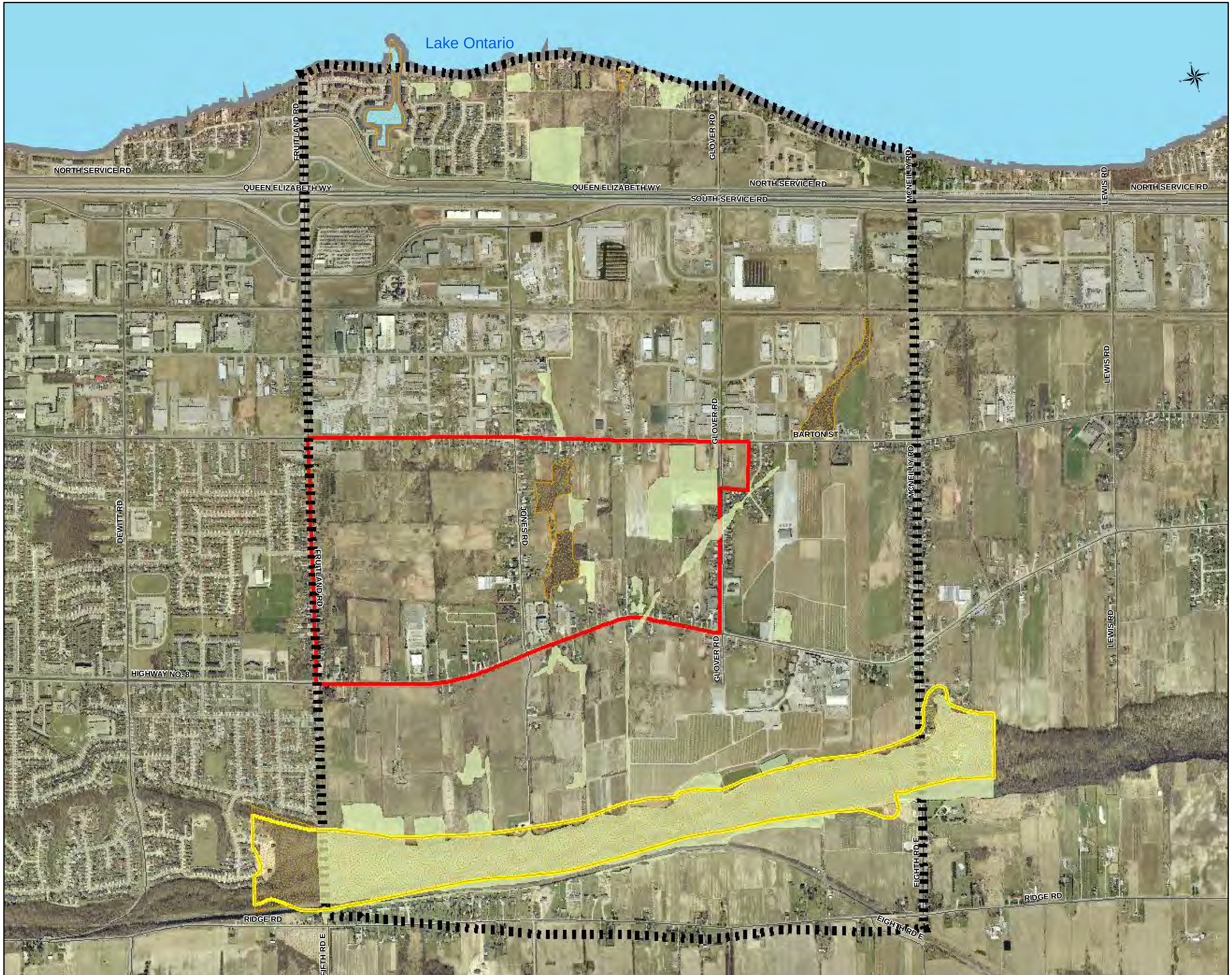
Key Hydrologic Features include the following:

(1) Permanent and intermittent streams;
(2) Lakes (and their littoral zones);
(3) Seepage areas and springs; and,
(4) Wetlands.

Key Natural Heritage Features include the following:

(1) Significant habitat of endangered, threatened, and special concern species;
(2) Fish habitat;
(3) Wetlands;
(4) Life Science Areas of Natural and Scientific Interest (ANSIs);
(5) Significant valleylands;
(6) Significant woodlands;
(7) Significant wildlife habitat;
(8) Sand barrens, savannahs, and tallgrass prairies; and
(9) Alvars.

The Plan defines Local Natural Areas as Environmentally Significant Areas (ESAs) as identified by the City of Hamilton, unevaluated wetlands, and Earth Science Areas of Natural and Scientific Interest. The Plan also defines Linkages as landscape areas that connect natural areas (City of Hamilton 2009b).



LEGEND:

- Study Area Boundary
- SCUBE West Boundary
- Core Areas
- ESA
- Linkages

NOTES:

0 100 200 400 600 800 1,000
Meters

Hamilton

Aquafor Beech Limited

SCUBE WEST SUBWATERSHED STUDY

City of Hamilton Urban Official Plan
Natural Heritage Syatem

FIGURE No. 3.3

DATE: June 7, 2010

The Plan's Schedule B (Natural Heritage System) illustrates Core Areas and Linkages, while Schedules B1-B8 (inclusive) illustrate specific KHF, KNHF and Local Natural Areas. These Schedules identify the following NHS elements within the lands subject to the Fruitland-Winona Secondary Plan:

- Two Core Areas are located along Watercourse 6 and four Linkages are scattered between Barton Street to the north, Highway 8 to the south, Jones Road to the west and Glover Road to the east. According to Schedules B-2 and B-4, both Core Areas are considered significant woodlands and a portion of one is a wetland.

- ScheduleB-4 shows two small wetlands located along Watercourse 7. According to Schedule B-2, one of these wetlands is also considered a significant woodland.

- Schedules B-5 and B-8 identify Key Hydrologic Features, including (i) Lakes and Littoral Zones and (ii) Streams, respectively. Schedule B-5 identifies three small features between Barton Street to the north, Highway 8 to the south, Fruitland Road to the west and Jones Road to the east. Schedule B-8 identifies Watercourses 5, 6 and 7 as Streams.

As previously noted, there are no Environmentally Significant Areas within the SCUBE West lands. However, the Devil's Punch Bowl Escarpment Environmentally Significant Area (ESA) extends along the southern edge of the study area of the SCUBE West Subwatershed Study.

Section C2 of the Urban Official Plan outlines policies regarding the designation and management of the City of Hamilton's NHS. Sections 2.3, 2.5 and 2.7 are particularly relevant to the SCUBE West lands.

Section 2.3.3 of the Plan states that the natural features and ecological functions of Core Areas are to be protected and enhanced. To accomplish this, vegetation removal and encroachment into Core Areas are generally not permitted and appropriate vegetation protection zones are to be applied to all Core Areas.

Section 2.5.10 of the Plan outlines guidelines for the minimum width of vegetation protection zones. These guidelines are summarized in Table 3.1. Section 2.5.11 of the Plan further states that widths are to be determined on a site-specific basis by considering factors such as the sensitivity of the habitat, the potential impacts of the proposed land use, the intended function of the buffer and the physiography of the site. Section 2.5.13 notes that narrower vegetation protection zone widths may be considered where an Environmental Impact statement confirms that a reduced vegetation protection zone will not negatively impact the existing features and functions of the Core Area.

Section 2.7 of the Plan states that it is intended that Linkages be protected and enhanced to sustain the NHS wherever possible. Section 2.7.2 of the Plan states that the City shall encourage the connection of Core Areas through the identification of Linkages; Section 2.7.4 further states that the City shall require the incorporation of Linkages into the design of new development requiring approval by the Plan to retain and enhance the cultural, aesthetic and environmental quality of the landscape, where possible.

Table 3.1: Guidelines for Minimum Vegetation Protection Zone Widths as defined by the Hamilton Urban Official Plan.

Feature	City of Hamilton Guideline for Minimum Vegetation Protection Zone
Coldwater Watercourse and Critical Habitat	30-metre vegetation protection zone on each side of the watercourse, measured from the bankfull channel
Warmwater Watercourse and Important and Marginal Habitat	15-metre vegetation protection zone on each side of the watercourse, measured from the bankfull channel.
Provincially Significant Wetlands and Locally Significant Wetlands (all evaluated wetlands)	30-metre vegetation protection zone, measured from the boundary of the wetland, as approved by the Conservation Authority or Ministry of Natural Resources
Unevaluated wetlands	Unevaluated wetlands greater than 2 hectares in size require a 30-metre vegetation protection zone, measured from the boundary of the wetland, as approved by the Conservation Authority or Ministry of Natural Resources. Unevaluated wetlands 2 hectares or less in size require a 30-metre vegetation protection zone, unless an Environmental Impact Statement recommends a more appropriate vegetation protection zone.
Woodlands	10-metre vegetation protection zone, measured from the edge (drip line) of the woodland.
Significant woodlands	15-metre vegetation protection zone, measured from the edge (drip line) of the significant woodland.
Areas of Natural and Scientific Interest (ANSI)	Life and Earth Science ANSIs require a 15-metre vegetation protection zone.
Valleylands	As required by the relevant Conservation Authority.

3.2 Environmental Features

3.2.1 Overview

The following sections provide an overview of the environmental features and functions of the study area of the SCUBE West Subwatershed Study. The natural ecosystem that existed prior to human settlement has been altered. Activities that have resulted in change include agricultural practices, construction of roads, highways, buildings and industries.

Defining the current state of the environment, as well as the relationship between each feature is necessary in order to characterize key environmental functions, define opportunities and constraints associated with future development, and to ultimately establish alternative strategies to protect, enhance or restore the environmental features over time.

For the purposes of this study, the term environmental feature has been used to describe various environmental or water related attributes which presently exist within the study area of the SCUBE West Subwatershed Study. These include the following:

- terrestrial features, including landforms, vegetation, wetlands and wildlife;
- aquatic features, including aquatic habitats, aquatic vegetation and aquatic communities;
- surface water resource features, including the quantity and quality of water in the streams, and associated floodplain features;
- groundwater resources, including the quantity and quality of water which is recharged and discharged from the groundwater table; and
- stream morphologic features including erosion.

It is important to recognize that environmental features can be highly inter-related because of their ecological functions and environmental pathways or linkages. For example, a vegetated floodplain feature may provide conveyance for floods and spring melts, provide habitat for plants and animals and provide shade for the watercourse, maintaining cool water temperatures for fish.

3.2.2 Surface Water Resources

The surface water component of this study reviews the existing stormwater drainage patterns within the study area of the SCUBE West Subwatershed Study and defines flood hazard lands through hydrologic / hydraulic modeling and floodplain mapping.

The primary function of a floodplain is the conveyance of flood waters during extreme storm events and spring melts. It is dependent upon the shape of the channel and associated floodplain, the flow rate and the location of structures (buildings, roads, etc.). Hamilton Conservation Authority regulates development applications within flood-susceptible areas such as the floodplains of watercourse systems. Future urban development is not permitted within the Regulatory Floodplain limits. Floodline mapping was undertaken for this study to identify areas susceptible to flooding under Regulatory Flood conditions. For this study area, Hamilton Conservation Authority defines the Regulatory Flood as the 100-year flood event.

3.2.2.1 Existing Drainage Patterns

Existing drainage patterns are illustrated in Figure 3.4. As shown, the study area is drained by three main watercourses:

- Watercourse 5 – This watercourse originates in the escarpment. The creek drains north from Highway 8 to CNR and a confluence with a tributary from the west. The creek continues to drain north to QEW and a confluence with the diversion of flow from Watercourse 6. The watercourse then outlets to Lake Ontario. Currently, a majority of the stormwater flows are conveyed to Watercourse 5 via overland flow routes, with the exception of a storm sewer system located along Fruitland Road. Commercial lands between Barton Street and QEW also discharge to Watercourse 5 via roadside ditches and channels.

- Watercourse 6 – This watercourse originates in the escarpment as two small tributary gullies. These two small tributaries drain north and join together at Highway 8. The creek then drains north from Highway 8 to CNR and is then diverted to Watercourse 5. Currently, a majority of the stormwater flows are conveyed to Watercourse 6 via overland flow routes. Commercial lands between Barton Street and QEW also discharge to Watercourse 6 via roadside ditches and channels.

- Watercourse 7 – This watercourse originates in the escarpment as two small tributary gullies. These two small tributary gullies drain northeast from Highway 8 to CNR. From here, the two small tributary gullies join together and drain north to QEW. Another tributary from the east side of the study area connects with Watercourse 7 at the QEW, then outlets to Lake Ontario. Currently, a majority of the stormwater flows are conveyed to Watercourse 7 via overland flow routes, with the exception of a small storm sewer system servicing the commercial area along Arvin Avenue. Currently, a majority of the stormwater flows are conveyed to Watercourse 7 via overland flow routes and roadside ditches.

Further descriptions and photographs for the main stream reaches are provided in Section 3.2.4.

3.2.2.2 Hydrology

Hydrology is the science which deals with the interaction of water and land, and the processes by which precipitation is transformed into runoff to the receiving watercourses or infiltrated into the groundwater system. One of the most dramatic changes brought about by urbanization is the change in stream hydrology. For example, the replacement of vegetation and undisturbed terrain with impermeable surfaces (i.e. pavement, roof tops, graded surfaces and the provision of an underground storm drainage network) results in greater interception of water that would naturally infiltrate into the ground, and instead provides a direct and rapid transport of surface runoff to streams.

As a result, groundwater recharge diminishes, which in turn could potentially affect baseflows within streams which rely on groundwater discharge. A more rapid rate of stormwater runoff from rainfall events can result in an increase in the total volume, peak flow and frequency of runoff occurrences. Uncontrolled, these hydrologic changes can result in increases in flooding, channel erosion, sediment transport, and pollutant loadings. These changes can also cause

SCUBE West

Subwatershed Study - Phase 1

Legend

- SCUBE WEST SUBWATERSHED
- STORM SEWER
- WATERCOURSE
- MONITORING STATIONS

Scale: N.T.S.

Figure 3.4

Hydrologic Model Setup

Aquafor Beech Limited

deterioration in natural channel morphology, fish and wildlife habitats, recreational opportunity and aesthetics.

It is important that the existing hydrologic characteristics of the study area and its watercourses be established. This information is critical in defining existing flood characteristics, defining Regulatory floodplain limits, and providing key information on the selection and design of stormwater management facilities for future urban development lands. For this study hydrologic modeling was undertaken to define flood flows within Watercourses 5, 6 and 7.

3.2.2.2.1 Model Selection and Setup

Initially, the hydrologic model selected for application in this study was MIKE-11. Streamflow and rainfall monitoring data from the winter of 2009 to summer 2010 was used to setup and adjust the model. Draft results from the MIKE-11 model were then reviewed with Hamilton Conservation Authority staff who expressed concerns over the use of the model for floodplain mapping purposes due to the lack of monitoring data and the number of points on the rating curve. As such, it was recommended that the draft hydrology be re-visited through new monitoring and modelling in 2012.

