Bay of Quinte Regional Master Drainage Planning Project

MAY 2011

SELBY CREEK

MASTER DRAINAGE PLAN

WaterPlan Associates

XCG

Quinte CONSERVATION

Bay of Quinte Remedial Action Plan

ACKNOWLEDGEMENTS

The Selby Creek Master Drainage Plan was undertaken as part of the 3-year *Stormwater Management/ Pollution Prevention and Control Plan for Bay of Quinte Municipalities.*

This project was a large team effort. Key agencies and individuals are acknowledged below.

Funding support was provided by three levels of government:

- Federal – the Great Lakes Sustainability Fund administered by Environment Canada
- Provincial – Ontario Ministry of the Environment
- Municipal – the Town of Greater Napanee

Substantial in-kind work effort was provided by the staff of:

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  - Bryon Keene, P.Eng., Water Resources Engineer;
  - Amy Dickens, GIS Specialist;
  - Tim Trustham, Plan Review Ecologist;
  - Brad McNevin, Fisheries Biologist;
  - Mark Boone, P.Geo., Hydrogeologist.
- The Town of Greater Napanee:
  - Charles McDonald, Director of Development Services
  - Vern Amey, Director of Public Works and Utilities
  - Raymond Callery, Chief Administrative Officer

Consultant support was provided by:

- WaterPlan Associates – Project Management and report coordination
- XCG Consultants – Hydrologic modeling and GIS mapping
- DigitalWorld – LiDAR Mapping

Executive Summary

The Selby Creek Master Drainage Plan (MDP) was prepared for the portion of the watershed within the Schedule C Land Use Official Plan for the Town of Greater Napanee. Additional lands were added to the study area to create a study area boundary that is based on Selby Creek sub-watershed limits as opposed to planning boundary limits.

The study was completed as a co-operative effort through the financial inputs and work efforts of the federal and provincial governments, Quinte Conservation, the Town of Greater Napanee and consultant support.

The Master Drainage Plan serves as a SWM strategy document to assist practitioners in developing SWM plans that take a watershed-based approach (as opposed to a site-specific approach) for proposed developments within the study area. Stormwater management guidance is provided at a sub-basin level. The following is a list of the major findings/conclusions of the report:

- **Water quantity controls** are required for specific sub-basins within the Selby Creek watershed to prevent adverse flooding impacts to people and property. Maximum allowable release rates on a flow per impervious area basis are provided.
    - Parking lot and rooftop storage systems on a site-by-site basis is the recommended approach to meet the given maximum release rate. End-of-pipe ponds are an alternative quantity control method if site constraints render parking lot storage to be not practical.
    - Centralized ponds will most likely not be practical due to the future land uses of Industrial or Commercial
- **Water quality control** to a Level 1 protection criteria (MOE, 2003) is required for each proposed development
    - Oil/grit separators are the recommended solution to meet water quality control requirements. However, site constraints may lead to an end-of-pipe facility being the most practical solution
- **Uncertainty and sensitivity of water quantity control recommendations**
    - Water quantity controls were determined with an un-calibrated hydrologic model. The modeled system is sensitive to the timing of hydrographs generated from sub-basins that will experience future developments. Since the model is un-calibrated, there also exists uncertainty in the lag and channel routing times used. Based on this uncertainty and the high sensitivity of inflow hydrograph timing, additional modeling in the form of calibration is required.
    - Quinte Conservation should install a hydrometric station on Selby Creek to develop an appropriate dataset for calibration of the hydrologic model.
    - In the interim (3 – 5 year horizon), the guidance developed for storage and peak flow release rate should be followed (see Table 7.7).

This report is intended to serve as a companion document to the Town of Greater Napanee Official Plan, providing stormwater management guidance for development approvals.

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1. INTRODUCTION

This Master Drainage Plan (MDP) has been prepared as part of a cooperative effort between the Town of Greater Napanee and Quinte Conservation. Funding for this project was provided by the Great Lakes Sustainability Fund and the Ontario Ministry of the Environment. It is part of a larger initiative to improve water quality around the Bay of Quinte by establishing Pollution Prevention and Control Plans in the communities encircling the bay as well as preparing selected Master Drainage Plans in developing areas of Belleville, Trenton, Picton and Napanee.

In general, the study area of the Master Drainage Plan (MDP) is based in part on the portion of the Selby Creek watershed that is located within the Schedule C Land Use Official Plan (OP) for the Town of Greater Napanee. Additional lands were added to the study area to create a study area boundary that is based on Selby Creek sub-watershed limits as opposed to planning boundary limits. In doing so, portions of the study area lie outside the portion of the watershed that is located within the OP. Refer to Map 1.1 for the study area boundaries.

The study area falls within the implementation area for stormwater management guidelines developed for the Bay of Quinte Remedial Action Plan (BQRAP). The stormwater management guidelines stipulate that water quality control targets for all development meet Level 1 (Enhanced) water quality criteria.

1.1 Cultural History

The Bay of Quinte was an important waterway to both Native Peoples and the early French explorers who traversed the area as early as 1615 a.d. The first Loyalists began to settle the region as early as 1784, which lead to clear cutting of the forests in order to develop the land for agriculture. The Napanee Valley Conservation Report – Salmon River Section (1957) notes that the majority of the Selby Creek watershed is class 3 agricultural land.

1.2 Existing Land Uses

Much of the lower watershed is utilized for agriculture and rural residential use, with the exception of the rapidly urbanizing area around the Highway 401 and County Road 41 interchange. Much of the upper watershed is reverting to abandoned fields and a secondary growth forest dominated by Red Cedar. Within the study area, the area below the Highway 401 is primarily urban and agricultural lands; whereas to the north of the Highway 401 corridor, there are commercial, light industrial, residential, agricultural and quarry activities mixed with abandoned agricultural fields and secondary growth forest.

1.3 Surface Water

The watershed of Selby Creek encompasses approximately 130 km^2; all of which is underlain by limestone. There majority of the drainage originates in the area of the hamlet of 'Hinch' located north of Newburgh, and drains in a south-westerly direction through the hamlet of Selby and through the north-western portion of the Town of Napanee, finally joining the Bay of Quinte west of the Town of Deseronto. There is one large tributary which captures drainage from south of the hamlet of Kingsford, joining the main channel south of the Hamlet of Marysville. In general, peak flows occur in the spring due to runoff from snowmelt and rain. Selby Creek is noted for low flow during the summer months, often leading to a dry channel at the hamlet of Selby.

2. SCOPE AND OBJECTIVES

The development of Master Drainage Plans (MDPs) for urban growth centers around the Bay of Quinte is part of a 3-year cooperative, multi-partner, Bay of Quinte Regional Master Drainage Planning Project initiative that includes: the federal government (Environment Canada through the Great Lakes Sustainability Fund), the Ontario provincial government (Ministry of Environment), Quinte Conservation (Project Coordinator), Lower Trent Conservation and local municipalities.

The Selby Creek MDP in Napanee is being completed in conjunction with the Norbelle Creek MDP in Belleville and the Hospital Creek MDP in Picton. Mayhew Creek MDP was completed in March 2009 and thus serves as a template for this MDP.

Each of the four Master Drainage Planning (MDP) processes for Napanee and the other urban growth areas around the Bay of Quinte is being conducted separately but in parallel with a Pollution Prevention and Control Planning (PPCP) analysis. Separate MDP and PPCP reports will be produced within the three-year program timeframe.

The ultimate goal of undertaking select MDPs is to identify and implement stormwater management strategies and treatments that will improve stormwater quality outflows entering the Bay. Collectively, the stormwater management improvements achieved through master drainage planning will provide overall ecological, health, recreation, tourism and aesthetic enhancement benefits to the Bay of Quinte.

For the Selby Creek MDP process, both the Town and Quinte Conservation are directly involved. Project input contribution from all partners includes both funding and commitment of in-house staff time. In addition, consultant support is included to undertake project management and specialized technical water quality and hydrology support functions.

Stormwater management associated with urban growth is the primary force driving water management planning for the defined MDP area.

SWM options are identified and evaluated from a technical, location, growth, and environmental standpoint. Detailed design is not part of this study. The Town will integrate the recommended agreed SWM treatments and associated policies into the Official Plan.

Beyond the strict analysis of determining the SWM requirements to control storm runoff from future growth, other related water management and planning issues have been integrated into the report. These include discussion of flooding and flood control, hydraulic capacity of channels and structures, channel erosion, fish, aquatic and terrestrial wildlife, vegetation, water quality sampling, soils and hydrogeology and planning analysis. Recommendations are made regarding areas identified requiring additional technical and policy analysis. Thus, the resultant plan expands beyond the traditional limited engineering concept of master drainage planning and establishes the framework for the development of a broader multi-disciplinary sub-watershed plan for the study area.

The MDP does not undertake a stream characterization analysis to determine the level of disturbance (i.e. re-location, enclosed in pipe, etc.) permitted by the Conservation Authority for a given watercourse or drainage channel. The applicable development watercourse setbacks will be established during the site plan review and permitting process undertaken by the proponent and reviewed by Quinte Conservation. Typical development watercourse setbacks can vary. A 15-metre setback is commonly used when the Regulatory floodline has been delineated for the given watercourse. In the case where the floodline is not defined, a 30-metre setback is used.

In consideration of the above-mentioned stormwater planning issues, the Master Drainage Plan is restrictive in terms of meeting SWM quality and quantity control objectives without being prescriptive as to specific treatments and locations – the development community is responsible for this level of detail to support their approval applications.

3. METHODOLOGY AND APPROACH

An issue common to Selby Creek and other candidate MDP project watersheds around the Bay of Quinte is that existing topographic mapping is generally limited to Ontario Base Maps with contour intervals of 5 meters and a vertical accuracy of only +/- 2.5m. This is not sufficiently precise to assess the stormwater management implications of proposed land use changes, especially in flatter areas. Therefore an integral part of the MDP planning process was to obtain laser-based high resolution LiDAR (Light Detection And Ranging) contour mapping and photography. This process enables the integration of lasers, global positioning and inertial navigation systems with fixed-wing (or helicopter) flights to achieve a high degree of vertical (~15cm) and horizontal (~30cm) map resolution.

The entire study area was flown and photographed by helicopter in early summer, 2008 and special LiDAR mapping was generated to enable detailed analysis of the defined urban growth area. LIDAR coverage within and adjacent to the study area is shown on Map 3.1.

A heavy emphasis was placed on digital GIS (Geographic Information Systems) mapping to illustrate and integrate various plan elements – the maps included in the map folio/attached fold-outs are numbered according to the report section in which they are referenced.

The Selby Creek watershed is discretized into sub-basins to enable the hydrology modeling process to determine cumulative pre-development (ie existing) flows at specified system locations as the basis for assessing impacts of and necessary SWM treatments for controlling future development.