Because the primary focus and purpose of the modelling was for floodplain mapping, the updated modelling was undertaken using the Visual Otthymo model. The model can be used to simulate watershed rainfall-runoff response for a mix of urban and rural land cover, such as that present in the study area watersheds.

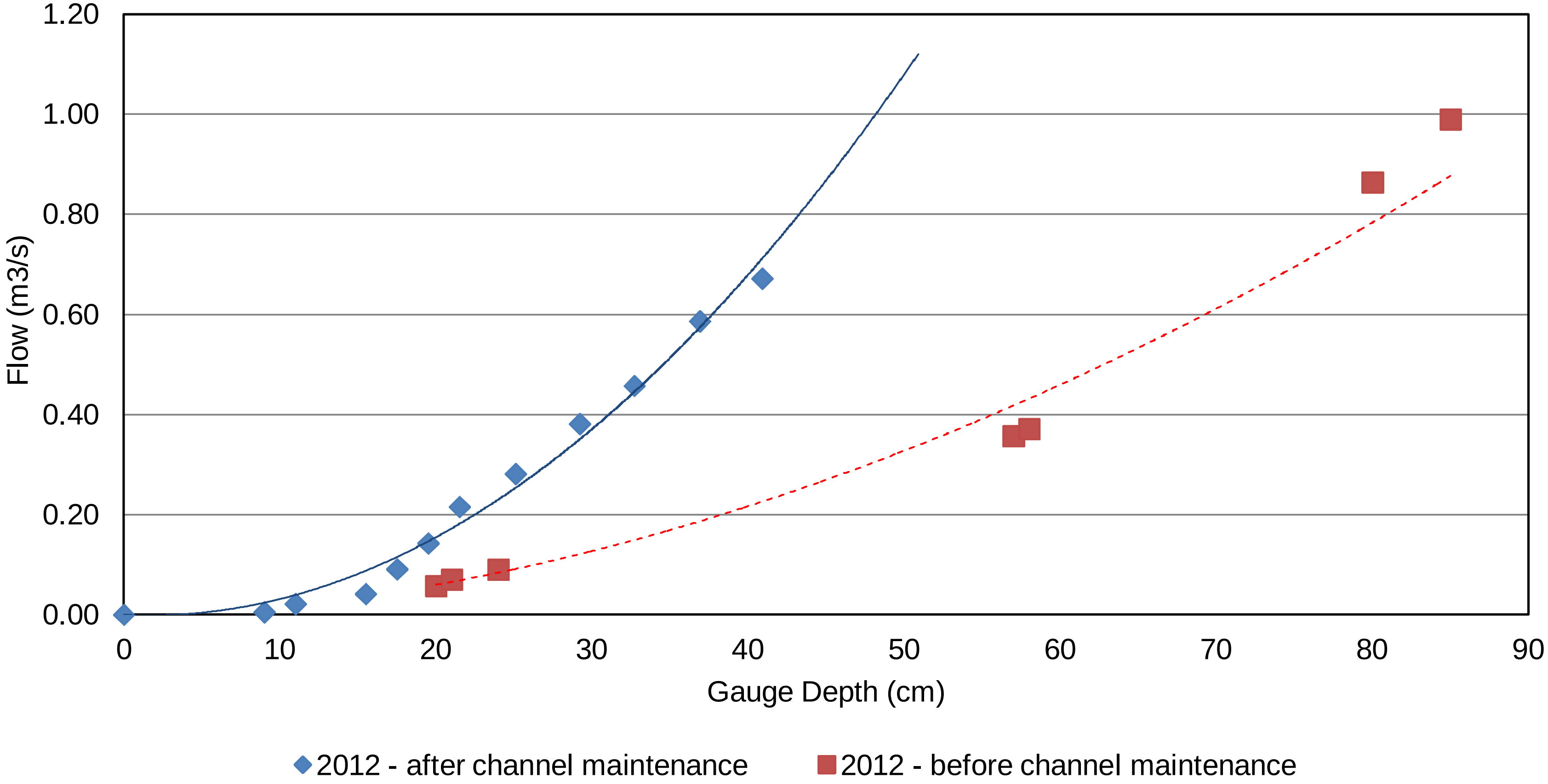
As illustrated in Figure 3.4, the Study Area was divided into approximately 45 subcatchments in order to provide peak flow estimates at key locations. Air photos, soils and landuse mapping were used to derive the model parameters, including drainage areas, runoff coefficients, percent imperviousness, basin slopes, and channel slopes. A summary of subcatchment parameters used in the hydrologic model is provided in Appendix A**.**

3.2.2.2.2 Streamflow and Precipitation Monitoring

Streamflow and rainfall monitoring was undertaken through the summer and fall of 2012 in support of the updated hydrologic modelling. A precipitation gauge was installed at the institutional facility at Jones Road and Highway 8, and streamflow gauges were also installed in Watercourse 5 and 6 near the South Service Road (Figure 3.4). The monitoring data was subsequently used to calibrate the hydrologic model (Section 3.2.2.2.3).

As part of the monitoring program, spot flow measurements were undertaken and correlated to the water level measurements at the two streamflow gauge sites in order to develop rating curves for each location. Part way through the monitoring period, on 03 July 2012, maintenance activities were undertaken by the city to clear debris and vegetation from the channels. As a result, two sets of rating curves were developed for each gauge; one for the period of record before the channel maintenance works and one for the period after the works. The resulting rating curves are illustrated in Figure 3.5 and Figure 3.6. As shown, sufficient spot flow measurements were taken to develop representative rating curves at both locations. These rating

FIGURE 3.5: Watercourse 5 Streamflow Gauge Rating Curve Development



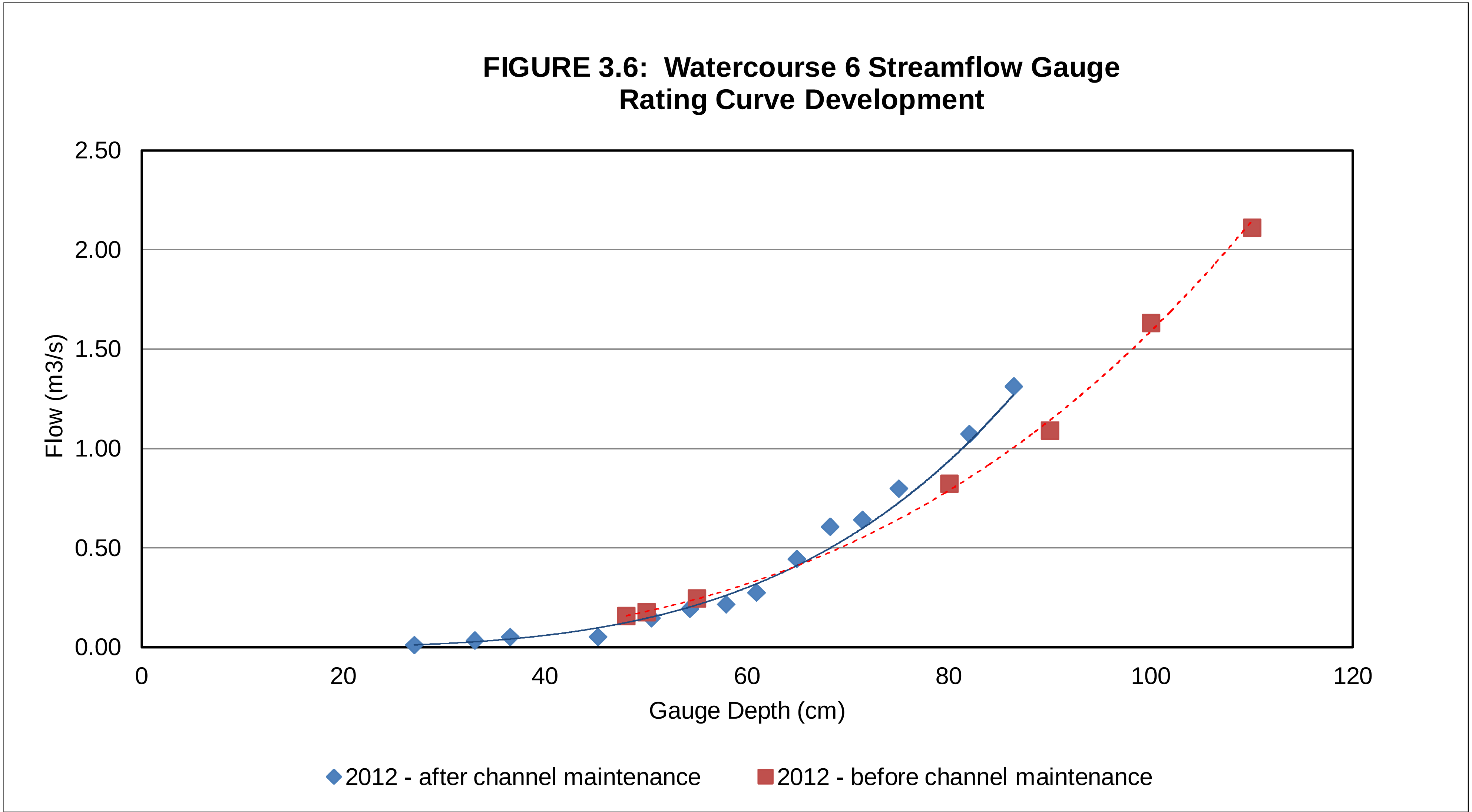


FIGURE 3.6: Watercourse 6 Streamflow Gauge
Rating Curve Development
Flow (m3/s)
2.50
2.00
1.50
1.00
0.50
0.00
0
20
40
60
80
100
120
Gauge Depth (cm)
2012 - after channel maintenance
2012 - before channel maintenance

curves were used to translate the water level monitoring data into hydrographs for use in model calibration.

3.2.2.2.3 Model Calibration

The basic hydrologic model setup was refined through calibration to ensure that the model was representative of the study area.

The rainfall and streamflow monitoring data was reviewed to identify potential rainfall-runoff events for use in the model calibration. The summer months were found to be relatively dry, with only a few significant rainfall-runoff events. A large frontal event associated with the remnants of Hurricane Sandy impacted the study area in late October.

Several candidate rainfall-runoff events from the summer of 2012 were screened and three were selected for model calibration. The late-October Hurricane Sandy rainfall event was selected for model verification. The rainfall depths for the calibration-validation events are summarized below:

- 6 June 2012 (model calibration), total rainfall = 14mm;
- 13 July 2012 (model calibration), total rainfall = 11.1mm;
- 27 July 2012 (model calibration), total rainfall = 50.9mm; and
- 27-30 October 2012 Hurricane Sandy (model verification), total rainfall = 63.7mm.

The selected storm events include the largest rainfall depths captured during the monitoring period. The events also cover storms ranging from short, intense summer thunderstorms, to the large frontal system recorded in the fall.

Observed hydrographs at the each of the two gauge sites were used to calibrate the model. In the calibration process, emphasis was placed first on minimizing the differences between observed and simulated runoff volumes, then on minimizing the differences between observed and simulated peak flow rates, and matching the general hydrograph timing and shape.

Simulated runoff volumes were calibrated by adjusting the soil curve number (CN) and initial abstraction (IA) parameters. This was done on a storm-by-storm basis to account for variable antecedent moisture conditions which were often very dry for the summer events. Peak flow rates and general hydrograph shape were then calibrated to better fit the observed data by adjusting the initial estimates of time-to-peak (Tp) and Manning’s roughness (n).

Once a reasonable set of results were obtained for the calibration events, other observed hydrograph from the 27-30 October event was used to verify the model calibration. Figure 3.7 and Figure 3.8 illustrate the results from the model calibration and verification process for Watercourse 5 and Watercourse 6, respectively. Table 3.2 compares observed and simulated runoff volumes and peak flows.

As illustrated, good results were obtained through calibration, with the simulated peak flow rates within approximately 0.5 m^3/s, or less, of observed values for all events at both gauge sites. In

FIGURE 3.7: Hydrologic Model Calibration-Validation Results - Watercourse 5

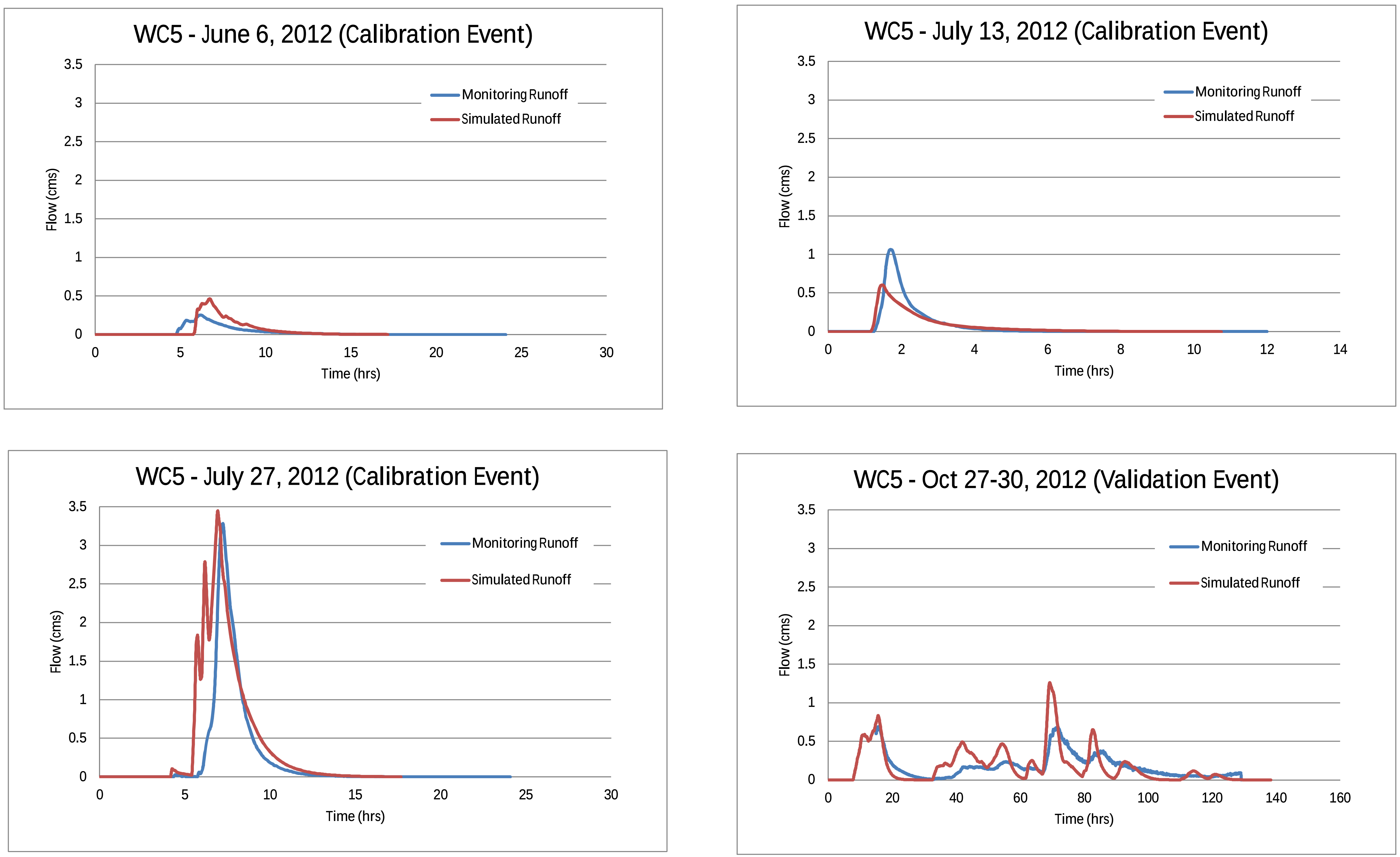


FIGURE 3.8: Hydrologic Model Calibration-Validation Results - Watercourse 6

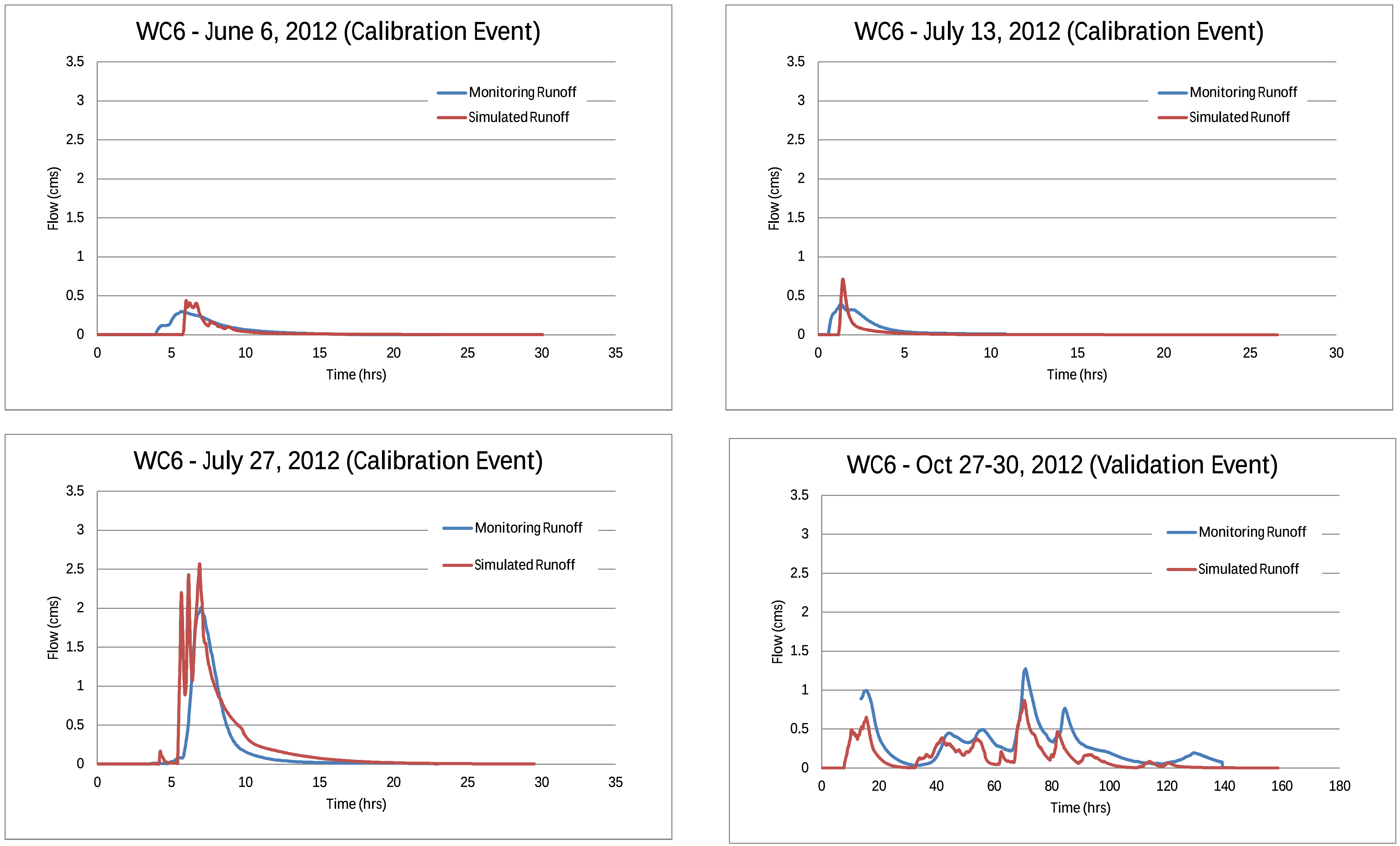


Table 3.2
Hydrologic Model Calibation/Validation Results

		Watercourse 5			
	Rainfall (mm)	Runoff (mm)		Peak Flow (cms)	
Storm		Observed	Simulated	Observed	Simultated
Calibration Event					
June 6, 2012	14	1.03	1.48	0.25	0.45
July 13, 2012	11.1	1.22	1.04	1.05	0.61
July 22, 2012	50.9	7.03	10.50	3.28	3.44
Validation Event					
Oct 27,2012	68.5	29.51	28.57	0.69	1.26

		Watercourse 6			
		Volume (mm)		Peak Flow (cms)	
Storm		Observed	Simulated	Observed	Simultated
Calibration Event					
June 6, 2012	14	2.01	1.44	0.30	0.44
July 13, 2012	11.1	1.53	0.90	0.39	0.71
July 22, 2012	50.9	7.22	10.39	2.00	2.56
Validation Event					
Oct 27,2012	68.5	48.56	33.69	1.28	0.87

general, the simulated hydrograph characteristics (i.e., volume, peak flows, shape) are reasonable.

3.2.2.2.4 Comparison to Historic Model Results

Once calibrated, the updated hydrologic model was then used to compare simulated peak flows to previous flood flow estimates from a 1990 study by Philips. The exact storm depths used in the 1990 study is unknown, however it is understood that a 12-hour SCS rainfall distribution was applied. As part of another background study in 2007 by Dillon, a 12-hour SCS storm was applied in the Stoney Creek area with a total 100-year rainfall depth of 85.8mm. For the purposes of comparing the updated 2012 model results with the 1990 Philip study, this design storm was applied. The results of the comparison are provided in Table 3.3a.

It is important to note that a direct comparison between flow rates is not possible at many locations due to changes in landuse (i.e. Existing 1989 vs. Existing 2012), as well as watershed diversions that have taken place. Nonetheless, the results from the two models are summarized, for comparison purposes, in Table 3.3a, and demonstrate a reasonable level of agreement.

3.2.2.2.5 Flood Flow Estimates

The calibrated hydrologic model was then applied to estimate flood flow rates for use in floodplain mapping at key locations throughout the study area watercourses. The Regulatory Flood event in the study area for floodplain management purposes is based on the 100-year flood flow.

A design storm approach was used to estimate the peak flows for the SCUBE West study area. With a design storm approach, a rainfall input (i.e. duration, return period depth, and temporal distribution) is selected and design flows are determined using specified antecedent moisture conditions and a computational technique such as a hydrologic model. It is assumed with this approach that peak flows which are generated are of approximately the same return period as the applied design storm.

City of Hamilton guidelines (September, 2007) suggest design storm depths based on long term data from the Mount Hope rainfall gauge station. Further, the guidelines suggest that various combinations of design storm distributions and durations be tested with the model. The 6-hour SCS distribution was selected for application as it resulted in the largest flows, on average, over the study area watercourses.

Table 3.3b and Table 3.3c summarizes the estimated flows and runoff volumes at key locations throughout the SCUBE West study area for a 6-hour, 100-year SCS design storm with a total rainfall of 101.6mm. Results are presented for two landuse scenarios:

- Existing (2012) landuses; and
- Future landuses based on the City's Official Plan.

Table 3:3a: COMPARISON OF 1990 & 2012 HYROLOGIC MODELS

	Philips, 1990 model			Aquafor Beech Ltd., 2012 model		
		100-yr Flow (m3/s)			100-yr Flow (m3/s)	
Location	**Drainage Area (ha) (approx.)**	**Existing (1989) Landuse**	**Future Landuses (full build-out to escarpment)**	**Drainage Area (ha)**	**Existing (2012) Landuses**	**Ultimate Landuses (full build-out to escarpment)**
Design Storm Type		**SCS**	**SCS**		SCSII - HCA	**SCSII - HCA**
Rainfall Depth (mm)		**unknow**	**unknow**		85.79	**85.79**
Watercourse 5.0						
Highway 8	136.8	4.7	7.0	119.6	5.0	9.4
Barton Street	191.5	6.6	8.8	170.7	5.2	9.8
Arvin Ave	205.4	7.8	10.2	184.6	6.6	11.6
CNR (total)	254.9	12.8	16.0	237.7	8.2	14.5
South Service Road	267.5	13.2	17.2	253.6	9.7	
QEW (total)	288.8	13.4	18.1	273.9	10.8	16.7
Lake Ontario	325.6	13.0	19.4	547.3	18.3	27.1
Watercourse 6.0						
Barton Street	160.0	4.4	4.6	146.3	2.7	7.2
CNR	175.9	4.9	5.3	202.8	4.6	7.2
QEW/Diversion	185.6	4.9	5.3	218.7	7.7	10.9
Watercourse 6.1						
Barton Street	11.9	1.2	1.2	11.9	0.6	2.2
CNR	38.0	3.2	4.2	33.5	4.1	6.3
South Service Road	56.2	3.0	5.6	50.4	5.9	7.3
North Service Rd/Lake Ontario				71.0	7.9	
Lake Ontario	68.7	2.6	3.9			10.5
Watercourse 6.2						
CNR	3.2	0.2	0.7			0.6
South Service Rd				11.40	2.1	2.3
QEW	12.0	0.7	2.3			
North Service Rd/Lake Ontario				16.80	1.6	2.0
Lake Ontario	23.0	0.9	2.0			
Watercourse 6.3						
Arvin Road				16.70	3.6	4.1
CNR	12.6	0.5	2.6	16.70	3.6	4.1
South Service Road				30.30	5.4	6.5
QEW	21.3	0.9	4.0	30.30	5.4	6.5
North Service Rd/Lake Ontario				47.70	5.8	7.2
Lake Ontario	37.8	1.9	5.3	47.70	5.8	7.2
Watercourse 7.0						
East Branch - HWY 8	88.5	6.0	7.4	88.2	2.6	5.0
East Branch - Barton St	128.5	4.3	6.2	148.5	2.8	10.0
West Branch - HWY 8	111.5	1.7	1.7	115.5	3.4	8.9
West Branch -Barton Str	158.3	4.0	4.0	158	3.4	6.1
Confluence (Total) - South of Barton St	286.8	8.0	9.9	306.5	5.6	16.2
CNR	308.7	8.4	12.2	329.9	5.9	13.4
QEW (Upstream of 7.2)	345.5	9.9	17.3	353.6	6.6	13.2
Lake Ontario	352.1	10.3	18.1	400.9	8.9	19.5

Table 3.3b
SUMMARY OF ESTIMATED FLOOD FLOWS

Location	Drainage Area	Existing (2012) Landuse						Future (Offical Plan) Landuses					
	(ha)	2yr flow	5yr flow	10yr flow	25yr flow	50yr flow	100 yr flow	2yr flow	5yr flow	10yr flow	25yr flow	50yr flow	100yr flow
Design Storm Type		SCSII 6 hrs						SCSII 6 hrs					
Rainfall Depth (mm)		40.03	56.5	67.6	81.6	91.9	101.6	40.03	56.5	67.6	81.6	91.9	101.6
Watercourse 5.0													
Highway 8	119.6	1.6	2.9	4.0	5.4	7.0	8.2	1.6	2.9	4.0	5.4	7.0	8.2
Barton Street	170.7	1.8	3.3	4.4	5.5	7.0	8.2	3.1	5.5	7.3	9.4	11.1	13.6
Arvin Ave	184.6	2.3	4.1	5.4	7.1	8.8	10.2	3.8	6.4	9.0	11.6	13.9	16.5
CNR (total)	237.7	2.9	5.0	6.7	8.9	10.7	12.4	5.3	8.7	11.8	15.2	18.1	21.8
South Service Road	253.6	3.5	6.0	7.9	10.6	12.7	14.8	5.9	9.8	13.1	17.1	20.3	24.4
QEW (total)	273.9	3.9	6.6	8.8	11.5	13.4	15.4	6.9	11.1	14.1	17.3	20.3	23.9
Lake Ontario	547.3	5.8	10.6	14.4	19.5	23.3	27.1	9.7	17.0	21.7	28.3	33.2	38.9
Watercourse 6.0													
Barton Street	146.3	0.7	1.5	2.1	2.9	3.6	4.4	2.0	3.5	4.6	6.4	7.6	8.9
CNR	202.8	1.7	2.8	3.7	4.9	5.9	6.9	2.8	4.5	5.8	7.6	8.8	10.2
QEW/Diversion	218.7	3.1	4.9	6.4	8.4	9.9	11.4	4.5	7.1	8.9	11.5	13.4	15.6
Watercourse 6.1													
Barton Street	11.9	0.2	0.4	0.5	0.6	0.7	0.9	0.8	1.3	1.8	2.4	2.8	3.2
CNR	33.5	1.8	2.7	3.6	4.5	5.2	6.0	2.8	4.3	5.5	6.9	8.3	9.5
South Service Road	50.4	2.7	4.2	5.2	6.5	7.4	8.3	3.8	5.4	6.6	8.3	9.5	11.1
North Service Rd/Lake Ontario	71.0	3.4	5.4	6.7	8.6	10.0	11.4						
Lake Ontario								5.0	7.4	9.1	11.7	13.7	15.9
Watercourse 6.2													
CNR								0.3	0.4	0.5	0.7	0.8	0.9
South Service Rd	11.40	0.9	1.4	1.7	2.2	2.6	3.0	1.0	1.6	1.9	2.5	2.8	3.2
QEW													
North Service Rd/Lake Ontario	16.80	0.7	1.1	1.4	1.8	2.1	2.4	0.9	1.4	1.7	2.2	2.6	3.0
Lake Ontario													
Watercourse 6.3													
Arvin Road	16.70	1.6	2.4	3.1	3.9	4.6	5.2	1.9	2.9	3.6	4.5	5.2	6.2
CNR	16.70	1.6	2.4	3.1	3.9	4.6	5.2	1.9	2.9	3.6	4.5	5.2	6.2
South Service Road	30.30	2.3	3.6	4.7	6.0	7.0	8.1	2.9	4.5	5.7	7.2	8.5	10.0
QEW	30.30	2.3	3.6	4.7	6.0	7.0	8.1	2.9	4.5	5.7	7.2	8.5	10.0
North Service Rd/Lake Ontario	47.70	2.1	3.6	4.7	6.4	7.5	8.7	2.9	4.8	6.2	8.2	9.8	11.5
Lake Ontario	47.70	2.1	3.6	4.7	6.4	7.5	8.7	2.9	4.8	6.2	8.2	9.8	11.5
Watercourse 7.0													
East Branch - HWY 8	88.2	1.0	1.6	2.1	2.8	3.3	4.0	1.0	1.6	2.1	2.8	3.3	4.0
East Branch - Barton St	148.5	0.8	1.6	2.2	3.0	3.6	4.1	0.9	1.6	2.2	3.0	3.6	4.1
West Branch - HWY 8	115.5	1.1	1.9	2.7	3.6	4.6	5.5	1.1	1.9	2.7	3.6	4.6	5.5
West Branch - Barton St	158	1.2	2.0	2.7	3.6	4.8	5.6	2.0	3.4	4.5	5.8	7.3	8.5
Confluence (Total) - South of Barton St	306.5	2.0	3.3	4.4	6.0	7.6	9.0	2.9	4.9	6.4	8.5	10.4	12.2
CNR	329.9	2.4	3.9	4.9	6.4	7.6	9.0	3.6	5.7	7.1	9.3	11.4	13.3
QEW (Upstream of 7.2)	353.6	2.8	4.3	5.5	7.2	8.5	9.7	4.6	7.4	9.2	11.7	14.1	15.9
Lake Ontario	400.9	3.5	5.6	7.2	9.7	11.5	13.3	7.6	11.7	14.4	18.2	21.9	24.9