The tasks undertaken to complete the Selby Creek Master Drainage Plan include:

- Characterize the hydrology, hydraulics, land use, hydrogeology, aquatic and land-based biology of the watershed from existing information and mapping;
- Define the urban growth areas;
- Disaggregate the watershed into relevant sub-basins;
- Using detailed LiDAR contour mapping of the growth area, undertake detailed hydrologic and hydraulic analysis of the regulatory flood flow in the streams within the growth areas;
- Undertake hydrogeological soils and water table analysis in the study area to determine which areas exhibit good infiltration and SWM treatment potential versus areas normally above the water table where SWM would not be appropriate;
- Preliminary investigation of the important terrestrial, aquatic and fisheries biology resources along Selby Creek and its tributaries, discuss existing impediments and enhancement opportunities;
- Define the characteristics of soils in the growth area and the potential for use of infiltration techniques to recharge the water table and sustain base flows;
- Define possible SWM options at both a conceptual and a preliminary engineering level;
- Assist the municipality in discussing options with the stakeholders and the public;
- Prepare an implementation plan as a companion document to the Town Official Plan.

Sections 11 and 12 describe the various SWM options for the Selby Creek watershed Specific SWM requirements for Selby Creek are described on a sub-basin basis. These sections also develop SWM management policies and strategies required to be undertaken by developers at the future site plan application phase.

4. CONSULTATION

The entire study area is located within the Town of Greater Napanee and the municipality is an integral MDP team member and funding partner. Town staff are directly involved along with staff from Quinte Conservation, including those involved and experienced in the Bay of Quinte Remedial Action Plan plus consultant support in the development of the planning and technical elements of the Master Drainage Plan.

Landowners, stakeholders and the general public will have an opportunity to review and comment on the draft Master Drainage Plan once the initial general watershed data gathering and analysis is documented and preliminary SWM policies are developed, prior to Town adoption of an SWM implementation strategy. After that, the Town will reference and link this document to the Town Official Plan to help guide the stormwater management issues for new development.

The Master Drainage Plan consultation process follows the Municipal Class Environmental Assessment guidance for Master Plan development. This permits the consultation process to 'piggy back' on the consultation process prescribed under the Planning Act if the MDP is carried out in concert with an activity under the Planning Act. Public input is requested at a minimum of one open house and one public meeting as well as during Town Council meetings.

5. BACKGROUND INFORMATION

Each project team member accessed and utilized data and information sources from their own component perspective, including field work as needed. Mapping was referenced both at the general watershed and detailed LiDAR levels of detail.

The LiDAR mapping described in Section 3 provided a detailed topographic base for Master Drainage Planning that enable the production of maps that can be combined to illustrate features of interest in various combinations. Unfortunately, the coverage of the LiDAR mapping did not encompass the entire study area. Ontario Base Mapping (OBM) 5-metre contour data were used to fill the gaps. LiDAR mapping also enabled area, length, slope and other measurements required for SWM calculations.

6. PRESENT AND FUTURE LAND USE

6.1 INTRODUCTION

The intent of including planning information in this document is to assist in assessing current runoff conditions and hydrology, and to determine appropriate storm water management treatments to enable future development in the portion of the Official Plan (OP) that is contained within the study area (approximately 11.0 km^2 of the total 20.4 km^2 OP area). This portion of the OP is centered on Selby Creek and runs both north-east and north-west, and south-west of the County Road 41/ Highway 401 interchange 579 (refer to Map 6.1).

The approach of the Official Plan (OP) for the Town of Greater Napanee as approved by the Minister of Municipal Affairs in February of 2002 and is in sync with master drainage planning and watershed planning, with a stated objective "to promote an ecosystem approach as an integral component of the land use planning process in order to ensure that growth and development are sustainable." (3.2.1.1)

The OP states "the Municipality should participate in relevant watershed and sub-watershed studies and, once they have been completed, implement the relevant land use and resource management findings by amendment to this (Official) Plan if necessary." (3.2.1.4)

The OP consolidation also stresses:

- the need to identify and protect sensitive groundwater recharge and discharge areas (3.2.1.6);
- the need to prepare subwatershed plans for urban areas (3.12.1.7) to facilitate the coordinated implementation of environmental goals and objectives;
- that boundaries of the Environmental Protection area are approximate. For interpretation, the best available data should be referred to or a site specific survey should be carried out. Technical input should be received from MNR or the CA (4.2.2.2);
- uses permitted in Environmental Protection areas are those which enable the preservation and conservation of the natural environment (4.2.2.1);

- "the use of environmentally sensitive areas is discouraged but may be considered on a watershed basis as part of the watershed and master drainage planning process where approved by the Municipality and CA" (4.2.3.2).

Over the 20 year horizon of the OP, the current form of development in the MDP growth area (the urban portion of the Selby Creek Master drainage area) is for industrial and commercial uses and not residential developments. Refer to Map 6.1 for the locations of the various land use designations. Over the 20 year horizon of the OP, lands in:
Lots 15 to 21 of Concession 2 located between Jim Kimmett Blvd and Highway 401 will be developed for commercial uses;
Lots 18 to 20 of Concession 2 between Jim Kimmett Blvd. and the CNR mainline will be developed for light industrial or business park industrial uses;
Lands north of Highway 401 in Lots 21 and 22 of Concession 3 will generally be developed for commercial uses;
Lands in Lots 23 to 29 of Concession 2 and south of the Good Year Road will be developed for a mix of industrial (including heavy industrial) uses; and,
Lands to the west of Lot 21 in Concession 3 are presently designated for Rural and Agricultural uses and it is not anticipated that this will change in the 20 year lifespan of the OP.

Within the Selby Creek drainage area, there is currently no residential development and no land has been designated for residential development.

6.2 Land Use Strategy

OP section 4.6.3 indicates an industrial area north of the CNR and east of County Road 41 as an extensive industrial growth area.

The OP shows lands in Lots 15 to 20 of Concessions 2 and 3 between the CNR mainline and Highway 401 as being in a Fringe Area designation. Section 4.6.5 deals with the fringe area. Some of these lands may be needed for development within the 20 year planning horizon. Prior to such lands being developed, the Town will require the preparation of a secondary plan showing proposed uses, services, storm water management provision, and so on. Such secondary plan is to be incorporated into the OP by way of amendment before such lands can be developed. Currently, the Town and landowners of land located between the CNR Mainline, County Road No. 1 (Belleville Road), Jim Kimmett Blvd., the eastern boundary of Lot 20 are considering the preparation of a secondary plan to facilitate the development of these lands for business park industrial and limited range of commercial uses. These lands are located in the heart of the proposed urban expansion portion of the Selby Creek master drainage planning area.

The OP designates the lands between Jim Kimmett Blvd and Highway 401 in the urban portion of the Selby Creek drainage area as Arterial Commercial. A significant portion of these lands have been developed for commercial and recreational use and include Wal Mart, an arena, a home hardware, hotel and other commercial uses. Approximately half of these lands remain to be developed.

6.3 Transportation & Service Corridors

Within the drainage areas, major roads such as Jim Kimmett Boulevard and the Belleville Road are now constructed. The remaining major road anticipated to be built is the extension of Industrial Boulevard from its terminus at the A&P site westward to County road No.1 at the overpass to the CNR mainline. Other roads to be constructed for the development of the lands to be part of the secondary plan referred to above would all be local roads.

7. HYDROLOGY AND HYDRAULICS

7.1 Stormwater Management Criteria

The hydrology and hydraulic study is based on the stormwater management criteria listed below.

- Based on the floodplain mapping previously completed by Crysler & Lathem Ltd. (1981), post-development peak flows on the main channel should not exceed the flow values used to generate the Selby Creek regulatory floodline.

- For those sub-basins discharging into a tributary that drains into Selby Creek, the post-development peak flows should be controlled at or below pre-development levels.

7.2 Previous Hydrologic Modeling Studies

In their "Marysville & Selby Creeks Floodline Mapping Study", Crysler & Lathem Ltd. (1981) applied the TR-20 hydrologic event model to simulate peak flows under existing conditions for a number of sub-basins and channel locations throughout the two watersheds. This analysis was completed to develop the regulatory floodline noted above. Refer to Map 7.1 for the sub-basin discretization used in the 1981 study.

The hydrologic analysis used in the afore-mentioned study was at a level of detail not suitable for the development of a MDP. Therefore, the hydrologic analysis used in the MDP was at a higher level of detail and therefore required the development of a new hydrologic model.

7.3 Hydrologic Model Overview

Determination of the stormwater management controls required to meet the stormwater management criteria listed above requires the use of a hydrologic simulation model of the event type. There are numerous candidate models of this type. XCG selected the model HEC-HMS (which was developed and is maintained by the U.S. Army Corps of Engineers) for the following reasons.

- It is in the public domain.
- It is used widely in Canada and the United States.

- It is the successor to HEC-1, the first version of which was published in 1968 and subsequently extensively revised in 1973, 1981 and 1990, and as such has subjected to extensive testing by the hydrologic community.
- It incorporates algorithms that have been published and peer reviewed in technical literature.

In the Crysler & Lathem Ltd (1981) study, the authors noted that floodline flows for Selby Creek are "the result of a snowmelt event on the main channel and the rainfall design storm on the tributaries." Generally, flood flows on sub-basins that are dominated by storage features such as wetlands, ponds, or flat channels will be governed by runoff volume and not runoff intensity. Rain on snowmelt events are typically associated with higher runoff volumes but lower intensities than rainfall events. Flood flows on watersheds that lack storage features and/or have steep gradients tend to be governed by high intensity rainfall events such as convective thunderstorms. Therefore, the findings of the study are to be expected.

To meet the objectives of the stormwater management criteria, storage requirements were determined using the rainfall design event used in the previous study. By only using the rainfall design event and not the rain on snowmelt design event to determine storage requirements, the assumption is made that the stormwater management criteria will be met under rain on snowmelt events as well. This approach was used to simplify both the hydrologic analysis and the stormwater management recommendations and is consistent with the industry-standard practice of using design storm rainfall events when determining the storage requirements for a development site.

The input used in the previous hydrologic model for the simulation of the rainfall flood events was the average of the 100-year Belleville and Kingston rainfall, distributed in time according to the SCS 12-hour distribution. To maintain consistency, the HEC-HMS model will use the same design rainfall events (refer to Section 7.4 for further discussion).

7.3.1 Data Requirements

Data required for modeling can be classified as meteorological data, watershed & channel data and reservoir data, as defined below.

- Meteorological data are essentially rainfall data, which are presented in the form of "Design Storms".
- Watershed & channel data include physiographic data (drainage area, length and slope), soils data and land use data, all on a sub-basin basis. Sub-basins are delineated in a process known as "basin discretization" - in the case of Selby Creek, Quinte Conservation staff used GIS procedures to discretize the overall basin and determine sub-basin data. The GIS developed areas were then reviewed and modified accordingly to best represent the existing physical features.
- Reservoir data include the locations of all reservoirs in the network and characteristics for each reservoir.

7.3.2 Three Conditions Modelled

Watershed data must be determined for three watershed conditions:

1. pre-development conditions,
2. future conditions; and
3. future conditions with stormwater management measures in place.

7.4 Design Storm

A design storm was developed in two steps for a 12-h storm duration for the 100-year return period.