Table 3.3c
SUMMARY OF ESTIMATED RUNOFF VOLUMES

Location	Drainage Area	Existing (2012) Landuse						Future (Offical Plan) Landuses					
	(ha)	2yr flow	5yr flow	10yr flow	25yr flow	50yr flow	100 yr flow	2yr flow	5yr flow	10yr flow	25yr flow	50yr flow	100yr flow
Design Storm Type		SCSII 6 hrs						SCSII 6 hrs					
Rainfall Depth (mm)		40.03	56.5	67.6	81.6	91.9	101.6	40.03	56.5	67.6	81.6	91.9	101.6
Watercourse 5.0													
Highway 8	119.6	8.7	16.4	22.4	30.3	37.4	44.0	8.7	16.4	22.4	30.8	37.4	44.0
Barton Street	170.7	9.2	16.9	23.0	31.4	38.1	44.7	11.5	20.0	26.5	35.4	42.4	49.3
Arvin Ave	184.6	2.3	4.1	5.4	7.1	8.8	10.2	12.6	21.5	28.3	37.5	44.7	51.7
CNR (total)	237.7	10.8	19.4	26.0	35.1	42.1	49.1	14.9	24.7	32.1	41.9	49.5	57.0
South Service Road	253.6	11.5	20.3	27.1	36.3	43.5	50.5	15.6	25.7	33.1	43.1	50.9	58.4
QEW (total)	273.9	11.9	20.9	27.7	37.0	44.3	51.4	16.2	26.6	34.3	44.5	52.3	59.9
Lake Ontario	547.3	12.2	21.4	28.3	37.7	45.1	52.3	16.0	26.3	33.9	44.1	51.9	59.5
Watercourse 6.0													
Barton Street	146.3	7.7	14.9	20.6	28.7	35.1	41.4	9.8	17.7	23.8	32.2	38.9	45.4
CNR	202.8	10.6	19.1	25.7	34.6	41.6	48.6	13.9	23.4	30.4	40.0	47.4	54.6
QEW/Diversion	218.7	11.5	20.3	27.0	36.1	43.3	50.3	14.7	24.5	31.7	41.5	49.0	56.3
Watercourse 6.1													
Barton Street	11.9	12.3	22.6	30.4	40.9	49.1	57.0	21.6	34.4	43.6	55.7	64.8	73.6
CNR	33.5	18.6	31.0	40.0	51.8	60.7	69.3	25.4	39.7	49.6	62.4	72.0	81.2
South Service Road	50.4	20.1	32.7	41.7	53.6	62.5	71.1	25.8	40.0	49.9	62.6	72.2	81.2
North Service Rd/Lake Ontario	71.0	17.8	29.4	37.9	49.0	57.5	65.7						
Lake Ontario								23.4	36.7	46.1	58.2	67.4	76.2
Watercourse 6.2													
CNR								25.8	40.3	50.5	63.5	73.2	82.4
South Service Rd	11.40	22.3	35.2	44.4	56.4	65.4	74.0	24.3	37.9	47.4	59.7	69.0	77.8
QEW													
North Service Rd/Lake Ontario	16.80	19.4	31.3	39.9	51.1	59.7	67.9	22.1	34.9	44.0	55.8	64.7	73.3
Lake Ontario													
Watercourse 6.3													
Arvin Road	16.70	24.6	38.9	48.8	61.7	71.3	80.5	27.4	42.3	52.6	65.8	75.7	85.0
CNR	16.70	24.6	38.9	48.8	61.7	71.3	80.5	27.4	42.3	52.6	65.8	75.7	85.0
South Service Road	30.30	23.7	37.5	47.1	59.6	69.0	78.0	27.0	41.7	51.9	64.9	74.6	83.9
QEW	30.30	23.7	37.5	47.1	59.6	69.0	78.0	24.0	37.7	47.3	59.8	69.1	78.1
North Service Rd/Lake Ontario	47.70	20.3	32.8	41.8	53.5	62.4	70.9	24.0	37.7	47.3	59.8	69.1	78.1
Lake Ontario	47.70	20.3	32.8	41.8	53.5	62.4	70.9	24.0	37.7	47.3	59.8	69.1	78.1
Watercourse 7.0													
East Branch - HWY 8	88.2	6.0	11.3	15.7	21.8	26.8	31.9	6.0	11.3	15.7	21.8	26.8	31.9
East Branch - Barton St	148.5	7.0	13.5	18.7	26.0	31.8	37.6	7.2	13.7	19.0	26.3	32.1	38.0
West Branch - HWY 8	115.5	6.7	13.0	18.1	25.2	31.0	36.7	6.7	13.0	18.1	25.2	31.0	36.7
West Branch - Barton St	158	7.8	14.6	20.0	27.6	33.7	39.7	9.3	16.6	22.2	30.1	36.4	42.6
Confluence (Total) - South of Barton St	306.5	7.4	14.1	19.4	26.9	32.8	38.7	8.3	15.2	20.7	28.3	34.3	40.4
CNR	329.9	8.2	15.2	20.8	28.4	34.6	40.6	9.5	16.9	22.7	30.6	36.9	43.1
QEW (Upstream of 7.2)	353.6	8.7	15.9	21.6	29.4	35.6	41.7	10.6	18.4	24.4	32.7	39.1	45.5
Lake Ontario	400.9	9.1	16.5	22.3	30.3	36.6	42.8	12.2	20.7	27.1	35.8	42.6	49.2

The flood flows associated with the Future landuse scenario were selected for use in subsequent hydraulic modelling to define flood profiles and floodplain mapping. The design storm and landuse scenario selection was also discussed with Hamilton Conservation Authority staff to confirm that the above approach would be appropriate for the purposes of floodplain mapping.

3.2.2.3 Hydraulics and Floodplain Mapping

Hydraulic modelling and associated floodplain mapping were undertaken to define flood hazard lands for Watercourses 5, 6, and 7 through the Secondary Plan Area within the SCUBE West study area.

3.2.2.3.1 Watercourse 5 and 6

In 2006, Dillon Consulting initiated work on the City of Hamilton's "Municipal Class Environmental Assessment Study for Watercourse System Improvements of Watercourse 5 & 6". Subsequently, as part of a January 2011 Hydraulic Assessment, Dillon has also developed a HEC-RAS hydraulic model and draft floodline mapping for the SCUBE West Watercourses 5 and 6.

Description of existing condition

Within the study area boundary, there are six watercourse crossings on Watercourse 5.0 and six watercourse crossing on Watercourse 6.0, including crossings on the diversion channel along the north side of the QEW. The diversion channel stems from Watercourse 6.0 where flows are diverted westerly across the QEW at Jones Street. The channel continues along the north side of the highway before a confluence with Watercourse 5.0.

The Stoney Creek's Master Drainage Plan, MDP (Philips, 1990) and QEW Drainage Report, QEWDR(UMA) determined that crossings along Watercourse 5 and 6, especially at the QEW and the CN rail, were under capacity. These reports also confirmed the presence of overbank flooding due to flat overbank topography and limited channel capacities as shown in the FDRP mapping. Where MDP and QEWDR drainage improvements were not implemented, flooding and conveyance issues as described above still exist within Watercourse 5 and 6. Based on field inspections completed in support of the Draft EA document, the structural conditions of the culverts on Watercourse 5 and 6 appeared to be in good condition and/or required some minor repairs. The only exceptions are the culverts on Barton Street on Watercourse 5.0 and 6.0 which were deteriorated and required replacement.

Based on the FDRP mapping, the flood plain along several reaches of Watercourses 5.0 and 6.0 north of Barton Street to Lake Ontario can be described as wide and undefined with potential spills between watersheds.

With respect to the secondary watercourses, south of the QEW, there are six crossings on Watercourse 6.1 and five crossing on Watercourse 6.3. The MDP and the QEWDR determined that these secondary crossings, especially at the QEW and the CN rail, were under capacity. The Draft EA document determined that some of the recommendations outlined in the MDP and QEWDR were implemented and improved conveyance issues. However, the proposed diversions to reduce the number of secondary crossings or upgrades to these structures have not be implemented or confirmed, therefore culvert capacity issues are still a concern on Watercourse 6.1 and 6.3. Based on field inspections completed in support of the Draft EA document, the structural conditions of the culverts on Watercourse 6.1 and 6.3 appeared to be in good condition, and/or require some minor repairs. The culverts and their openings are significantly silted in, which limits the conveyance capacity.

The small size channels (shallow and narrow) and the flat overbank topography results in limited channel capacities and overbank flooding.

Hydraulic Model Selection

The hydraulic analysis was undertaken using the Hec-RAS hydraulic model by the U.S. Army Corps of Engineers which computes water surface profiles using the standard step method and routines to analyze bridge and culvert structures.

Cross-Sections and Parameters

A base model was assembled using ArcGIS software and the City of Hamilton DTM (2007). This spatial data was used to define channel cross-section, stream centrelines, and overbank locations. “Low flow” channel dimensions were also coded into the model base on field measurements conducted by the staff from the Hamilton Conservation Authority.

There are several areas of the watercourse that are not well defined and the HCA survey data in these areas illustrate channel inverts well below the resolution of the City’s DTM information. For the purpose of this study, an inferred stream centreline was generated based on contour interpretation, nearby HCA survey data, and air photo review. Floodplain mapping of these areas will be determined based on contour interpretation, the inferred stream centreline, and top widths evaluated from Hec-RAS. These areas are:

- Along Watercourse 5.0, immediately downstream of Fruitland Rd (between sections 2221 and 2150);
- Along Watercourse 5.0, halfway between Hwy 8 and Barton (between sections 1693.967 and 1537.457);
- Along Watercourse 6.0, downstream of Hwy 8 (between sections 2232.182 and 1785.033)

In addition to the main watercourse branches, an additional reach was modelled in between Watercourses 5.0 and 6.0 to represent the diversion upstream of the QEW. The reach is named Watercourse 5/6_combined and extra cross-sections were created downstream of the confluence to represent the diversion in the Hec-RAS model.

Culvert Structures and Parameters

Most bridge and culvert structures were coded into the model with data provided by the City of Hamilton based on survey data received January 18, 2010 including:

- Bridge/culvert dimensions;
- Material (i.e., concrete, steel, etc)
- invert/obvert elevations;
- road profiles

Additional surveys were completed by Aquafor Beech Limited in 2013 for the culvert crossings within the SCUBE West development lands:

- Watercourse 5 at Barton Street;
- Watercourse 5 at Fruitland Road; and
- Watercourse 6 at Barton Street.

Other inputs include entrance and exit loss coefficients and Manning's roughness values which were selected based on the type, condition and layout of the infrastructure, material and suggested values summarized in the Hec-RAS Reference Manual. Bounding cross-sections were adapted with increases to the expansion and contraction coefficients; 0.3 and 0.5 were used respectively as per the Hec-RAS Reference Manual.

Starting Surface Elevation

A sensitivity analysis was completed to determine the appropriate starting water surface elevations as input for the downstream boundary condition. Two scenarios were considered:

- Normal depth assuming an average slope of 0.005 m/m; and
- Assumed starting water surface elevation assuming a headwater elevation for crossings along the QEW.

For the secondary crossing, CulvertMaster was used to calculate maximum headwater elevations for the applicable QEW crossing and assuming a tailwater elevation at the downstream channel spill point. It was determined that the assumed starting water surface elevation resulted in higher initial starting downstream boundary conditions than the normal depth assumption (less than 2% difference). However, the upstream water levels under both assumptions equalized less than 200 m upstream and did not affect any upstream crossings with respect to hydraulics.

For the primary watercourse, the spill point elevation downstream of the QEW crossing was assumed as the starting downstream boundary elevation. This elevation is higher than the normal depth assumption by approximately 1 m but the upstream water levels equalized less than 300 m depth was assumed as the model's starting downstream boundary condition. summarizes the downstream boundary conditions for each assumption.

Table 3.4: Comparison of downstream conditions

Reach	Normal Depth (assumed s=0.005 m/m)	*Know Water Level	Difference (m)
5&6 combined	77.68	78.8	1.12
6.1	80.53	81.0	0.47
6.3	79.76	80.0	0.24

*Know water level for 5&6 combined reach based on downstream spill point and for 6.1/6.3 based on CulvertMaster analysis

Model Results

The Dillon study applied draft flood flows within the model to estimate the extent of the Regulatory floodplain. As with earlier floodplain mapping, previously completed in 1990 as part of the FDRP program, the Dillon study found that large overbank areas are susceptible to flooding within the lower reaches of the watercourses, particularly behind the CNR line as well as other areas behind the QEW and South Service Road. Further, due to the flat topography within the lower watercourse reaches, spilling of floodwaters between watersheds was also predicted. To investigate further, the Dillon study setup two versions of the hydraulic model:

- "Without spills" – this model assumes that all of the flood flows continue in the downstream direction without adjustment for possible losses due to spill out of the watershed;
- "With spills" – this model included the use of lateral weirs to simulate spills out of the watershed at select locations. In doing so, the flood flows were reduced in the downstream direction to account for the losses.
- The Dillon study then applied the HEC-RAS model to investigate potential bridge and culvert improvements to reduce the flood extents within these watercourses.

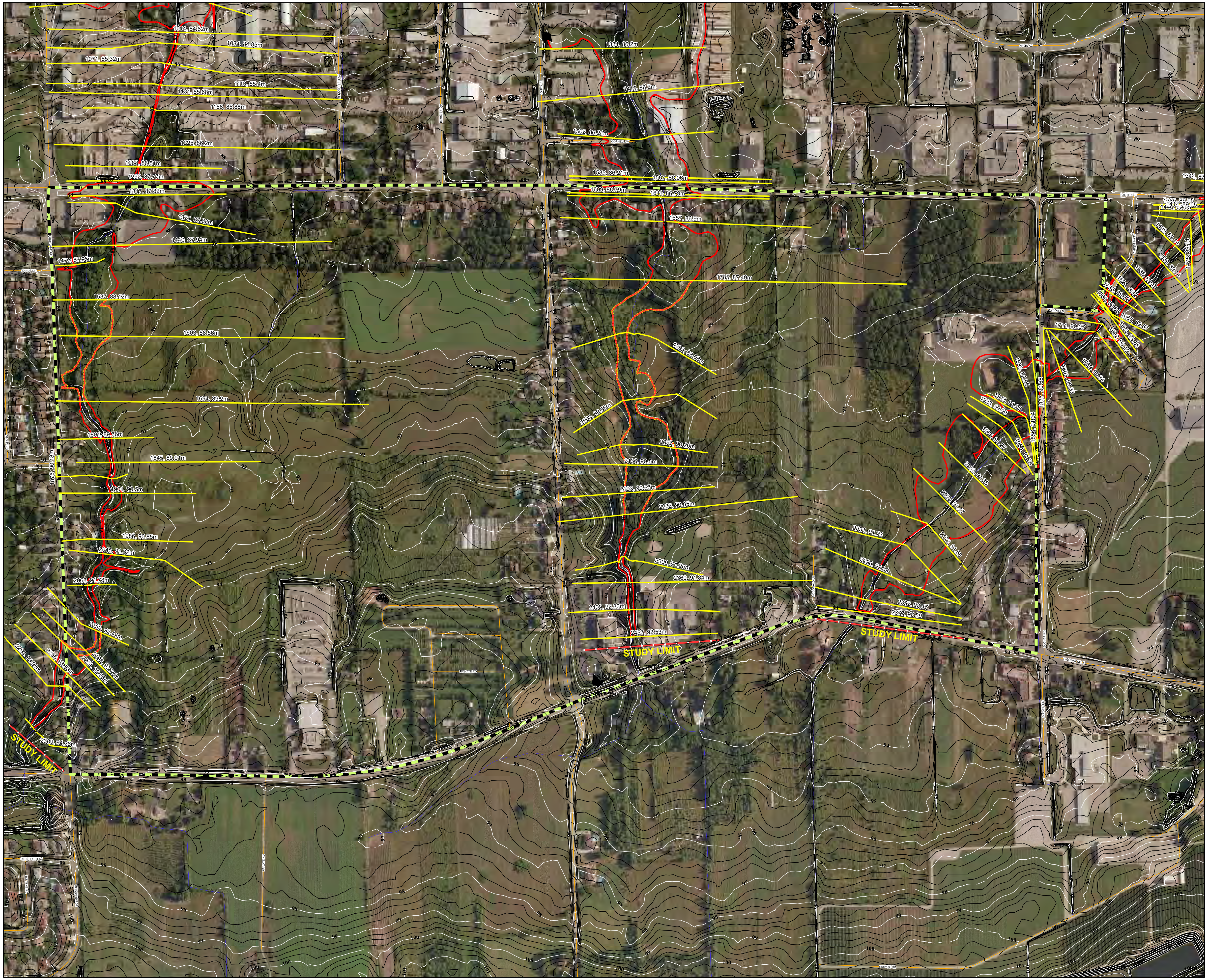
As part of this current Subwatershed Study, the two Dillon models (i.e. "with spills" and "without spills") were obtained for use in defining floodlines through the Secondary Plan Area within the SCUBE West study area. The updated floodlines are based on the flood flow estimates from the updated hydrologic modelling. As noted in Section 3.2.2.2.5, the flood flow estimates associated with Future landuses (Table 3.3b) were selected for application within the model. The resulting flood profiles and hydraulic model results are provided in Appendix A.

Results from the HEC-RAS model were exported and the HEC-GeoRAS extension and ArcGIS tools were applied to plot the resulting floodplain extents onto the topographic mapping. The resulting floodplain mapping extents are illustrated in Figure 3.9a (south of Barton Street) and Figure 3.9b (north of Barton Street).

For the purposes of this Subwatershed Study, floodline mapping efforts were focused on the Secondary Plan Area lands, south of Barton Street (Figure 3.9), to define the limits of future development and to aid in Block Planning Servicing studies within these lands. The model results and associated floodlines over the Secondary Plan Area lands are identical between the two models (i.e. "with spills" and "without spills") as all of the spill sites are located downstream of Barton Street.

Future refinement of the hydraulic model and floodline mapping is anticipated at the block planning stage over those reaches where the creek location is poorly defined on the existing topographic mapping. Discussions between the City of Hamilton and HCA planning staff identified the requirements as follows:

- A Block Servicing Strategy, for the area identified as Block 1 on Map B.7.4-4 – Block Servicing Strategy Area Delineation, shall determine the floodplains for the following two locations:
    - Along Watercourse 5.0, immediately downstream of Fruitland Road (between sections 2221 and 2150); and,
    - Along Watercourse 5.0, halfway between Highway No. 8 and Barton Street (between sections 1693.967 and 1537.457).



KEY MAP

LEGEND:

- Potential Spill Location
- Station, 100 Year Flood Elevation
- 100 Year Storm Floodline
- 100 Year Storm Floodline*
- Contour - 1m Interval
- Contour - 0.25m Interval
- SCUBE West Boundary
- Streams

NOTES:

*Further Analyses Required to Refine and Finalize Floodlines (Future Studies)

0 100 200 400

Meters

Hamilton

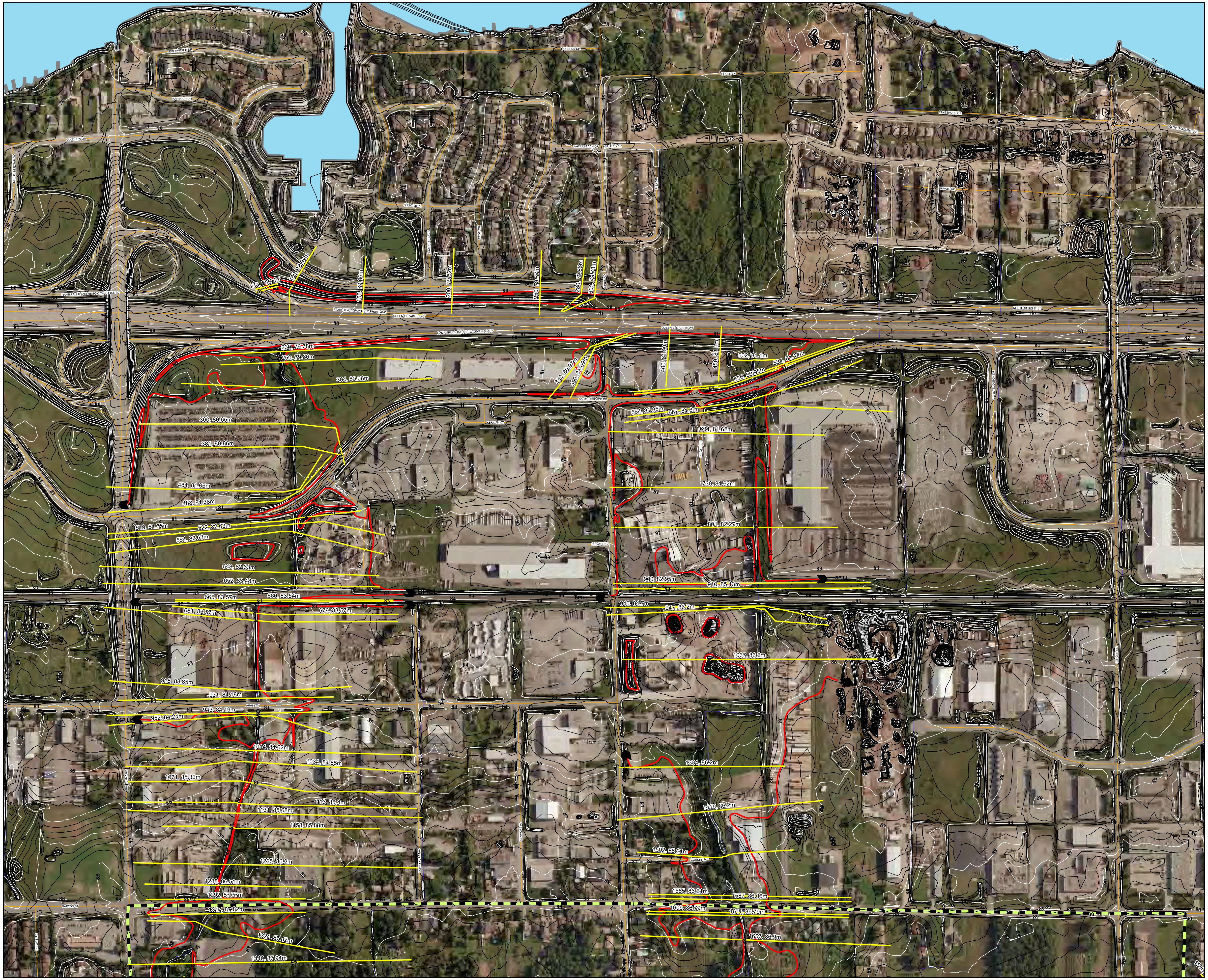
Aquafor Beech

STONEY CREEK URBAN BOUNDARY EXPANSION FLOODPLAIN MAPPING
Watercourse 5, 6 & 7

100 Year Storm Without Spills

FIGURE No. 3.9a

DATE: May 2013



KEY MAP

LEGEND:

- Potential Spill Location
- Station, 100 Year Flood Elevation
- 100 Year Storm Floodline
- 100 Year Storm Floodline*
- Contour - 1m Interval
- Contour - 0.25m Interval
- SCUBE West Boundary
- Streams

NOTES:

*Further Analyses Required to Refine and Finalize Floodlines (Future Studies)

0 100 200 400

Meters

Hamilton

Aquafor Beech Ltd.

STONEY CREEK URBAN BOUNDARY EXPANSION FLOODPLAIN MAPPING
Watercourse 5, 6 & 7

100 Year Storm Without Spills

FIGURE No. 3.9b

DATE: May 2013

- A Block Servicing Strategy, for the area identified as Block 2 on Map B.7.4-4 – Block Servicing Strategy Area Delineation, shall determine the floodplains for the following location:
- Along Watercourse 6.0, downstream of Highway No. 8 (between sections 2232.182 and 1785.033).

With respect to the creek reaches located north of Barton Street (Figure 3.10), several potential spill points were identified. Precise delineation of the spills were difficult to quantify due to the flat topography of the area, however, the locations of the spills are generally consistent with the results of the earlier 1990 FDRP mapping. Potential spills locations include the following:

- On Watercourse 5, floodwaters potentially spill west towards Fruitland Road, between South Service Road and Arvin Avenue (“with spills” and “without spills” models);
- On Watercourse 5, floodwaters potentially spill east towards Jones Road at the CNR (“without spills” model only);
- On Watercourse 6, floodwaters potentially spill west towards Jones Road, between the CNR to just south of the end of Arvin Avenue (“without spills” model only);
- On Watercourse 6, floodwaters spill east towards Watercourse 6.1 at the CNR (“without spills” model only);
- On Watercourse 6.1, floodwaters potentially spill west towards Watercourse 6.0 at the CNR and at Barton Street (“with spills” and “without spills” models);
- On Watercourse 6.1, floodwaters potentially spill east towards Watercourse 6.3 at the CNR (“with spills” and “without spills” models);
- On Watercourse 6.3, floodwaters potentially spill west towards Watercourse 6.1 at the CNR and Arvin Avenue (“with spills” and “without spills” models);
- On Watercourse 6.3, floodwaters potentially spill east towards Watercourse 7.0 at the CNR and Arvin Avenue (“with spills” and “without spills” models);

All of the potential spill points were located north of Barton Street, outside the Fruitland-Winona Secondary Plan (SCUBE West) area. Future refinement to the hydraulic model downstream of Barton Street and associated floodline mapping is anticipated to be undertaken as part of separate future Environmental Assessment studies.

Flood Levels

Table 3.5: Compares the FDRP and updated water levels at the upstream end of each crossing

	Watercourse 5.0 WSEL (m)		
Croosing ID	FDRP(1990)	Aquafor(2013)	Difference(m)
QEW	80.22	79.78	-0.44
South Service Road	81.13	81.75	0.62
Railway	83.49	83.54	0.05
Barton Street	87.72	87.82	0.1
Fruitland Road	93.37	93.58	0.21
Croosing ID	Watercourse 6.0 WSEL (m)		

	FDRP(1990)	Aquafor(2013)	Difference(m)
QEW	80.57	80.97	0.4
South Service Road	81.19	81.35	0.16
Railway	84.83	84.7	-0.13
Barton Street	86.78	86.79	0.01
	Watercourse 7.0 WSEL (m)		
Croosing ID	FDRP(1990)	Aquafor(2013)	Difference(m)
QEW	81.59	79.46	-2.13
South Service Road	81.69	79.46	-2.23
Railway	85.76	83.87	-1.89
Barton Street	89.25	89.05	-0.2
Glover Road	90.92	91.04	0.12

The updated results show an increase in water level (0.62 m) at the South Service Rd crossing on Watercourse 5.0. The FDRP mapping considered flow reductions in spill areas and thus utilized lower flows at this crossing. The updated model did not account for flow reductions and thus resulted in a higher flood elevation. However, from , minimal changes in the lateral extents of the floodplain are observed. This is attributed to the significant spill point into Fruitland Road on the westside of the floodplain and the steep channel slopes on the east side of the floodplain and along South Service Road embankment. Improvements undertaken by MTO at the QEW are reflected in a reduction in the flood level on Watercourse 5 at this location.

3.2.2.3.2 Watercourse 7

A pair of HEC-RAS hydraulic models developed by AECOM for Watercourse 7 were provided to the study team for use in this study. It is understood that the models were developed as part of other environmental assessment studies investigating channel and culvert improvements. The models included:

- a base model for the reach of Watercourse 7 extending upstream from Lake Ontario to approximately Arvin Avenue;
- a second model which includes channelized watercourse improvements and an upgraded culvert structure at the CNR line.
- The second model was included over the appropriate reach within the base model, and then extended upstream from Arvin Avenue to Highway 8 as part of this study.

The model extension was undertaken as follows:

- representative cross-sections were coded into the model extension using ArcGIS software and the City of Hamilton's digital terrain model (DTM).
- culvert structures were surveyed and coded into the model. Survey information included opening dimensions, material, invert elevations, and road profile (overflow) elevations;
- "low flow" channel dimensions were coded into the model to match surveyed invert elevations;

- flood flow estimates from the updated hydrologic modelling (Section 3.2.2.2.5) were applied to the appropriate reaches within the model.

The resulting flood profiles and hydraulic model results for Watercourse 7 are provided in Appendix A.

The results from the HEC-RAS model were exported and the HEC-GeoRAS extension and ArcGIS tools were applied to plot the resulting floodplain extents onto the topographic mapping over the Secondary Plan Area, south of Barton Street. The resulting floodlines are illustrated in Figure 3.9.

Table 3.5 compares the FDRP and updated water levels at the upstream end of each crossing on Watercourse 7. As shown, channel and culvert crossing improvements on Watercourse 7 at the QEW have resulted in reduced flood elevations within the downstream reaches.

3.2.2.4 Water Quality

There is little background information available on the water quality for the watercourses within the study area, however, conditions were estimated, in a general manner, based on typical conditions found in other areas with similar land uses. Agricultural land uses are the dominant land use within the study area of the SCUBE West Subwatershed Study and the stream flow in these features is surface runoff dominated.