Total rainfall depths were taken from the Atmospheric Environmental Service's (AES) updated "Rainfall Intensity – Duration – Frequency Values" for Belleville, Ontario, station number 6150689 (discussions with Quinte Conservation staff identified that the sole application of Belleville rain was more appropriate than averaging the Belleville and Kingston stations). Rainfall depths for several return periods are provided in Table 7.1; for the purposes of this report only the results of the 100-year event will be discussed

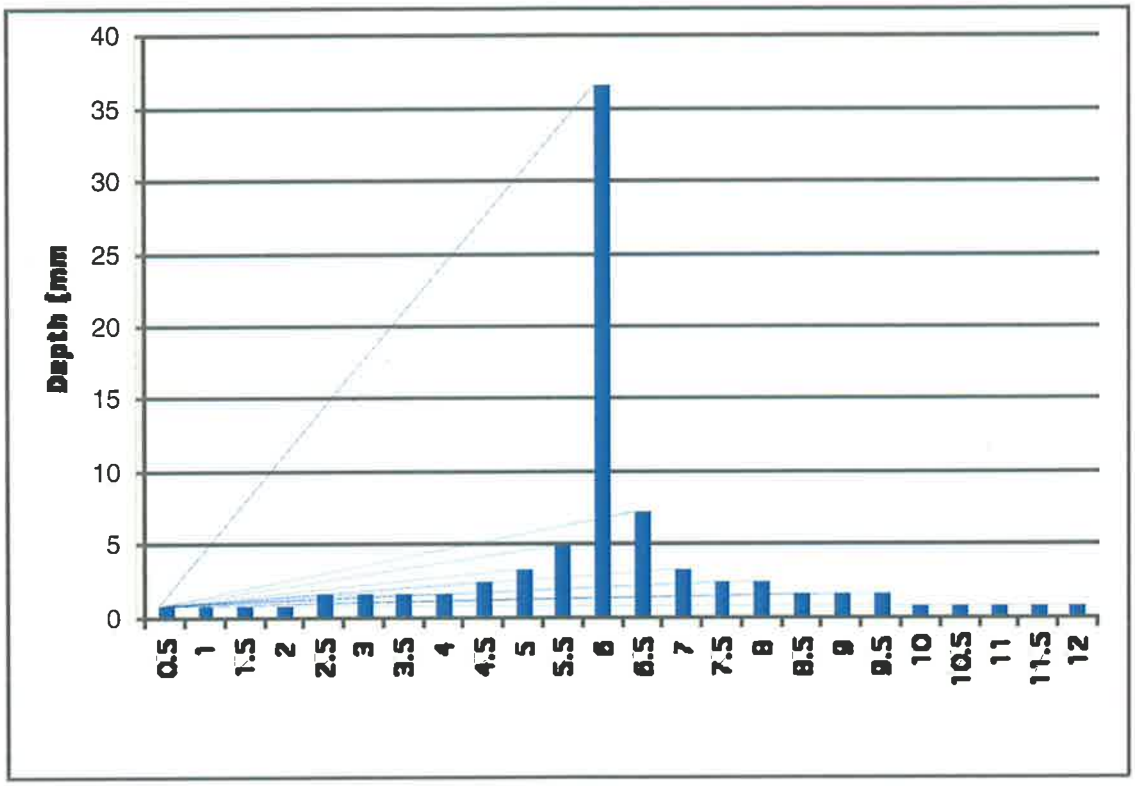
Table 7.1 Design Storm Rainfall Depths

Return Period (years)	5	10	25	50	100
12-hour depth (mm)	53.2	60.1	68.7	75.1	81.5[1]

Estimated by Environment Canada (IDF 1960 – 2003)
[1] The rainfall depth applied in the previous study was 81.3 mm

Thirty-minute values of rainfall depth were determined by applying the SCS 12-h displayed in Figure 7.1 to the 100-year, 12-h depth given in Table 7.1. This distribution is deemed to be the most appropriate since the distribution was used by Crysler & Lathem Ltd. in their 1981 Floodline Mapping Study for Marysville and Selby Creeks.

FIGURE 7.1 SCS 12-HOUR DESIGN STORM TEMPORAL DISTRIBUTION



7.5 BASIN DISCRETIZATION

7.5.1 SUB-BASIN ELEMENTS & PARAMETERS

Sub-basin elements: An element refers to a component of the hydrologic event model. Elements incorporate algorithms that attempt to represent flow generation and routing processes. Sub-basin elements (of area A, in km^2) represent two processes:

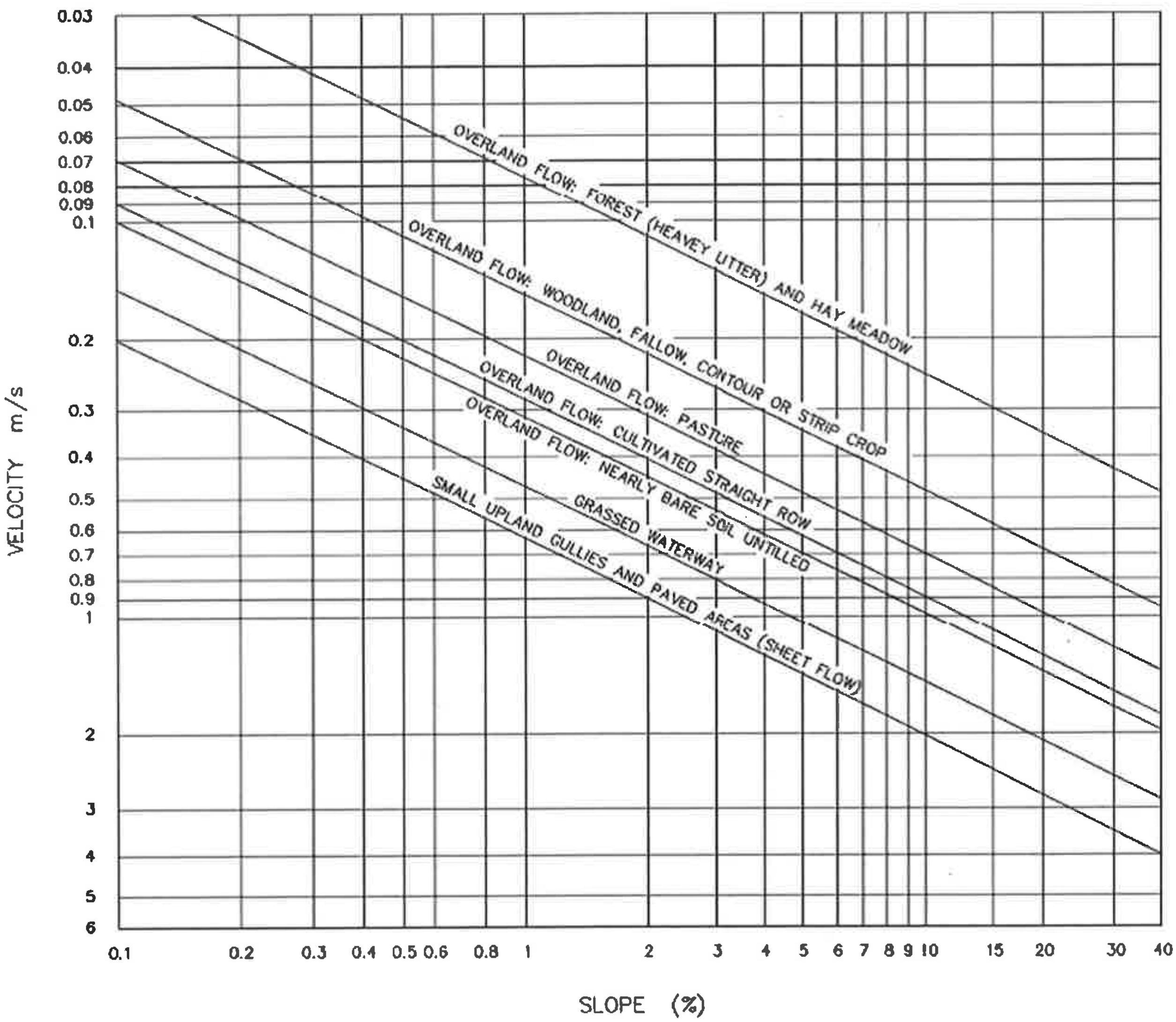
1. abstractions (or losses) from rainfall, and
2. routing of net water input through the sub-basin.

In this study, abstractions are modeled using the SCS curve number algorithm. This algorithm has one primary parameter, the curve number, CN. The values used for CN are those corresponding to antecedent moisture condition II (AMC-II), the average condition preceding annual floods. Values for CN were selected from tables developed by the US Soil Conservation Service, where CN depends on soil type and land use. The algorithm has one additional parameter, the percent of the total sub-basin area that is impervious.

Watershed routing is modelled using the SCS dimensionless unit hydrograph algorithm. This algorithm has one parameter, sub-basin lag time. An equation developed by Watt and Chow (1986) was used to estimate lag time for sub-basins 001, 003 and 005a; the upland method was used to develop lag time for the remaining sub-basins (refer to Figure 7.2 for the velocity versus slope relationship for various land cover types). The Watt and Chow lag time equation is as follows:

$T_p = 0.000326\,(L/S^{0.5})^{0.79}$ where
T_p = time to peak in hours,
L = basin length in meters, and
S = basin slope in m/m.

FIGURE 7.2 UPLAND METHOD: VELOCITY VERSUS SLOPE FOR VARIOUS LAND COVER TYPES



The sub-basin discretization for this study used the sub-basin discretization from the 1981 study (refer to Map 7.1) as a starting point. It is beyond the scope of this MDP to create a hydrologic model to simulate the entire watershed. As such, the downstream limit of the study area was chosen to be where Selby Creek crosses Oliver Side Road. This point was chosen because the contributing drainage area to this point captures the portion of the watershed that encompasses the Official Plan.

As per the 1981 study, the boundaries of sub-basins 001 and 003 remain the same under this study. Using the LIDAR-generated contours, sub-basins 005 and 007 were further discretized into small sub-basins since the Official Plan area is located within these sub-basins. The following general principles guided the configuration of the 005 and 007 sub-basins into smaller sub-basins and the development of the hydrologic model in general.

- Sub-basin elements were provided to represent the drainage basin routing process for all sub-basins obvious on the LIDAR generated topographic map.
- Sub-basin elements were added when a significant change in land use was anticipated.
- Reservoir elements were added where a reservoir existed or was anticipated.
- Channel elements were added to represent the translation in channels.
- Junction elements were added to link sub-basin hydrographs or tributary hydrographs with each other or with the main branch.

Refer to Map 7.2 for the sub-basin delineations. The sub-basin naming convention is based on the 1981 Crysler & Lathem study.

Reservoir elements: Reservoir elements, which represent constructed storage or detention ponds, are modelled using the modified Muskingum method. This method requires two relations: reservoir storage-elevation relation, and outflow structure hydraulic description.

Channel elements: Channel elements, which represent the process of channel routing, are modelled using a simple lag routine. The routine does not adjust the discharge it only affects the timing. Timing was adjusted based on the length of channel and an assumed velocity of 0.8 m/s. Channel routing remained constant for all simulations.

Junction elements: The outflow from a junction is equal to the sum of all inflows to the junction.