Watercourses 5, 6 and 7 are warmwater streams that are typically nutrient rich, with nutrients such as total phosphorus occurring at concentrations above the provincial water quality objective (PWQO) of 0.03 mg/l. Levels of bacteria, *E. coli* are also probably moderately high, in the order of 500 – 1000 cts/100 mls, well above the PWQO of 100 cts/100 ml. Trace metals, such as copper, lead and zinc, are likely close to the PWQO, however it is expected that concentrations of these parameters regularly exceed their respective guidelines in the vicinity of the QEW as a result of road runoff. Chloride concentrations may also be high in the vicinity of the QEW, however, it is unlikely that concentrations would exceed the fisheries guideline of 252 mg/l.

3.2.2.5 Constraints and Opportunities - Surface Water

Based on the above hydrologic and hydraulic assessment, future development constraints and opportunities related to surface water resources may be summarized as follows:

- No new development will be permitted within the potentially flood-susceptible lands defined by the Regulatory (100-year) Floodplain limits.

- Future development lands will require flood (quantity) control facilities to control post-development peak flows to pre-development levels in order to prevent increase to downstream flow rates and flood frequency. Water quality and erosion control requirements are discussed in Section 4.3.4 and 4.3.3, respectively.

- Source and conveyance control stormwater measures, where feasible, should be applied to preserve the existing hydrology and minimize increase in runoff volumes and flow rates. The potential to infiltrate stormwater associated with future development is discussed further in Section 4.3.2

3.2.3 Groundwater Resources

Hydrogeology is the study of water movement below the ground surface (groundwater). Precipitation, both as rain and snow, infiltrates below ground surface and temporarily stored underground. Where groundwater is stored in sand and gravel deposits or fractured bedrock, called aquifers, it is available to supply drinking water to local wells or to discharge as baseflow to adjacent streams.

Recharge areas, where water infiltrates into the groundwater system, are usually areas of highly permeable soils such as sands and gravels. Discharge areas are characterized by springs and seepage areas. These discharge zones supply streams with clear, cool and oxygenated water as baseflow to help support aquatic life.

A review of the geology and hydrogeology of the study area was undertaken in order to gain an understanding of the groundwater resources within the study area, including potential groundwater recharge and discharge locations. The main sources of information include:

- Hamilton Groundwater Resources Characterization and Wellhead Protection Partnership Study (Charlesworth and Associates and SNC Lavalin 2006);
- Quaternary Geology, Grimsby Area (Feenstra 1975):
- Bedrock Topography, Grimsby Area (Feenstra 1981).

Water well records, geology and soils maps were reviewed to characterize the groundwater system. In addition, the logs of several monitoring wells and piezometers on this and the contiguous property were provided by the City of Hamilton, including investigations by two firms:

- Stantec advanced three boreholes on the SCUBE West property in December 2009 and fitted with monitor wells.
- Jagger Hims advanced three boreholes on the continuous SCUBE East property in July 2007.

The SCUBE West area is characterized by a thin overburden of silty clay till (Halton Till) over weathered shale bedrock. Three boreholes on the property revealed overburden thickness between 1 and 3.7 metres. On the contiguous SCUBE East property, the overburden ranges between 3.0 and 9.1 metres in thickness.

The hydraulic conductivity of the bedrock is of the order of 10^{-6} metre/second. Based on the piezometric surface, it was concluded that areas above the Escarpment represent the dominant groundwater recharge regime in the Grimsby-Winona area, and groundwater discharge was anticipated further north extending to Highway 8 (Charlesworth and Associates and SNC Lavalin 2004, s. 4.2.4, 4.2.5 and Map 2.16D).

3.2.3.1 Physiography and Geology

The Niagara Escarpment and Lake Iroquois Plain represent the dominant physiographic features within the study area. The Niagara Escarpment marks the ancient shoreline of Lake Iroquois, and the Iroquois Plain represents the relatively flat lowlands between the escarpment and present day Lake Ontario. The SCUBE West lands are situated within the Iroquois Plain which is characterized by Queenston Shale bedrock overlain by Halton Till, with consists of silty clay till with fine sand lenses. An isolated area of sand and gravel deposits is located near the base of the Escarpment, south of Highway No. 8.

The geology of the Study Area is illustrated in Figure 3.11, and geologic cross-sections are illustrated in Figure 3.12 and Figure 3.13. As shown, the southern portion of the Iroquois Plain through the study area is characterized in large part by shallow bedrock with a relatively thin layer of Halton Till, often less than a metre in thickness and thickening to the north to 3+ metres.

Within the northern portion of the subwatershed, beginning north of Barton Street and extending to the Lake Ontario shoreline, the bedrock shelf drops off rapidly. Immediately north of the QEW, the Halton Till thickness exceeds 20 metres.

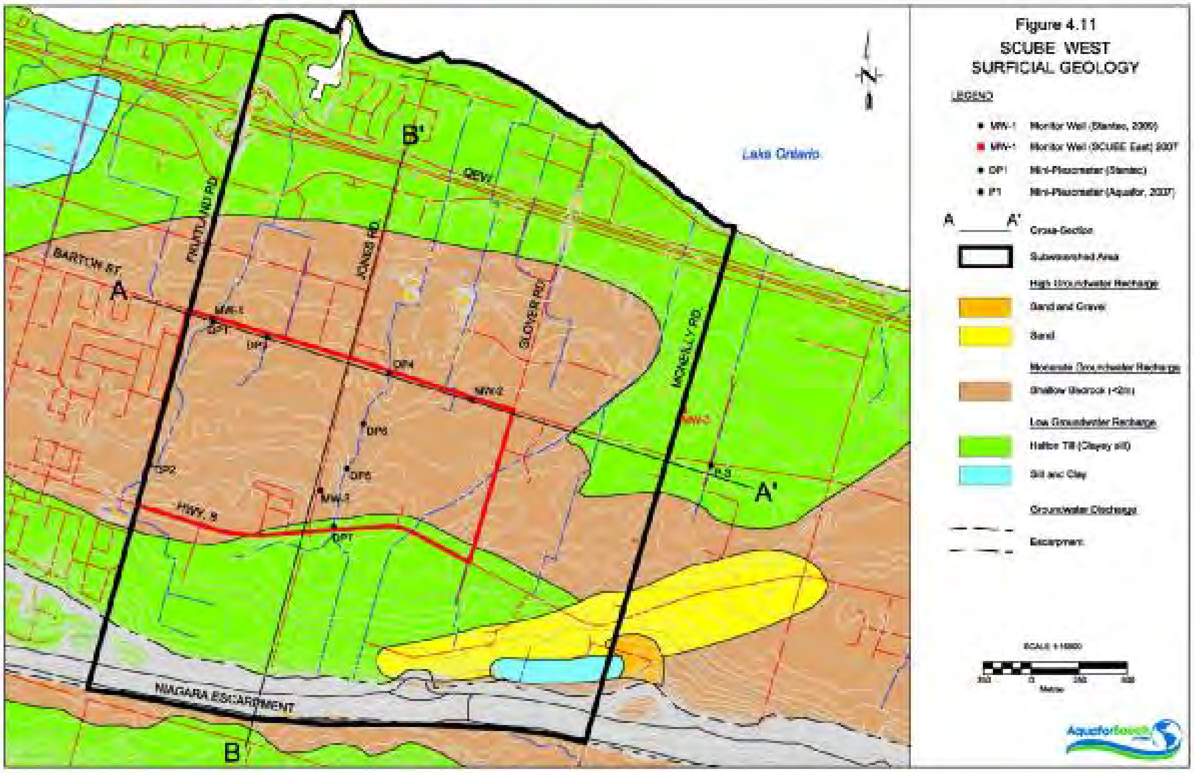


Figure 3.11: Geology of the SCUBE West study area (after Feenstra, 1985) with Stantec Monitor wells and piezometer locations. Monitor P-3 on SCUBE East from Jagger Hims (2007)

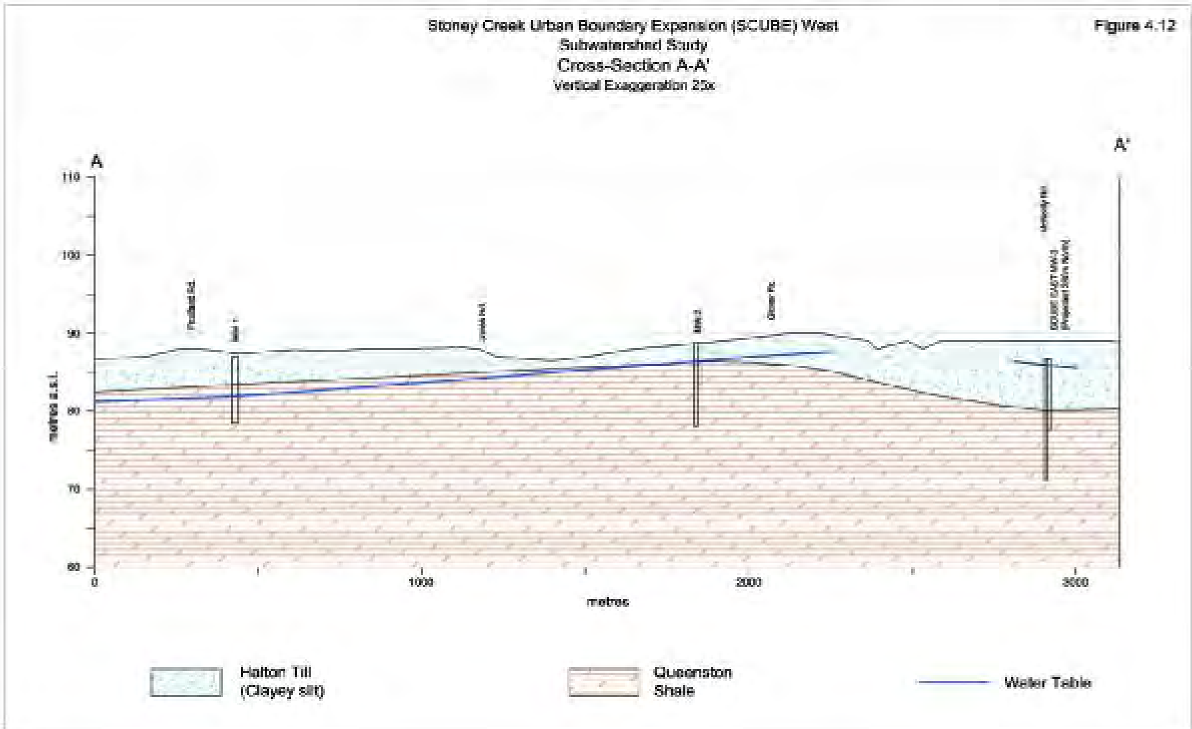


Figure 3.12: SCUBE West cross-section A-A' (east-west)

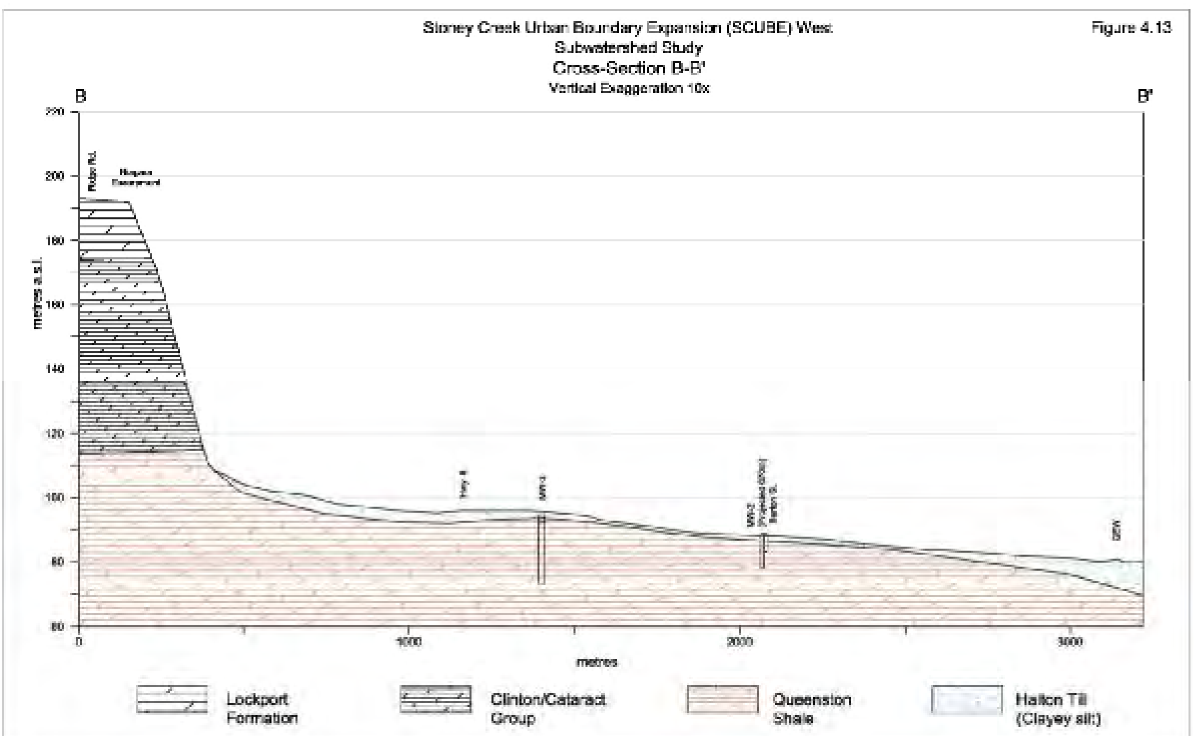


Figure 3.13: SCUBE West cross-section B-B' (north – south)

3.2.3.2 Infiltration and Groundwater Recharge

Groundwater recharge occurs as rainwater and snowmelt infiltrate through the soils into the groundwater table. The groundwater may then, in turn, serve other important functions such as supply of baseflows to local streams or water supply to local wells. The recharge potential of an area is characterized by its soils. For example, sands and gravels may have a high recharge potential of up to approximately 300 mm per year, whereas clay soils may have recharge potentials as low as 50 mm per year.

Based on the 2009 boreholes advanced by Stantec, the SCUBE West area is characterized by a relatively low recharge potential and relatively shallow piezometric surface (<5 metres below ground surface). In particular, it is noted that the silt till and several metres of the underlying shale bedrock are dry in the boreholes logs. This observation suggests that the overall recharge potential across SCUBE West is very low and that there is a degree of hydraulic separation between shallow weathered shale bedrock and deeper, more competent, shale bedrock. There is a band of sand at the base of the Escarpment where higher infiltration potential is expected, although this represents a small area of the subwatershed.

The base of the Niagara Escarpment is an area of groundwater discharge, where many of the streams have their headwaters and upward gradients are observed in some of the streambed piezometers.

Vertical hydraulic conductivity of clay soils was determined with a Guelph permeameter on one location by Stantec (2010), resulting in a value of 8×10^{-8} metre/second.

3.2.3.3 Water Budget

In order to determine the existing infiltration rates for the study area, a basic water budget was prepared for the existing land use condition using monthly values for precipitation and temperature for near the Vineland Rittenhouse meteorological station (1971 – 2000 climate normals from Environment Canada.). As shown in Table 3.6, on average, the area receives approximately 887 mm of precipitation per year.