7.5 Pre-Development Case (2010)

General Description

The pre-development case is based on the portion of the Selby Creek drainage basin (see Map 7.2) that is located north of and within the Town of Napanee, a drainage area of approximately 85 km^2. Additional lands drain into Selby Creek, prior to discharging into the Bay of Quinte about 7 km west of Deseronto, where its drainage area is 139 km^2.

Basin Discretization

Sub-basins were defined in collaboration with Quinte Conservation staff. Contributing drainage areas to each point were calculated using GIS interpretation of LIDAR and OBM mapping and field checking and then confirmed/modified by XCG to represent actual conditions.

Drainage Network

The Selby Creek drainage basin was delineated in such a way that it could easily be compared to the previous work completed by Chrysler & Lathem (1981). As such the following groupings of sub-basins have been identified:

- sub-basins that drain from the north (sub-basin 001) and west (sub-basin 003) thru the Hamlet of Selby;
- those sub-basins between the Hamlet of Selby and downstream of the Town of Napanee. Sub-basins range from005a to 005o; and
- those sub-basins located downstream of the Town of Napanee and upstream of Oliver Side Road. Sub-basins range from 007a to 007g.

Soils

The distribution of soil types is shown in Map 7.3. Data for this figure were taken from the Soil Survey of Lennox & Addington County (Gillespie et al. 1963). The soil data was used to determine the appropriate CN value for each sub-basin (as indicated in Table 7.2). According to Crysler & Lathem (1981), "Soils of the basins involved tend to be a mixture of Farmington loam underlain by limestone in the more agricultural southern halves of the basins. While the soil is only a few inches deep over much of the region, some deeper glacial till occurs in the stream valleys and towards the north where this region borders on the limestone moraines."

Developed Areas

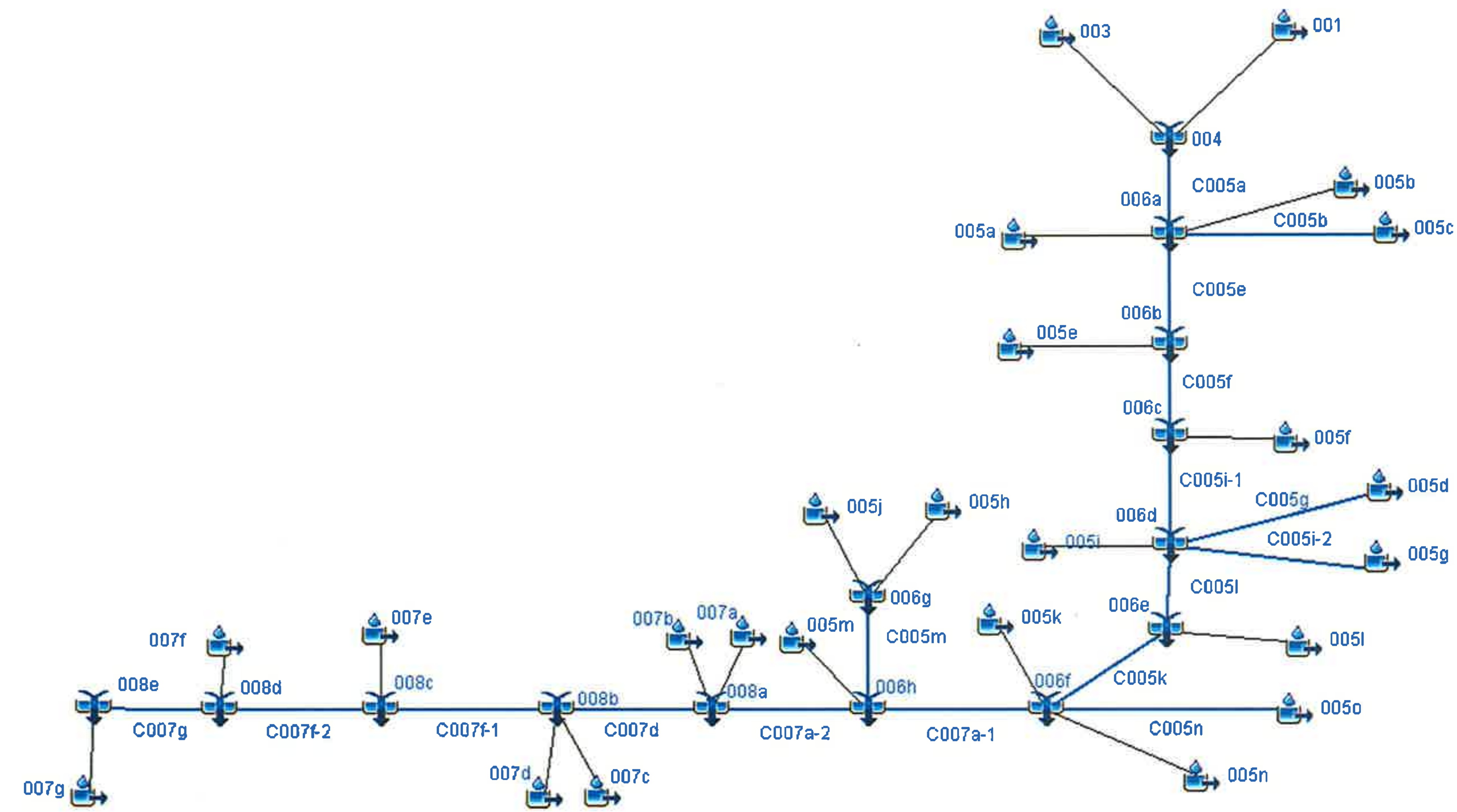
Developed areas under existing conditions are generally restricted to the portion of the drainage basin a) immediately north of HWY 401 along HWY 41 and b) south of HWY 401. The type of development is commercial or light industrial and there are a few stormwater management ponds. These ponds were not modeled as they were considered to have negligible hydrologic impact on the creek system.

The model schematic for pre-development conditions is shown in Figure 7.2.

Sub-basin Parameters

Estimates of the sub-basin parameters for pre-development conditions (area, time to peak, imperviousness and curve number), were determined using topographical and soils data provided by GIS procedures (see Table 7.2). It is noted that the curve number only applies to the pervious surfaces of the given sub-basin.

FIGURE 7.3 HEC-HMS MODEL SCHEMATIC FOR PRE-DEVELOPMENT CONDITIONS



= Sub-basin element; =addition of two or more sub-basin hydrographs; = Reservoir element

TABLE 7.2 SUB-BASIN PARAMETERS – PRE-DEVELOPMENT CONDITIONS

Sub-Basin	Area (sq. km)	Time to Peak (min)	% Impervious (%)	SCS CN for Previous Surfaces
001	11.5	228	0	72
003	27.4	350	0	74
005a	17.1	183	0	73
005b	1.36	85	0	83
005c	1.24	50	0	73
005e	1.31	48	0	70
005f	0.86	25	0	63
005d	0.68	68	0	70
005g	2.50	89	0	71
005i	0.69	22	10	80
005l	0.34	27	55	83
005k	0.32	32	30	83
005n	0.61	16	20	83
005o	0.43	32	60	83
005h	1.53	61	5	83
005j	0.49	37	0	83
005m	0.22	9	25	83
007a	0.71	34	0	83
007b	0.15	9	0	83
007c	0.35	15	0	83
007d	0.65	38	0	83
007e	1.03	70	0	83
007f	8.87	286	0	78
007g	4.75	184	0	73

Channel Parameters: The channel elements are summarized in Table 7.3.

TABLE 7.3 CHANNEL PARAMETERS – ALL CONDITIONS

Channel	Approximate Length (m)	Lag (min)
C005a	4000	109
C005b	1500	41
C005e	1850	51
C005f	650	18
C005i1	950	12
C005i2	450	25
C005l	400	11
C005k	400	11
C005n	-	10
C005m	250	7
C007a1	950	26
C007a2	500	14
C007d	1800	49
C007f1	400	111
C007f2	700	19
C007g	2000	55

Sub-Basin Flows – Pre-development Conditions: Peak flows, at the outlet of each sub-basin and at selected junctions, for the case of the 12-h, 100-year rainfall input are given in Table 7.4. These peak flow estimates were then compared to those calculated by Crysler & Lathem using the 100 year storm; a close agreement was found which confirms similar assumptions in both modeling exercises.

For comparative purposes the HEC-HMS 100 year storm peak flows were then compared to those used to delineate the floodline by Crysler & Lathem Ltd. (1981) and are shown in Table 7.5. It is noted that there has been substantial development within some of the sub-basins within the study area since the 1981 study; however, the area of the sub-basins with the increased impervious level represent about 3% of the total study area. Therefore, it is concluded that the 2010 study area hydrologic conditions can be compared to the 1981 floodline peak flow results. In general, with the exception of 006a, the HEC-HMS flows are smaller than those used to generate the floodline (note: the differences in peak flow are relatively small). Since a rainfall event was used to generate the HEC-HMS peak flows, this is consistent with the assumption that rain on snowmelt events tend to produce the larger peak flows on the main channel of Selby Creek.

The peak flow from Sub-basin 006a was determined to be higher using the HEC-HMS model as compared to the peak used to delineate the floodline. This deviates from the Crysler & Lathem finding that the rain on snowmelt design event determined the floodline peak flow for Sub-basin 006a. This disparity can most likely be attributed to the finer resolution of the HEC-HMS model.

TABLE 7.4 SUB-BASIN AND JUNCTION FLOWS – PRE-DEVELOPMENT CONDITIONS

Sub-basin	Pre Peak Flow (m^3/s)	Junction Node On Selby Creek	Peak Outflow (m^3/s)
001	11.4	004	31.3
003	22.2		
005a	21.7	006a	41.2
005b	5.1		
005c	3.7		
005e	3.3	006b	41.3
005f	1.7	006c	41.3
005d	1.4	006d	41.7
005g	4.5		
005i	5.6		
005l	3.7	006e	41.7
005k	2.8	006f	41.7
005n	6.7		
005o	4.5		
005h	7.4	006h 006g[1]	41.7 9.9
005j	3.2		
005m	3.0		
007a	4.7	008a	41.7
007b	1.8		
007c	3.4	008b	41.7
007d	4.1		
007e	4.4	008c	41.7
007f	10.4	008d	46.2
007g	5.8	008e	47.2

[1]: Node on small tributary just upstream of Selby Creek

TABLE 7.5 COMPARISON OF HEC-HMS PEAK FLOWS WITH FLOODLINE PEAK FLOWS

Junction Node on Selby Creek	HEC-HMS Peak Flow (m^3/s)	Floodline Peak Flow[1] (m^3/s)
006a	41.2	37.5
006b	41.3	43.5
006c	41.3	43.5
006d (Highway 401)	41.7	43.5
006e	41.7	43.5
006f	41.7	43.5
006h	41.7	49.5
008a	41.7	49.5
008b	41.7	49.5
008c	41.7	49.5
008d	46.2	49.5
008e (Downstream Limit of Study Area)	47.2	53.5

[1]: Flows based on Crysler & Lathem Ltd. (1981) for floodline delineation

7.6 Future Conditions Case

The basin and sub-basin boundaries for the post-development conditions case are identical to those defined for the existing conditions case.

7.6.1 Planned Development

Planned development was defined by the Official Plan of the Town of Greater Napanee. In summary, there is no significant change in land use anticipated for sub-basins 001, 003, 005b and 005j. For the remainder of the basin, the Official Plan designates development and future land use that is significantly different than existing conditions. In general, the future land use that differs from existing is commercial or industrial. Refer to Map 7.4 for the future land use conditions on a sub-basin basis.

7.6.2 Sub-Basin Elements, Parameters and Flows

Model elements: Channel elements in the pre-development conditions model were retained with no change in parameter values. The impact of changes in land use was modeled by changes in sub-basin parameter values for relevant sub-basins.

Sub-basin elements and parameters: Parameters were determined as follows (displayed in Table 7.6).

- Sub-basins were first divided into two categories: a) those for which a change in land use is anticipated according to the Official Plan and b) those for which no change is planned.
- Parameters for category "b" sub-basins were set equal to those used in the pre-development conditions model.
- Category "a" sub-basin were then classified as:
  - category "a1", those sub-basins that discharge into a tributary channel prior to discharging into Selby Creek or those sub-basins discharging directly into Selby Creek that may increase peak flows at critical nodes along the stream, and for which stormwater quantity control would be required; and
  - category "a2", those sub-basins discharging directly into the main channel of Selby Creek, and for which no stormwater quantity control would be required, subject to checking.
- Parameter values for category "a" sub-basins were revised as follows:
- The abstractions sub model was revised to include a value for impervious area.
- The time to peak in the routing sub model was re-evaluated to reflect the effect of faster runoff from developed surfaces where applicable.

TABLE 7.6 SUB-BASIN PARAMETERS – FUTURE CONDITIONS

Sub-catchment	Area (sq. km)	Time to Peak (min)	% Impervious (%)	SCS CN for Pervious Surfaces
001	11.5	228	0	72
003	27.4	350	0	74
005a1	16.25	174	0	73
005a2	0.85	10	100	98
005b	1.36	85	0	83
005c	1.24	40	60	69
005e	1.31	45	18	70
005f	0.86	20	76	68
005d	0.68	55	80	65
005g	2.50	71	74	69
005i	0.69	22	64	77
005l	0.34	22	60	81
005k	0.32	26	56	81
005n	0.61	13	79	81
005o	0.43	25	80	81
005h	1.53	49	18	83
005j	0.49	30	0	83
005m	0.22	7	65	81
007a	0.71	34	57	81
007b	0.15	7	74	81
007c	0.35	10	32	83
007d	0.65	38	29	81
007e	1.03	56	31	83
007f	8.87	260	0	78
007g	4.75	167	0	73

7.6.3 WATER QUANTITY STORAGE REQUIREMENTS

The total impervious area within the study area increases from about 86.0 hectares to 810.0 ha under full build-out conditions. Therefore, with this increase in impervious area, it is evident that water quantity controls will be required.

Category a1 sub-basins that discharge to tributaries were easily identified by examination of topography and watercourse location; category a1 sub-basins discharging directly into Selby Creek were identified by the following methodology.

1. Post-development flows were calculated at each node on Selby Creek with stormwater controls accounted for on sub-basins discharging to tributaries.

2. Post-development flows were compared to floodline flows at each node on Selby Creek.

3. Sub-basins that cause post-development peak flows to exceed existing conditions peak flows on Selby Creek nodes were classified as category a1; otherwise they were classified as a2.

Category a1 sub-basins require water quantity controls. Water quantity controls were modeled by creating hypothetical reservoirs that represent parking lot and rooftop storage systems. The use of parking lot and rooftop storage systems, as opposed to traditional end-of-pipe systems, is encouraged since the future land use designations are industrial or commercial. Refer to Section 11 for further discussion of the advantages of using rooftop and parking lot storage to provide the required water quantity control and alternative options.

The following assumptions were made in developing the storage-discharge relationship for parking lot and rooftop storage systems per catchment.

- The catchment was divided into lots of 2 ha in size. This is an assumption for the purposes of the hydrologic analysis. Lots that differ in size from the assumed 2 ha still require water quantity controls.
- The impervious level of the catchment was used to determine the impervious area for each lot
- The impervious area per lot was separated into rooftop area and parking lot area
    - 75% of the impervious area was assumed to be parking lot area
    - 25% of the impervious area was assumed to be rooftop area
- Parking Lot storage was based on storage cells with a maximum ponding depth of 0.3 m and side slopes of 1.5%. Therefore, the overall storage cell top area was 1600 m^2 (40 m X 40 m). One orifice with a diameter of 75 mm was used per lot. The diameter of the orifice coincides with typical municipal standards.
- Rooftop storage was based on storage cells with a maximum ponding depth of 0.15 m and side slopes of 1.0%. Therefore, the overall storage cell top area was 900 m^2 (30 m X 30 m).One Zurn control device was used per cell. If the rooftop area exceeded 900 m^2, multiple Zurn control devices were used per roof. The control device has a flow rate of 0.23 L/s/inch per notch. 4 notches were used per Zurn control device, with the exception of sub-basin 005c, which used 3 notches per device. The number of notches was optimized to maximize rooftop storage during the 100-year storm.
- For a given catchment, the parking lot storage-discharge relationship was determined by multiplying the parking lot storage per lot by the number of lots in the catchment at various stage increments. The same procedure was used for the discharge values. Development of the rooftop storage-discharge values used the same procedure as the parking lot procedure.
- Each sub-basin was further discretized into three smaller catchments to represent the parking lots, rooftops and pervious surfaces. The parking lot catchment and rooftop catchment were routed through the parking lot reservoir and rooftop reservoir, respectively.

Table 7.7 summarizes the estimated stormwater control requirements per sub-basin and the resultant peak outflow per sub-basin (including the effects of stormwater control) and the peak outflow for nodes on Selby Creek. Map 7.4 depicts the sub-basins that encompass the portion of the watershed within the OP area and indicates the stormwater control requirements per sub-basin, where applicable.

As indicated in Table 7.7, stormwater control requirements are expressed as a required unit release rate in flow per unit impervious area (L/s/ha).

TABLE 7.7 SUB-BASIN & JUNCTION FLOWS – POST-DEVELOPMENT CONDITIONS WITH QUANTITY CONTROLS IMPLEMENTED

Sub-basin Category	Sub-basin	Stormwater Control		Post Peak Outflow (m^3/s)	Pre Peak Outflow (m^3/s)	Junction Node on Selby Creek	Post Peak Outflow (m^3/s)
		Release Rate (L/s/impervious hectare)	Storage Volume (m^3/impervious hectare)				
b	001	-	-	11.4	11.4	004 (Inflow into Study Area)	31.3
b	003	-	-	22.2	22.2		
a2	005a	-	-	21.4	22.1	006a	**41.5**
b	005b	-	-	5.1	5.1		
a1	005c	25	406	3.7	3.7		
a2	005e	-	-	5.2	3.3	006b	41.6
a2	005f	-	-	11.0	1.7	006c	41.6
a1	005d	20	460	1.5	1.4	006d (Highway 401)	**43.6**
a1	005g	25	448	6.6	4.5		
a2	005i	-	-	8.2	5.6		
a2	005l	-	-	4.1	3.7	006e	**43.6**
a2	005k	-	-	3.4	2.8	006f	**44.0**
a1	005n	25	420	3.9	6.7		
a1	005o	25	477	4.4	4.5		
a1	005h	25	480	7.3	7.4	006h 006g	44.3 10.2
b	005j	-	-	3.2	3.2		
a1	005m	25	477	1.7	3.0		
a1	007a	25	410	3.6	4.7	008a	45.2
a1	007b	25	441	0.6	1.8		
a1	007c	35	348	2.9	3.4	008b	46.7
a1	007d	20	476	3.0	4.1		
a1	007e	20	481	4.1	4.4	008c	48.4
b	007f	-	-	10.4	10.4	008d	**53.2**
b	007g	-	-	5.8	5.8	008e (Downstream Limit of Study Area)	**58.8**

Bold values indicate an exceedance of the value used to calculate the floodline

For Category b sub-basins (including 001, 003, 005b, 005j, 007f and 007g), which are not subject to development, no stormwater control is required and the peak outflow for post-development conditions is identical to the peak outflow for pre-development conditions.

For Category a1 sub-basins (including 005c, 005d, 005g, 005n, 005o, 005h, 007a, 007b, 007c, 007d, and 007e), the peak outflow for post-development conditions with water quantity controls is less than or equal to the peak outflow for pre-development conditions. The noted exceptions are sub-basins 005d and 005g, which exceed the respective pre-development peak flow rates. In these cases, stormwater control is required to maintain main channel flows less than floodline flows or to avoid changing peak flows in the smaller tributaries.

Under post-development conditions, 005D and 005G exceed the pre-development levels by 15% and 50%, respectively. Further water quantity controls would be warranted to reduce the post-development peak flows to pre-development levels. Restricting the outflow from parking lot and rooftop storage systems is deemed to be not feasible. The results of the modeling indicate that reducing the outflow will cause these storage systems to overflow, thus worsening the situation. Therefore, there are two options remaining. The first option is to construct end-of-pipe facilities on a site-by-site basis or as centralized ponds serving multiple lots while still employing rooftop and parking lot storage systems. The second option is to conduct a hydraulic analysis on the conveyance corridors within sub-basins 005D and 005G to the confluence with Selby Creek to a) assess flooding impacts due to the increase in peak flows and b) determine channel improvements and/or culvert replacements required to reduce the flooding impacts back to pre-development levels.

A preliminary examination of the storage requirements if the first option were to be employed indicates that approximately 22000 m^3 of storage would be required for the entire 005G sub-basin, which equates to approximately 85 m^3 /ha. Sub-basin 005D was not examined since the post-development peak flow exceeded the pre-development level by only 15%. Since the future land use designation of sub-basin 005G is primarily industrial, it is assumed that the use of centralized ponds is not practical. Historically, industrial developments have not constructed centralized ponds due to the possibility of contaminating the stormwater and the difficulty in determining which development is liable. As a result, the preferred option has been the construction of ponds serving individual developments. On a site-by-site basis and assuming a 2 ha lot, the storage requirements equate to approximately 170 m^3/lot. A 125 mm diameter orifice was assumed to be the outlet control.

To avoid the construction of ponds on a site-by-site basis, the second option is the recommended option. It is beyond the scope of this MDP to conduct a hydraulic analysis. Therefore, to facilitate development approvals, it is the responsibility of the development community to conduct the hydraulic analysis and take the appropriate steps to mitigate any flooding and/or erosion issues arising from the increased flow regime.

For Category a2 sub-basins (005a, 005e, 005f, 005i, 005l, and 005k) which discharge directly into Selby Creek, the peak outflow for post-development conditions is greater than the peak outflow for pre-development conditions. However, the resultant Selby Creek peak flow is less than or equal to the floodline peak flow at the respective nodes. Therefore, stormwater control is not required to maintain main channel flows less than floodline flows.

Although water quantity controls are not required for the afore-mentioned sub-basins for the purposes of floodplain management, stormwater controls or watercourse improvements may be required to mitigate the impact of increased runoff volume, peak flow and erosion rates associated with development along these tributaries. Further studies to evaluate mitigation design solutions are recommended.