Table 3.6: Thornthwaite Evapotranspiration Component

Month	Average Monthly Precipitation (mm)	Average Daily Temperature (°C)	Potential ET (mm)	Actual ET (mm)
January	63.8	-4.0	0	0
February	55.7	-3.3	0	0
March	70.7	1.1	3.06	3.06
April	74.6	7.1	33.6	33.6
May	74.7	13.4	79.38	78.7
June	80.6	18.8	115.2	113.6

July	79.7	21.9	139.3	123.7
August	74.2	21.0	122.4	105.2
September	88.8	16.9	84.24	84.24
October	70.1	10.6	42.75	42.75
November	79.3	4.9	17.01	17.01
December	74.5	-0.8	0	0
TOTALS	**886.6**			**601.86**

Evapotranspiration (ET) was calculated according to the Thornthwaite and Mather model (Thornthwaite and Mather, 1957) which uses an accounting procedure to allocate water among various components of the hydrologic system. Inputs to the model are monthly temperature and monthly precipitation. Outputs include monthly potential and actual evapotranspiration, and soil moisture storage. Using a water retention value of 250 mm (corresponding to moderately-rooted vegetation in a clay loam soil), the estimated annual evapotranspiration over the study area is approximately 602 mm (Table 3.6).

The evapotranspiration depths were subtracted from the precipitation to derive a value for the annual water surplus, which is 285 mm (Table 3.7), which is then partitioned between infiltration into the ground and runoff. Using an infiltration coefficient derived from the MOE Stormwater Management Planning and Design Manual (2003), based on the topography, soils, and vegetation cover of the area.

Table 3.7: Water Budget for the SCUBE West Study Area

Water Budget Component	Source of Information	Value (mm/year)
Annual Precipitation (P)	Environment Canada climate normal for Vineland-Rittenhouse meteorological station	886.6
Actual Evapotranspiration (ET)	Thornthwaite & Mather monthly calculation	601.9
Water Surplus	P – ET	284.7
silty clay soils (Halton Till):		
Recharge	Infiltration factor of 0.4*	114
Runoff	Water surplus – Recharge	171
sand/gravel deposits:		
Recharge	Infiltration factor of 0.7**	199
Runoff	Water surplus – Recharge	86

* Infiltration factor for Halton Till with rolling topography (0.2) + impervious soils (0.1) + cultivated land (0.1) = 0.4
** Infiltration factor for sand/gravel deposits with rolling topography (0.2) + pervious soils (0.4) + cultivated land (0.1) = 0.7

As shown in Table 3.7, the estimated annual groundwater recharge for the silty clay soils over the majority of the study area is approximately 114 mm per year. The isolated area of sand/gravel deposits near the base of the Niagara Escarpment has a significantly higher annual recharge rate of approximately 199 mm per year. The remainder of the water surplus (171 mm on clay soils and 86 mm on sandy soils) is partitioned to overland runoff.

These data are consistent with the water balance calculated by Stantec (2010), where overall infiltration was calculated at 14.2% of annual precipitation, of the order of 125 mm annually.

3.2.3.4 Groundwater Monitoring

The boreholes and streambed piezometers installed by Stantec in December 2009 were discussed in s. 4.2.3. Their locations are illustrated in Figure 3.11.

In addition to the monitoring wells, seven streambed drive-point piezometers were installed in November 2009 in watercourses within the study area. The water levels in the streambed piezometers were measured on 4 occasions (December 10, 2009, February 17, May 10 and August 6, 2010).

The major conclusions from the groundwater monitoring program are summarized below:

- The groundwater in the monitoring wells was found to be 2 to 5 metres below ground surface.

- One nested well indicates a slight upward gradient, suggesting the water at depths greater that 5 metres in bedrock is confined by the overlying shale and overburden.

- Streambed piezometers in the between Highway 8 and Barton Street have a downward gradient (i.e., the streams are “losing”). Two piezometers at Barton Street (DP-1 on Watercourse 5 and DP-4 on Watercourse 6) had neutral to slightly upward gradients in December 2009, noted by Stantec (2010) to be associated with woodlots. At the three other times, all piezometers had downward gradients (i.e., the streams were “losing”).

- Piezometer DP-6, located downstream of the pond on Watercourse 6, exhibited an upward gradient in May and August 2010.

Groundwater from the monitor wells was analyzed in December 2009. Results from the monitoring program indicate the following:

- Two of the 3 monitor wells had elevated concentrations of chloride and sodium (salt), sulphate, hardness, total dissolved solids (TDS) and electrical conductivity. The elevated sulphate, sodium and chloride in the groundwater are attributed to the Queenston Shale bedrock;

- Metals are present in concentrations below the Ontario Drinking Water Standards, with the exception of iron and manganese which have elevated background concentrations in the Queenston Shale;

- Groundwater samples contain only trace levels of nitrate (≤1 mg/L), non-detectable nitrite and variable amounts of ammonia (0.06 – 9.5 mg/L), the higher values being associated with the deeper bedrock wells. The concentrations of total phosphorus are highly variable (0.05 – 0.64 mg/L), although dissolved orthophosphate ion was non-detectable (<0.01 mg/L). Stantec concluded that current land use practices have not had a major impact on nitrogen in groundwater.

3.2.3.5 Constraints and Opportunities - Groundwater

Based on the above groundwater assessment, future development constraints and opportunities are summarized below.

3.2.3.5.1 Silt/Clay Till (Halton Till)

Although the groundwater recharge potential for the majority of the developable SCUBE West lands are classified as "low", future stormwater management planning should include measures to minimize changes to the existing groundwater recharge rate of approximately 114 mm per year. This will, in turn, help to minimize future increases in runoff rates.

3.2.3.5.2 Sand/Gravel Deposit:

These granular soils, situated near the base of the Escarpment at the southeast corner of the subwatershed areas, represent a zone of high groundwater recharge potential. Given its function as a potential contributor of baseflow to stream reaches to the north, the existing recharge potential of approximately 200 mm per year from this feature should be protected through future source and conveyance control stormwater management measures which promote the infiltration of clean runoff.

3.2.4 Fluvial Geomorphology

A summary of geomorphic field investigations from previous study was completed in order to describe existing conditions and channel characteristics of Watercourses 5, 6, and 7 which lay within the defined SCUBE WEST study area (Figure 3.14). The watercourses generally flow north within the study area, from the Niagara Escarpment towards Lake Ontario. Surficial geology and watershed characteristics were also reviewed to document the watercourse environment and to evaluate stream reaches.

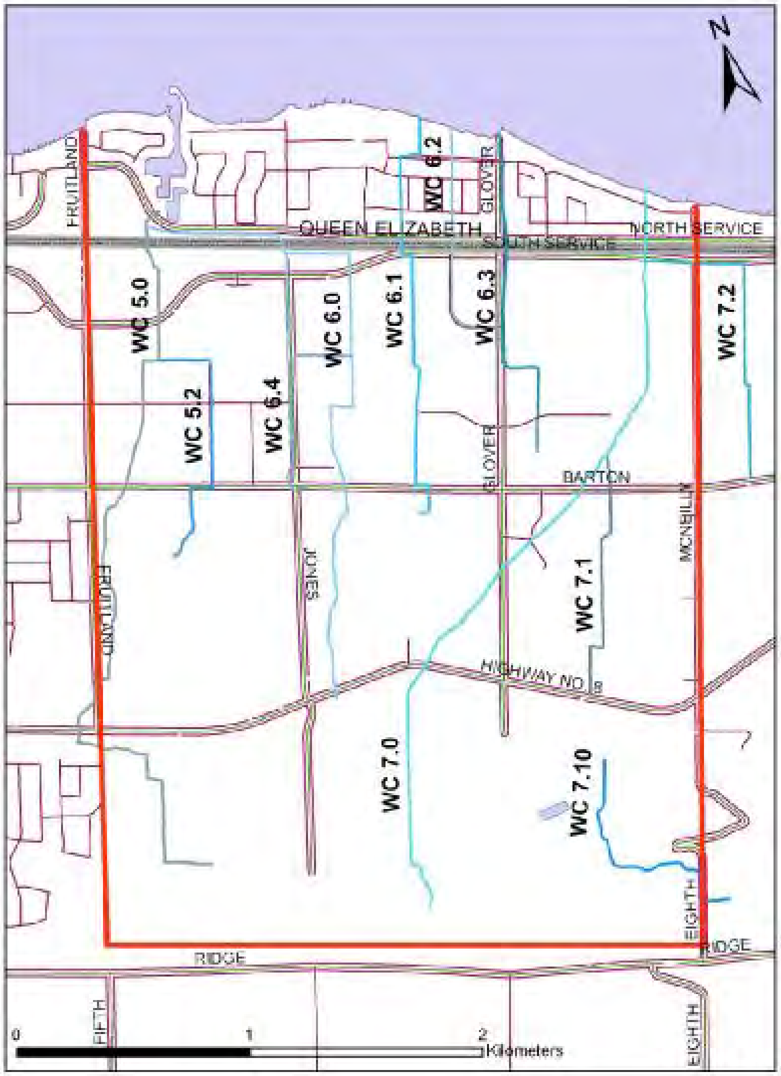


Figure 3.14: Watercourses within SCUBE West study Area.

The naming convention used in Figure 3.15 was taken from Dillon (2007) for WC 5 and WC 6, and extended for WC 7.

3.2.4.1 Physiography, Drainage Network, and Landuse

As the Niagara Escarpment represents the dominant physiographic feature within the three watersheds, surface drainage patterns originate from the escarpment and uplands. The study area is situated within the relatively flat lowlands between the escarpment and Lake Ontario. Most of the channels have been straightened and channelized by development, agricultural practices, and roadway ditches. Watercourse 7 represents the largest subwatershed within the study area, with two first-order tributaries which initiate within agriculture fields at the toe of the escarpment, draining north towards confluence downstream Barton St, and ultimately flowing into Lake Ontario. Downstream of Barton Street the channel passes through a mixture of commercial, industrial and undeveloped lands, and is flanked by residential development at the mouth.

Watercourses 6.1, 6.2, 6.3 are small drainage features contained within the lowlands, generally flowing in a northerly direction into the lake. Landuse in the lowlands has been historically industrial and open space, however, recent residential developments have continued to result in modified drainage patterns downstream of North Service Road. Watercourse 6.0 is the longest of the watercourses within subwatershed 6, and initiates within agricultural lands at the base of the escarpment. Between Highway 8 and Barton St the watercourse flows through primarily undeveloped lands, however, is severely encroached upon by residential development immediately upstream of Barton. The channel then flows through industrial lands until it is routed along the QEW into Watercourse 5.0.

Watercourse 5.0 is the primary drainage feature within the subwatershed. It initiates at the base of the escarpment in open space and agricultural fields, and passes through residential properties north of Highway 8 where the banks are composed of intermittent bank treatments. WC 5.2 is a drainage feature, which flows into 5.0 upstream of the CN rail line. Immediately downstream of the QEW, WC 5.0 confluences with WC6.0 prior to draining into Newport Harbour.

Surface geology mapping as displayed in Figure 3.15 indicates that the study area sediments primarily consist of clayey silt from Halton Till materials at the lower extents of the channels. These sedimentary units represent fluctuations of glacial ice and meltwater during deglaciation of the Lake Ontario basin. Generally, this sedimentary environment imparts fine and cohesive characteristics to both valley and upland soils, however channel bed material within the valleys is somewhat variable due to local alluvial accumulations of coarse material and artificial fill/debris. Upstream of the Halton Till is a Queenston Shale formation, typical to the base of the escarpment. It is a soft, red shale with a veneer of clay, silt, sand, gravel, and diamicton.

3.2.4.2 Reach Delineation

Reach delineation is an approach whereby a watercourse is spatially grouped by channel characteristics and processes. Stream reaches are lengths of channel that display relative homogeneity with respect to the controlling and modifying influences of channel form. As such, channel characteristics, functions and processes are relatively constant within a reach, and reaches can be used to help identify management objectives and restoration opportunities. Reaches were defined by Dillon (2007) for WCs 5 and 6 and verified through field investigation, and by Aquafor for WC 7. Figure 3.16 identifies the reach breaks.

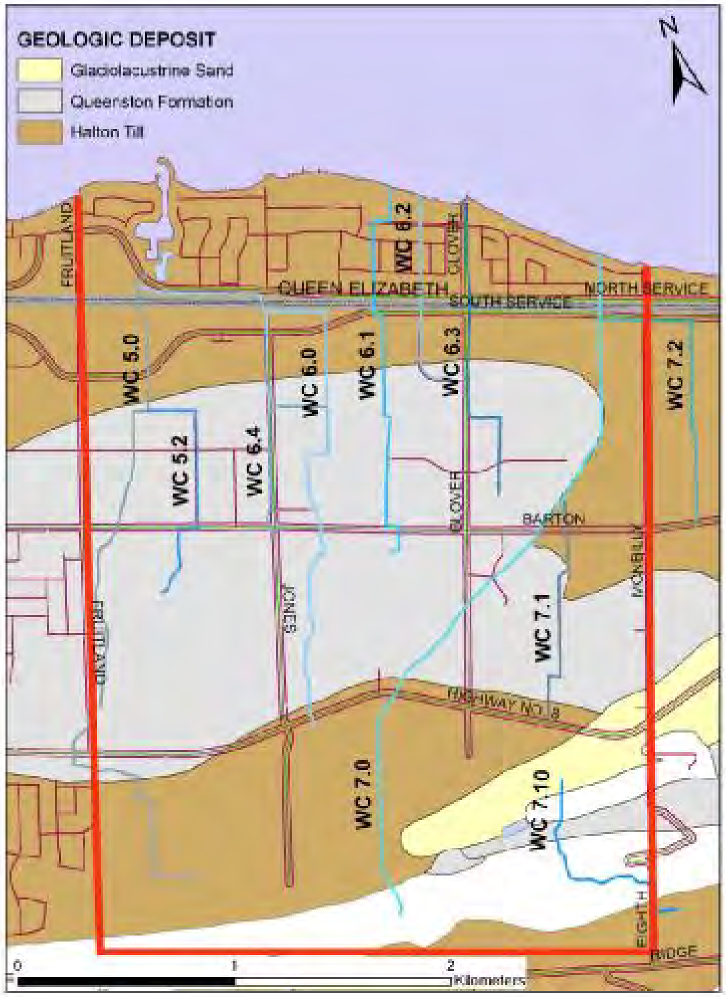


Figure 3.15: Physiography of the SCUBE West study area (Feenstra 1975)

3.2.4.3 Existing Channel Conditions

Dillon (2007) characterized the existing geomorphic conditions of Watercourses 5 and 6. The descriptions have been summarized, and define the watercourses from the mouth at Lake Ontario to the upstream extents. For photographic representation of the Watercourses 5 and 6 refer to Appendix B. Aquafor Beech performed a synoptic assessment of Watercourse 7 to provide geomorphic characterization and photographic representation.