There are four junction nodes where the post-development peak flow, with stormwater control, exceeds the flow used to generate the floodlines. In the first case, node 006a exceeds the floodline flow in both the pre-development and post-development conditions models. The difference in this case is likely the finer resolution used in the HEC-HMS model as compared to the TR-20 model used in the original model work completed in 1981. For junction 006f, the exceedance is small, of the order of 2%. Such a small difference is of no concern for two reasons.

i. It is less than the uncertainty in either the HEC-HMS modelling or the original TR-20 modeling completed in the 1981 study.
ii. The HEC-HMS flows are 10-minute averages. When these 10-minute flows are average over 30 minutes, which would approximate the real-world situation, the 30-minute average flow is approximately the flow used to generate the floodline.

The remaining two junctions, namely 008d and 008e, exceed the floodline flow by 8.0% and 10%, respectively. Hydraulic modeling using HEC-RAS modeling software was completed to determine the impact of increasing the peak flow from 53.5 m^3/s (the floodline peak flow at this location) to 58.8 m^3/s (under full build-out conditions) on the Regulatory water surface profile. Rather than modeling a substantial length of Selby Creek, the hydraulic modeling was limited to the Oliver Side Road crossing of Selby Creek, which corresponds to the downstream limits of the MDP study area, The Floodplain Mapping indicates that there is a 10 cm Regulatory water surface elevation differential from upstream of the crossing to downstream of the crossing. This suggests that the crossing represents a constriction in the floodplain. As a result, it is reasonable to assume that the maximum increase in the Regulatory surface profile caused by the increase in peak flow would occur at this crossing. Modeling results indicate that this crossing would experience an increase in the 100-year regulatory floodline by about 5 cm as a result of the increase in peak flow.

The Selby Creek Floodplain Mapping was completed using contours at 2-metre intervals with 1-metre interpolation. Overall, the anticipated increase of the regulatory floodline in the vicinity of the Oliver Side Road crossing of about 5 cm is within the elevation accuracy range of the contour mapping used to generate the Floodplain Mapping. Therefore, the Regulatory floodline increase is considered negligible; as a result, the increase in peak flow is not a concern from a floodplain management perspective.

Stormwater controls are essential to ensure that post-development condition peak flows do not exceed those flows used to delineate the floodline.

8. SOILS AND GROUNDWATER

The urban development of a rural watershed typically results in an increase in impervious area and a corresponding decrease in recharge to the underlying aquifers. This decrease in recharge can result in impact to users of groundwater such as properties serviced by private wells and nearby creeks, which rely on discharge of groundwater to maintain baseflow during periods of low runoff. Urbanization can also result in the introduction of contaminants to an area, potentially leading to contamination of the underlying groundwater resource. Such contaminants could include runoff from roads, de-icing agents, fertilizers, pesticides etc. To protect vulnerable groundwater resources, proper development of a watershed requires careful consideration of the hydrogeologic conditions. Efforts are required to maintain the natural hydrologic balance of a developing area through proper watershed planning and implementation of effective storm water management solutions. Such measures are developed in consideration of the physical and ecological characteristics of the watershed to consider sensitive areas and possibly implement effective storm water management measures to promote groundwater recharge and manage sources of potential contamination.

To assist with the development of a suitable master drainage plan for the Selby Creek Study Area, a summary of the hydrogeologic conditions has been completed. This summary is provided through an overview of the hydrogeology of the area as determined through a review of a variety of sources of information such as the Quinte Regional Groundwater Study (Dillon, October, 2004) and Ontario Water Well Records.

8.1 Geology

The landscape of the Selby Creek watershed has been formed in direct relation to geology of this area. The underlying geology serves as the foundation for the area and provides control on the various hydrogeologic processes which occur in a watershed. For the purposes of this summary the geology will be divided into two distinct classifications; first the bedrock geology and second the overburden geology or soils.

8.1.1 Bedrock Geology

The Selby Creek watershed is located within the physiographic region referred to as the Napanee Plain which is comprised of a layer of thin soil over limestone bedrock. The limestone bedrock, as mapped by Map 8.1, is comprised of limestone of the Verulam Formation underlain by limestone of the Bobcaygeon Formation. The Verulam formation covers the majority of the study area, exception of small areas at the north and south where the Bobcaygeon formation is found. These limestone units were formed as a result of the deposition of sediment on the floor of an Ocean which covered this area approximately 400 to 500 million years ago. The Verulam formation is the younger of the two rock types and is described as finely crystalline limestone of pale to medium brown color. The surface of the bedrock has been mapped as illustrated by Map 8.2 with slope predominantly in a southern direction towards the Napanee River, from elevations of 135 to 80 metres.

8.1.2 Overburden Geology

The soils of the study area are as mapped by Map 8.3, illustrating a number of different soil types which include: a silty to sandy till, silt and clay, organic peat and muck and areas of thin drift cover. The silty sand till soils are generally found throughout the southern portion of the study area with large areas of thin drift over bedrock in the north. The other soil types are found in isolated pockets dispersed throughout with the peat and muck associated with swamps. The topsoil layer found above the main soil types is comprised of clay and clay loam of moderate to low permeability. The distribution of soil depth has been mapped by Map 8.4 with areas of shallow soil in white throughout the north. Areas of greater soil depth in the range of 1.5 to 10 metres are mapped in green throughout the south. The records for water wells drilled within the area, as located by Map 8.5, confirm shallow soil conditions with the majority of wells reporting less than 3 metres of soil depth.

8.2 GROUNDWATER

Rural residences within the study area rely on private wells as a source of domestic water supply. To provide information about this supply and local groundwater conditions a review was completed of the records for wells located within the study area as illustrated by Map 8.5. From review of 334 records it is evident that the local groundwater supply is obtained from a shallow limestone bedrock aquifer. Water bearing zones in this bedrock are typically encountered at depths of 6 to 15 metres at elevations of 85 to 115 metres. In the absence of significant deposits of low permeability soil or rock above the aquifer it is interpreted as being unconfined, meaning that the aquifer receives direct recharge from precipitation infiltrating the ground surface. The flow rates of the wells are considered suitable for domestic use at less than 5 gallons per minute. However many wells are reported as dry or with rates of less than 1 gallon per minute. The water quality of the aquifer is recorded by the well drillers and was reported for the majority of the wells as fresh based on taste or smell. However, some wells were recorded as encountering sulphur, salt and mineral water. These are natural water quality problems which may be associated with wells that have been drilled too deep into zones containing water that has been in the ground for a long time.

Further information about ground water conditions, was taken from the Quinte Regional Groundwater Study (2004). This includes maps of water table elevation and depth to water maps as illustrated by Maps 8.6 and 8.7, respectively. From Map 8.6 it can be seen that the water table elevation is highest (120 metres) along the northern portions of the study area and decreases (minimum of 90 metres) to the south towards the Napanee River. The areas in dark blue on Map 8.6 can be considered as zones of groundwater discharge and areas in red as groundwater recharge. The depth to the water table map, as illustrated by Map 8.7 was prepared in consideration of the water table elevation map using topographic mapping. From this mapping, the depth to the water table was determined as ranging from near surface up to a maximum of 15 metres in depth. Areas of shallow water table (indicated as dark blue and green on Map 8.7) are generally found throughout with greater depth along the divides of the various sub-watershed (topographically high areas). Overall the depth to the water table in the study area can be considered as relatively shallow at an average depth of approximately 5 metres. In general, in terms this map can be loosely construed as representing areas of ground water recharge in the upland areas of great water table depth with areas of ground water discharge in the lowland areas adjacent to watercourses.

8.3 OVERVIEW

From the review of hydrogeological information about the Selby Creek Study Area the following conclusions can be made:

- The area is underlain by limestone bedrock containing a shallow aquifer used by local residents for supply,
- Soils are predominantly shallow at depths of less than 3 metres above bedrock and are of moderate to low permeability,
- The shallow limestone aquifer is not protected from surface activities and is vulnerable to contamination,
- The water table generally follows the topography with areas of recharge in topographically high areas and discharge along the water courses,
- the depth to the water table ranges from near surface up to a maximum depth of 15 metres and averages at approximately 5 metres,

From this overview of the hydrogeologic setting the area can be described as being susceptible to contamination and generally does not exhibit a high potential for the artificial infiltration of storm water. Based on the interpretation of groundwater movement, potential exists for the migration of contaminants with the groundwater to areas of discharge along the surface water courses.

8.4 RECOMMENDATIONS

To mitigate the potential impacts of urban development on the Selby Creek Study Area, various methods of control exist to promote maintenance of the hydrologic cycle through promotion of ground water recharge. Lot level controls and infiltration end-of-pipe facilities are encouraged where feasible. Refer to Section 11 for further discussion.

9. ECOLOGY

9.1 NATURAL AREAS

Several wetlands have been evaluated within the Selby Creek watershed (utilizing the Southern Ontario Wetland Evaluation System) and are listed below (it is noted that Selby Creek is also referred to as Sucker Creek).

- Hall Landing Coastal Wetland,
- Lower Sucker Creek Wetland,
- Upper Sucker Creek Wetland,
- Sucker Creek Tributaries Wetland,

- Beachwood Swamp,
- Hempfly Swamp, and
- Hinch Swamp.

The wetlands which front onto the Bay of Quinte are noted for their use by raptors during fall migration. In addition, mapping indicates that the Tyendinaga Alvar and the Northwest Deseronto Alvar are found within the lower reaches of the watershed. Although small, the Deseronto Alvar is noted for its representation of Side-oats Gramma grassland (which is quite rare in Ontario), good quality Canada Blue Grass mesic grassland and Tufted Hairgrass wet mesic grassland. Also, this site contains an excellent example of Bouteloua curtipendula grassland and Tufted Hairgrass grassland within the southern Napanee Plain region of site district 6-15. The site contains unusual alvar and prairie remnants in better-than-average condition, which contains four 2S plant species, which are Carex bicknellii, Bouteloua curtipendula, Panicum leibergii, Sporobolus heterolepis (NHIC, 2010). Alvars are globally imperiled ecosystems which form in very few areas of the planet (Great Lakes and Northern Europe), and are noted for the rare species which are endemic to the areas.

9.2 Vegetation Communities

The original forest cover of the watershed would be broadly described as a shade tolerant hardwood type, dominated by the presence of Sugar Maple, Beech, Basswood, Black Cherry and White Ash, with components of White Oak, Red Oak, and Hickory. Lowlands within the watershed were likely dominated by Silver Maple, White Elm and Black Ash (Napanee Valley Conservation Report, 1950). Given the moderating affects of winter temperatures from the close proximity of the Great Lakes and local soil types, it is expected that the coniferous components of the original forest were minimal. The forest cover of the lower Selby Creek watershed may have been cleared in patches for early agriculture by First Nations people; however, the clearing would have began in earnest during the settlement of the Loyalists. In addition to forest cover, at least small portions of the watershed were originally covered by alvar and wetland plant communities.

The vegetation within the study area is dominated by abandoned fields and secondary growth, immature forests – primarily dominated by Red Cedar, White Pine, Poplar, Bur Oak, and Green Ash. Refer to Map 9.1 which shows the ecological features for the portion of the study area that lies within the Official Plan area. Agricultural and developed lands, cultural woodlands, and a meadow marsh along a portion of Selby Creek are the dominate features within the said area.

9.3 Fisheries

At discharge point of Selby Creek into the Bay of Quinte, Selby Creek is buffered by coastal wetlands, which are noted for their lack of disturbance (Lower Selby Creek Wetland). These wetland areas would be significant spawning and nursery habitat for the fish, which inhabit the Bay, particularly Sucker, Pike and Walleye. Further upstream (north of the Town of Napanee), the system has several naturally low flow areas which would impede summer migration for fish. The Selby Creek system can be considered as a ‘warm water’ fish community.

A fisheries assessment conducted by the Ministry of Transportation for the Highway 401 interchange at County Road 41 during May of 1999 yielded White Sucker, Northern Redbelly Dace, Fathead Minnow, Bluntnose Minnow, Blacknose Dace, Larval Minnows, Banded Killifish, Brook Stickleback, Rock Bass and Pumpkinseed. The Bluntnose Minnow and Fathead Minnow are noted to dominate the fish community at this location (MTO, 2004). However, as part of this report, further field work was conducted during the field season of 2009 over the entire system. Utilizing a backpack electrofisher, Northern Pike, Bluntnose Minnow, Golden Shiner, Brookstickleback, Central Mudminnow, Fathead Minnow, Northern Redbelly Dace, Banded Killifish, and Pearl Dace were captured at five sample sites. These fish species are tolerant of warm water temperatures (Coker, et. al.; 2001). Based on mapping provided by Fisheries and Oceans Canada, no species at risk are present within the Selby Creek watershed (Doolittle, et. al., 2007).

9.4 Wildlife

According to the Canada Land Inventory, the watershed has moderate limitations to the production of waterfowl due to the lack of suitable marsh edge and steep topography. The Natural Heritage Information Centre indicates two species of special concern within the study area: Milksnake and Stinkpot Turtle (both have Provincial 'Threatened' status). In addition, the Provincially 'Endangered' Loggerhead Shrike is noted within the Selby Creek watershed (NHIC, 2010).

10. WATER QUALITY CONDITIONS

10.1 Historic Water Quality Data

Water quality data for the watershed is limited. Information collected by the Ministry of Transportation for Highway 401 and County Road 41 interchange upgrades indicated water temperatures in the 20.5 - 28 C (warm) range (MTO, 2004).

10.2 Benthic Investigation

Selby Creek is part of the Ontario Benthos Biomonitoring Network with benthic macroinvertebrate communities collected at seven monitoring sites from 2005 to 2009. Samples from each date and site were assessed for community health using a weighed average with tolerance values called the Hilsenhoff Biotic Index, %EPT representing sensitive organisms, and community Richness. Majority of the sites were considered possibly impaired with some samples showing signs of healthy communities. Water chemistry results for nutrients and general chemistry at two of the sites had elevated levels in Iron (>0.3 mg/L), Total Phosphorous (>0.03 mg/L), Dissolved Organic Carbon (> 5 mg/L), Hardness (>100 mg/L), Manganese (>0.05 mg/L), and Sodium (> 20 mg/L).

10.3 Provincial Water Quality Monitoring Network

The Provincial Water Quality Monitoring Network (PWQMN) measures water chemistry for the purpose of monitoring ambient (background) conditions. The Selby Creek system does not have a permanent water quality monitoring station as Selby Creek is not part of the Provincial Water Quality Monitoring Network.

10.4 Water Temperature/Base Flow Measurements

For the purposes of this study, five water temperature monitoring sites were established to collect water temperatures throughout one growing season. The average temperatures were recorded at the five monitoring sites and based on the Ontario Stream Assessment Protocol, these average temperatures would be indicative of a 'cold water' system, which is influenced by groundwater discharge.

Therefore, it is recommended that Selby Creek be classified as a cold water system.

11. STORMWATER MANAGEMENT

As development proceeds in the study area, it must do so in concert with management of stormwater runoff to mitigate water quantity and quality impacts.

11.1 Policy

- All development shall be accompanied by measures intended to minimize the degradation of water quality that are consistent with the Ontario Stormwater Management Planning and Design Manual (MOE, 2003).

11.1.1 Water Quality Control

- Lot level controls and measures are encouraged.
- The level of water quality control for facilities shall be the ***Enhanced Protection***, which corresponds to the long term removal of 80% of suspended solids.

11.1.2 Water Quantity Control

In general, water quantity controls are required for proposed developments if the development will cause:

1. undesirable geomorphic change in the watercourse,
2. an increase in flood risk potential, and/or
3. degrade an appropriate diversity of aquatic life and opportunities for human uses.

The level of water quantity control required for future developments to prevent an increase in flood risk potential has been determined in Section 7.6.3. Map 7.4 indicates which sub-basins require water quantity controls and the maximum allowable release rate. Water quantity controls may also be required based on items 1 or 3 noted above, which Map 7.4 does not address. Therefore, developers are encouraged to arrange a pre-consultation meeting with Quinte Conservation staff and Town staff to discuss whether water quantity control is warranted based on site-specific information.

11.2 Selection of SWM Servicing Options

As discussed in Section 7, the use of parking lot and rooftop storage systems is the recommended method to meet the water quantity control requirements. The combination of parking lot and rooftop storage systems was chosen since it is the most efficient and cost-effective water quantity control system for individual sites.

There may be site design constraints that render the use of rooftop and parking lot storage systems not feasible for the development site. Alternative on-site storage options could include underground tanks, parking median depressions, green roofs, cisterns, end-of-pipe facilities, etc. The on-site road cross-section could also incorporate road-side ditches complete with outlet control structures, which would enable stormwater detention. Curbs with cut-outs for drainage could be used in this case.

For sites employing rooftop and parking lot storage systems, the most feasible solution to meet water quality control objectives is most likely the use of an oil-grit separator. Furthermore, for individual lots employing an end-of-pipe pond to meet the required release rate, the use of an oil-grit separator may be an option to meet water quality control objectives if the site is using storm sewers. If storm sewers are not used, water quality controls will need to be accomplished in the end-of-pipe facility.

It is foreseen that the feasibility of using a centralized SWM facilities that treats multiple sites is limited due to the commercial and industrial proposed land uses in the study area. The reason being that:

- Commercial designated lands may have different SWM requirements than industrial designated lands since industrial stormwater infrastructure may require hazard spill containment contingency treatment. As such, SWM treatments for commercial developments should be distinct from and not mixed with SWM for industrial development,
- It is difficult to accurately plan the timing of development, which is a prerequisite to planning a centralized facility, and
- It has been the experience of the authors that developers of commercial and industrial developments favour providing the necessary SWM on a site-by-site basis.

The hydrologic analysis of the Selby Creek watershed indicated that the system is sensitive to the timing of inflows into Selby Creek and the location of water quantity controls. The hydrologic analysis only simulated the impact of parking lot and rooftop storage systems. With the assumption that the outflow from individual lot stormwater ponds is similar to rooftop and parking lot storage, any proposed centralized stormwater ponds will require confirmation that the proposed storage system does not cause adverse flooding impacts. Therefore, Quinte Conservation should be consulted prior to planning any centralized stormwater controls.

Overall, the onus is on the developer to be compatible with guidelines in the Master Drainage Plan, relevant provincial and local polices and planning requirements.

Should end-of-pipe facilities be employed, avoiding the placement of the SWM facilities in significant natural areas is required– designs must be enhanced in favour of minimizing impacts and mitigating any habitat losses.

11.2.1 Lot-Level Controls

Many options are available to reduce the volume of storm runoff at the source and promote groundwater recharge for protection of the natural environment. These measures are generally suitable for roof-top drainage since it is likely that the runoff from roofs is relatively contaminant-free runoff. Such potential measures are listed below. Roads and parking lots are excluded due to high suspended solids content which could plug such systems and the presence of other potential contaminants which could impair ground water quality.

- Reduced lot grading,
- Directing roof leaders to ponding areas,
- Directing roof leaders to soak away pits,
- Use of rain barrels
- Infiltration trenches,
- Pervious pipes,
- Grassed swales and vegetated filter strips, and
- Pervious catch basins.

The use of lot level controls for infiltration of storm water may be considered at the planning stage for the development of individual properties as they occur. Confirmation on the potential of a property to incorporate such measures would be required (refer to Section 11.2.2). It is recommended that such measures be made a condition of all draft plan approvals for future development such that they may be evaluated and implemented where feasible. A program to educate the public and homeowners about the need, use and maintenance of lot level controls would be of benefit and compliment such a program. General education about storm water and contaminants in it would also be of benefit to the local watershed.

With respect to sediment and pollutant removal, pre-treatment source controls such as grassed or wet swales and vegetation filter strips are encouraged as they reduce the cleanout frequency of end-of-pipe facilities such as oil-grit separators and perhaps capture finer sediment particles that oil-grit separators are not effective at capturing.

11.2.2 End-of-Pipe Facilities

For sites employing an end-of-pipe facility to meet water quality control requirements-and perhaps water quantity control requirements, the acceptable end-of-pipe SWM Facilities for the Enhanced Protection level according to Table 3.2 of MOE (2003) are as follows:

- infiltration
- wetlands,
- hybrid pond/wetland, and
- wet pond.

Based on the conclusions noted in Section 8, there is limited opportunity for infiltration due to physical constraints in the study area, specifically the soil underlying the SWM facility and proximity to bedrock. The feasibility of infiltration can be based on the two noted constraints below.

- According to Schueler (1987), "infiltration BMPs cannot be applied on sites with soils that have infiltration rates (fc) less than 0.27 inches/hour as defined by the least permeable layer in the soil profile. This excludes most "C" and "D" soils which cannot exfiltrate enough water through the subsoil."
- Schueler (1987), also points out that "A close bedrock layer prevents an infiltration BMP from draining properly. Therefore, if the bedrock layer extends to within 2 to 4 feet of the bottom of an infiltration BMP, the site is not feasible".

Therefore, site-specific geotechnical data is required to determine if infiltration as an end-of-pipe SWMP is feasible. Where possible, infiltration is recommended.

The water quality storage volumes for the four SWM facilities are tabulated as a function of impervious level in Table 3.2 of MOE (2003). The portion of that table applicable to Enhanced Protection level is provided below as Table 11.1.

TABLE 11.1 WATER QUALITY STORAGE (M^3/HA) FOR ENHANCED PROTECTION LEVEL

SWMP Type	Impervious Level			
	35 %	55%	70%	85%
Wetlands	80	105	120	140
Hybrid Wet Pond/Wetland	110	150	175	195
Wet Pond	140	190	225	250
Infiltration Basin	25	30	35	40
* Of the specified storage volume for the storage facilities, excluding infiltration basins, 40 m^3/ha is extended detention; the remainder represents the permanent pool.				

It is important to note that the extended detention volume is based on the greater volume figure derived by the 40 m^3/ha formula (as per MOE, 2003) or the runoff volume generated by a 4-hour duration storm with a total rainfall volume of 25 mm. The pond should be designed such that the extended detention volume has a drawdown time of approximately 24 hours (or greater).