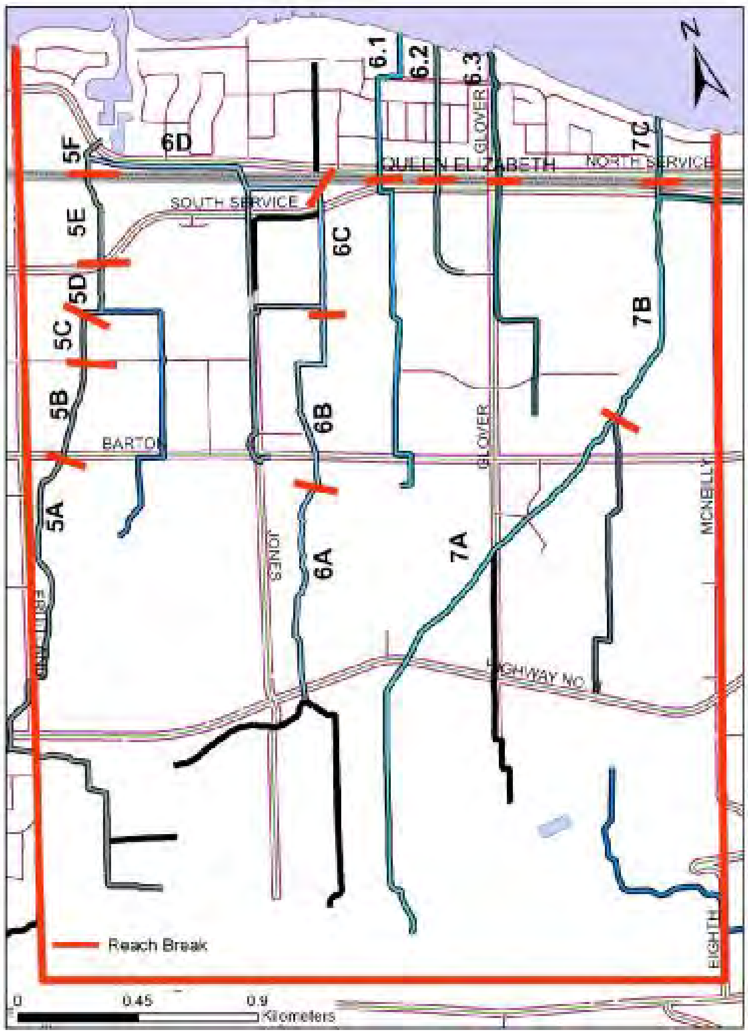


Figure 3.16: Reach delineation of watercourses within SCUBE west study area.

3.2.4.3.1 Watercourse 5

Reach 5F – Lake Ontario to QEW

The mouth of WC 5 is conveyed underground into a private marina off Lake Ontario. Upstream, between North Service Road and the QEW, the watercourse has been hardened with geogrid material along the bed and banks, and is trapezoidal in form. Cattails and grasses protrude through the geogrid material.

Reach 5E – QEW to South Service Road

This reach is described as significantly unstable, with dominant channel adjustments, as indicated by rapid geomorphic assessment, in the form of widening and degradation. It is approximately 260 m in length and bound along the right bank by a car scrap yard. The channel has been historically straightened, and minor planform development is apparent. Flood levels are largely contained within an incised channel with minimal access to floodplain relief, and bank angles are near vertical. A knickpoint was observed approximately 30 m upstream of the QEW and has exposed native clay material on the downstream extent. A knickpoint precipitates channel degradation as it migrates upstream, and is often the impetus to a new series of channel evolution. A large woody debris jams was observed, causing local bank scour and backwater conditions upstream.

Reach 5D – South Service Road to CN Rail

This reach is similar to 5E, with a straightened planform bound by industrial development along the left bank and undeveloped land to the right. The channel is described as unstable with widening noted as the dominant mode of adjustment. There is a vegetated buffer of approximately 10 – 15 m composed of brush and grasses with intermediate sized trees sparsely located. Where the planform is developing and the channel is widening exposed tree roots were observed. Photographic inspection identifies some riffle-pool morphology along the reach.

Reach 5C – CN Rail to Arvin Road

This reach runs parallel to the CN Rail until a 90 degree bend towards Arvin Avenue. The watercourse is described as significantly entrenched along the entire reach, with minimal floodplain access. Riparian vegetation was consistently exposed at the roots with medium to large trees leaning or fallen into the channel. Parking lots and private road access lines both the banks, with approximately an 8 – 10 m riparian corridor. The banks along this reach are described as intermittently hardened. The channel exhibits minimal morphological features.

Reach 5B – Arvin Road to Barton Street

Upstream of Arvin Avenue, channel alteration, in the form of bank hardening with minimal floodplain relief continues to result in bank undermining and unstable conditions. However, the severity of the rate of erosion lessens as the reach nears its upstream, undeveloped headwaters. Reduced watershed stressors, and lessened stream power (due to reduced drainage area in these upper reaches) result in an overall reduction in the degree of erosion in comparison to the downstream reaches. Though attenuated, the dominant process remains channel widening, as evident by basal scour, fallen vegetation, and top of bank fracture lines.

Reach 5A – Upstream Barton Street

Upstream of Barton Street, Watercourse 5.0 exhibits a more natural form, and is described moderately stable. The channel has access to its floodplain, and wider riparian corridors. Private channel treatments are intermittent throughout the reach, however, the majority of the banks are untreated and allowed to adjust naturally.

3.2.4.3.2 Watercourse 6

Reach 6D – Confluence with WC 5 along QEW

The most downstream reach of WC 6.0 has been artificially constructed to divert flow into WC 5, reach 5F. The channel is a straight ditch which runs parallel to the QEW on the south side for the upstream half, then crosses to the north side through a concrete culvert. Aerial photography suggests the bends at each change of direction are at right angles. The ditch appears vegetated with minimal riparian cover. The low energy system is not conducive to planform development, and the channel appears to remain consistent to the constructed alignment. The root binding strength of the vegetative cover will help maintain the existing channel form.

Reach 6C – QEW to CN Rail

Upstream the QEW the watercourse is a loosely defined, hummocky channel, set within a shallow valley feature. Channel banks have slumped in many locations but do not exhibit signs of mass failures. Although the reach is low in energy, a function of its low slope, the reach was classified as unstable, with the mode of adjustment identified as planform adjustment. The channel thalweg varies between well-defined and undefined, and alternates between a single and multi-threaded channel. The slumping banks are likely the remnants of historical, more active erosion. At present, the low flow channel is establishing its alignment, rearranging and reforming the low profile. Private property limited access upstream of South Service road, however, heavily eroded banks were apparent from the roadway. The riparian corridor along this section is approximately 10 in width and mature vegetation. Industry flanks the table lands to both sides of the reach.

Reach 6B – CN Rail to Barton St

This reach has been shaped to flow along property boundaries, with two 90 degree bends in the middle. Similar to the downstream reaches, it is a low energy system with low erosive power, however, the straightened planform is conductive to meander development. The channel has moderate floodplain access throughout the reach, and morphology consists of long pools with low velocities. Immediately upstream Barton Street the channel is heavily impinged upon by residential development, with primary residences flanking the top of bank on either side. The reach was classified as unstable with channel widening the dominant form of adjustment.

Reach 6A – Upstream of Barton St towards the Escarpment

This reach is the most natural in planform, with minimal channel treatments and impingements on the channel. The channel runs through a series of undeveloped areas and agricultural fields, and is only confined downstream of highway 8 where the banks are hardened with gabion. Still a low energy system, erosion is minimal. Morphological features were not defined along this section, however, pooling and backwater conditions was observed. Throughout the reach the floodplain is accessible and well vegetated.

Watercourse 6.1

The watercourse at South Service Road consisted of a vegetated (cattail and grasses) ditch, with no significant morphological features. Channel banks are low in profile and span over 10 m in width. Property access was restricted upstream where industrial lands confined the channel, however, no instabilities were observed for accessible vantages. Channel definition at Barton Street is further marginalized as manicured grass ditches with no riparian vegetation were defined. A small drainage feature was noted at the terminus of Arvin Ave, the upstream extent of the watercourse. Overall the channel was classified as stable and of low sensitivity to erosion.

Watercourse 6.2

From Lake Ontario to the QEW the watercourse is classified as a low-energy system which flows intermittently through good riparian cover. The banks are low in profile and referred to as stable. Morphological features are not identified, as flows were defined as stagnant, and channel bottoms covered with muck. Upstream of the QEW the watercourse is a grass ditch manicured by property owners.

Watercourse 6.3

Downstream of the QEW the watercourse flows for only a short distance of open channel, before entering a small stormwater management facility. This channel can be characterized as cattail lined, ditch drainage having no morphological significance. The watercourse is enclosed downstream of this SWM pond to its outlet to Lake Ontario.

3.2.4.3.3 Watercourse 7

These reaches were walked by Aquafor to provide a synoptic level assessment. Representative photos for each reach are provided.

Reach 7C – Lake Ontario to QEW

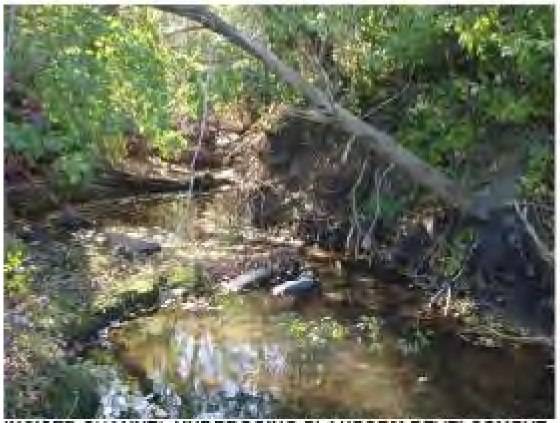
This reach is confined between two 3 m high armourstone retaining walls approximately 9 m apart. A recently constructed alluvial channel meanders back and forth between the retaining walls, with a riffle-pool morphology. Vegetation is growing within the corridor, however, not mature enough to provide cover to the low-flow channel. The channel bed and banks are predominantly composed of gravel and cobble size roundstone, and remain stable.

CONFLUENCE OF REACH 7C WITH LAKE ONTARIO

FACING UPSTREAM TOWARDS QEW

Reach 7B –QEW to Barton Street

The watercourse upstream of the QEW is incised and is gradually undergoing planform development. Erosion was noted along the right bank (facing upstream) with minimal risk to the industrial infrastructure or property on the table lands. Flows though this reach were at extremely low velocities, indicating erosion only occurs at high flood levels. The banks were well vegetated with mature riparian cover for the majority of the reach, however, the corridor was less than 15 m in width. Where the channel crosses the CN Rail line a grade control structure is encountered upstream of the culvert. This creates backwater conditions upstream for over 50 m, flooding the corridor and depositing fine sediment. Downstream of the grade control the morphology was dominated by long pools with short riffles. Overall the reach was classified as moderately stable, with minor erosion upstream of the QEW.



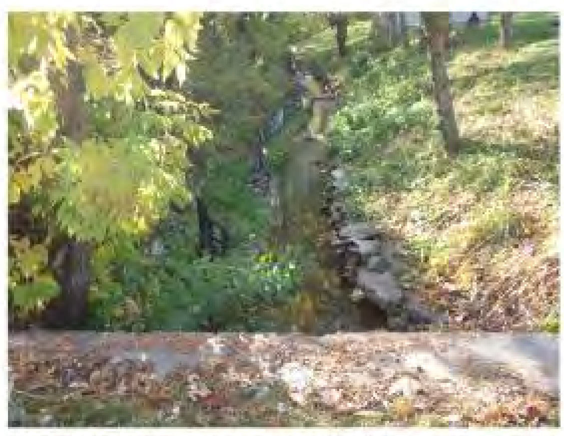
INCISED CHANNEL UNDERGOING PLANFORM DEVELOPMENT

GRADE CONTROL AT CN CULVERT CREATING BACKWATER CONDITIONS

<u>Reach 7A – Upstream Barton Street</u>

This reach is heavily influenced by the residential neighbourhood south of Barton Street. The downstream extent of the reach is lined by manicured grasses and straight in planform for approximately 150 m. Until the headwaters the reach the flows through residential yards with intermittent bank treatments and private crossings. Many long pools were identified between private culverts and crossings, indicative of a low-gradient channel. Channel treatments are used to maintain the straight planform as residents have built structures to the top of bank throughout. The reach was generally stable with minimal erosion.

LOW GRADIENT CHANNEL WITH LONG POOL FEATURE AND MANICURED BANKS



NARROW CHANNEL THROUGH RESIDENTIAL NEIGHBORHOOD WITH INTERMITTENT BANK TREATMENTS

3.2.4.4 Restoration Opportunities and Considerations - Geomorphology

One of the objectives of the sub-watershed study is to minimize erosion and ensure stability and health of the streams as future development occurs. Within the study area, existing erosion hazards were identified where mitigation should be considered, primarily along Watercourse 5 and 6. Future stormwater management planning should include erosion control facilities to prevent impacts from future developments. Likely impacts include flood conveyance and increased erosive stresses.

3.2.4.4.1 Increase Riparian Corridor Width

Each of the watercourses within the study area has been altered to a straightened planform alignment. This is done to increase developed landuse, however, these actions often have implications. Structures which line the narrow riparian corridor are at risk when the channel begins to retain a sinuous form through planimetric development. Where possible, the corridor width should be increased with extended boundaries where structures stand. This will negate the need for hardened channel linings which are currently found in disrepair through the study area. Where possible, the corridor should be vegetated with native species to provide binding strength to the banks and increase aquatic habitat health.

3.2.4.4.2 Reconnect Flood Plain Access

At the downstream ends of the primary watercourses (typically upstream of the QEW) the channel has become entrenched with minimal floodplain relief. The low-slope conditions provide velocities and shear stress not likely to cause erosion, however, when flood flows occur and are completely contained within the channel, the increased depths will induce erosive stresses to exceed the critical thresholds of bed and banks.

3.2.4.4.3 Removal of Organic and Inorganic Debris

Throughout the study area numerous areas are littered with organic and artificial debris. Removal of this material during development phases will improve aquatic habitat, locally reduce potential erosion impacts, and improve conveyance.

3.2.5 Aquatic Resources

This, and the terrestrial section summarizes interim work which was undertaken as part of the Phase 1 and 2 reports. Subsequent to the completion of the Phase 1 and 2 reports additional meetings with HCA, MNR and the City were held to address items relating to rare and endangered species. The findings from these discussions are provided in Chapter 8 Natural Heritage System.

Watercourses draining the study area generally have their headwaters on the Niagara Escarpment and drain northward into Lake Ontario. The primary watercourses are Watercourses 5, 6 and 7. All three are generally small features that have been highly modified for agricultural purposes and in some cases, further modified to facilitate urban development. See Figure 3.17 for Aquatic Resources.

3.2.5.1 Background Information

There are four background reports that provide a summary of the fish communities and habitats within these watercourses:

1) Aquatic Habitat and Fisheries Impact Assessment – Watercourses 5, 6, 7 and 9 (SNC Lavalin, December 1991)
2) Natural Heritage Assessment of Lands Bounded by Fruitland Road, Glover Road, Highway 8 and Barton Street, Draft Report (Dillon Consulting Limited, 2009)
3) Dillon Consulting Limited. 2007. The City of Hamilton Watercourse 5 & 6 Class Environmental Assessment Study Draft Report.
4) Appendix B of Watercourse 7 – Creek System Improvements Class EA (Philips Engineering Limited, September 2003)