11.2.3 WATER QUANTITY CONTROL IMPERVIOUS LEVEL LIMITS

Stated water quantity control storage requirements are based on assumed impervious levels on a sub-basin basis. These assumed impervious levels were based on the land use designations per the Official Plan for the Town of Greater Napanee and the following assigned impervious level per land use:

- Arterial Commercial – 80%
- Industrial – 80%
- Fringe – 80%
- Aggregate – 0%

- Major Institutional – 80%
- ES/Flood –0%
- Open Space –0%

Runoff and peak flows generated from development lands are a function of the impervious level. Therefore, developments that exceed the aforementioned impervious levels should consult with Quinte Conservation to discuss the appropriate stormwater quantity control requirements. This is especially important due to the sensitivity of the Selby Creek system to changes in hydrologic conditions.

Town planning staff have indicated that a portion of the area designated as 'Fringe' between the CNR mainline and the abandoned rail line to Desoronto will likely be converted from the assumed industrial/commercial to residential in the future (refer to Map 6.1). This area of interest is located within Sub-basin 007e (refer to Map 7.4). A model scenario was undertaken whereby the impervious level in Sub-basin 007e was adjusted to reflect the change in land use from industrial/commercial to residential. Per the model results, residential developments should provide the storage requirement of 481 m^3 per impervious hectare as per Table 7.7.

12. MASTER DRAINAGE PLAN IMPLEMENTATION

12.1 INTRODUCTION

The cost of stormwater treatment is approaching that of sanitary servicing and the ultimate goal of the Master Drainage Plan (MDP) is to identify and implement stormwater management (SWM) policies, strategies, guidelines and treatments that will improve stormwater quality entering the Bay of Quinte while being practical.

The report defines the general SWM guidelines and approach, with ultimate responsibility on the development community to define the appropriate blend of SWM measures and to develop designs. Developers are responsible at draft plan stage to undertake sufficient SWM analysis to review and compare SWM alternatives, define the feasibility of their preferred option and submit a SWM report to support their draft plan application.

Once draft plan conditions are formalized by the Town, in consultation with the Conservation Authority, the developer must complete a final SWM design supported with related detailed technical studies (ie. geotechnical, ecological, floodline) as may be required to clear draft plan conditions and achieve SWM approval for their development to proceed.

Information provided in the first 11 sections of the report, along with the support maps and appendices, establish the watershed setting from a physiographical, natural and ecological resources, land use and urban growth, hydrological, water quality, groundwater and general stormwater management perspective. This forms the baseline for defining existing environmental features and protection requirements and establishing SWM requirements on a sub-catchment basis to accommodate future growth.

The following is a summary of the stormwater management concept outlined in the report:

- Water quantity controls are required for some of the sub-basins posed for development while not for others. Where required, water quantity controls are based on a maximum allowable release flow rate per impervious area (L/s/ha). Refer to Map 7.4 for locations where storage is required and the associated release rate;
- Due to the future land use designations of Commercial and Industrial, the use of rooftop and parking lot storage systems is recommended to meet the water quantity controls and an oil-grit separator is recommend to meet water quality controls;
- For sites that require water quantity controls and where site and/or road drainage system constraints prohibit the use of either rooftop or parking lot storage (or both), an end-of-pipe facility is required;
- An infiltration basin as an end-of-pipe facility is most likely not feasible because of physical constraints in the study area, specifically the soil permeability and proximity to bedrock. Site-specific geotechnical data would be required to determine if an infiltration basin is feasible.
- The size of the individual lot may prohibit the use of the types of ponds that have a permanent pool. For ponds that do not have a permanent pool (dry ponds), further water quality treatment (i.e. oil/grit separator) to achieve the Enhanced Protection criteria will be required; and,
- Centralized stormwater ponds have not been proposed due mainly to the Commercial and Industrial future land designations. Due to the sensitivity of the watershed to changes to the hydrologic conditions, any proposed centralized ponds will require consultation with Quinte Conservation staff. Some forms of storage can worsen flooding downstream due to superimposition of peak flows.

12.2 Uncertainty and Sensitivity of Water Quantity Control Recommendations

The model developed for the Selby Creek watershed is un-calibrated; this is typical of most models used for Master Drainage Planning and for stormwater modeling in general. However, the results generated for the pre-development conditions are similar to those for the floodline delineation completed in 1981; this indicates that the assumptions used to develop the models are consistent for the two studies.

A review of the results of the post-development conditions suggests that there is a clear potential of coincident peaking of flows generated in the north with release of stormwater control systems. Controlling the flows in some areas and not in others appears to be an appropriate approach. That being said, the modeled system is sensitive to variations in lag time and channel routing time. Based on the high sensitivity of these parameters and the resultant effect on peak flows additional modeling in the form of calibration is required.

It is essential that stormwater management be implemented as soon as possible due to the sensitivity of the hydraulic response of Selby Creek.

- Quinte Conservation should install a hydrometric station on Selby Creek to develop an appropriate dataset for calibration of the hydrologic model.

In the interim (3 – 5 year horizon), the guidance developed for storage and peak flow release rate should be followed (see Table 7.7).

12.3 Floodplain Mapping Revisions

Quinte Conservation regulates any proposed works that has the potential to modify the Selby Creek floodplain as per regulation enacted under subsection 28 (1) of the Conservation Authorities Act (Development Interference with Wetlands and Alterations to Shorelines and Watercourses, O. Reg. 97/04). However, Conservation Authority staff have noted modifications to the floodplain (i.e. fill placement) over the years that may have modified the Regulatory Floodline in the vicinity of the modification. Given the modifications and the fact that the floodplain mapping of Selby Creek was completed in 1980, it is recommended that the floodplain mapping per updated.

12.4 Town of Greater Napanee Implementation Requirements

12.4.1 General Recommendations

Implementation recommendations are categorized according to whom has primary implementation responsibility – the Town of Greater Napanee, Quinte Conservation or the development community, each prefaced by brief information and policy statements from the MDP process.

Recommendation 1 - The Town will adopt this Master Drainage Plan report as a companion document to the Official Plan, to provide SWM and other water resources engineering and planning guidance to ongoing Town planning and development review for Selby Creek within the defined MDP growth area.

Recommendation 2 – The guidance developed for storage and maximum allowable post-development peak flow release rates should be followed until further calibration of the hydrologic model is completed by Quinte Conservation.

Recommendation 3 - The Town, in conjunction with Quinte Conservation, should explore incentives and support for developers and private landowners to increase the use of lot level controls. For example, roof runoff rain barrel subsidies, cisterns, wet swales, green roofs, etc.

Recommendation 4 - The Town should draft, adopt and implement a site alteration bylaw. Such a measure would insure that grade alterations are not conducted prior to the approval of a grading/site plan.

Recommendation 5 - Geotechnical analysis and evaluation of infiltration potential by the developer is a required condition of all draft plan approvals for future development, with infiltration measures maximized and implemented as part of the SWM plan insofar as feasible.

12.2.2 Pond Maintenance Recommendations

Recommendation 6 - The Town should require a minimum 2-year maintenance holdback from developers to ensure the ensure the final SWM infrastructure and facilities meet functional requirements.

Recommendation 7- The Town should require submission of a minimum 20-year maintenance cycle by the developer, including sufficient funding commitment from the developer to do periodic monitoring and carry out maintenance work. This requires a sediment build-up calculation to be developed, including a built-in safety factor. This will be determined in conjunction with Quinte Conservation.

12.4.3 Environmental Recommendations

Recommendation 8 - To ensure that development is undertaken in an environmentally sensitive manner, the Town should require new development and/or re-development to provide environmental studies where deemed necessary to identify impacts and offer mitigation measures to protect the environmental features.

12.5 Quinte Conservation Implementation Requirements

Recommendation 9 - Quinte Conservation will maintain and update the HEC-HMS model in the future.

Recommendation 10 - Quinte Conservation should install a hydrometric station on Selby Creek to develop an appropriate dataset for calibration of the hydrologic model.

12.6 Developer Implementation Requirements

Developers, in consultation with Quinte Conservation and Municipality, must consider many key factors as listed in Section 12.1 to determine what specific SWM treatment or combination of treatments is most appropriate for various areas within each sub-basin.

12.6.1 Submission Requirements

Recommendation 11 - Developers are responsible to follow the SWM guidelines in this MDP report as approved in accordance with accepted MOE stormwater management planning and design in preparing SWM submissions and designs to accompany development applications to the Town of Greater Napanee and Quinte Conservation. Developers must:

- satisfy quality storage requirements (Level 1 water quality control protection criteria),
- meet the MOE design guidelines, and,
- follow the water quantity control guidelines (refer to Table 7.7 and Map 7.4 for storage requirement values). Peak flows developed by the HEC-HMS model at the outlet of each sub-basin and at selected junctions should be considered benchmarks against which flows for post-development conditions are compared.

Recommendation 12 –Submission of as-built drawings and sign-off of the completed SWM works by a qualified Water Resources Engineer are both an integral part of the process to ensure that the approved SWM treatment is constructed and performing according to plan and are required prior to the release of associated performance securities.

Recommendation 13 –Proposed developments located within the study area that exceed the stated impervious level limits (refer to Section 11.6.3) will require additional study to determine the appropriate on-site water quantity control volumes to be used. A pre-consultation meeting with Quinte Conservation is recommended prior to proceeding further into the development of the stormwater management plan.

Recommendation 14 - Developers are required to discuss SWM options in general with the Town and Quinte Conservation prior to undertaking detailed analysis, modeling (if necessary) and design.

Recommendation 15 – Geotechnical Analysis and evaluation of infiltration potential by the developer is a required condition of all draft plan approvals for future development if infiltration is a proposed SWM treatment method.

12.6.2 SWM Pond Requirements

Although stormwater ponds have not been emphasized as a recommended SWM solution, the following are the recommendations for developments where stormwater ponds are proposed.

Recommendation 16 - Developers must ultimately be charged for procuring SWM sites, be responsible for designing and developing the approved treatment facilities and for ongoing maintenance and performance monitoring cost until facilities are assumed by the Town.

Recommendation 17 – Stormwater pond design should consider both immediate and long-term planned development storage requirements.

Recommendation 18 - The developer's consultant should use the storage values noted in Table 7.7 to determine the storage requirements.

Recommendation 19 - Developers must base their SWM pond designs on off-line ponds. On-line ponds may be feasible on small tributaries provided that the purpose of the pond is limited to water quantity control only. Water quality control will need to be completed off-line. Pre-consultation meeting with Quinte Conservation is required to determine the feasibility of an on-line pond from a fisheries, floodline, and other environmental impact perspectives.

Recommendation 20 - The developer should be required to pay for water quality sampling (i.e. Total Suspended Solids) for a two-year period after the facility is constructed to ensure the facility is functioning within design parameters and if not, undertake appropriate re-design and reconstruction and pay for all associated costs. The water quality sampling would involve sampling both the inlet to and outlet from the SWM facility to establish removal efficiency and provide sediment loading data required to determine the clean-out frequency of the pond. Studies have indicated that continuous sample (as opposed to grab sample) during runoff events is required to accurately determine the removal efficiency of the pond.

Recommendation 21- The developer must plant the periphery of the SWM ponds with 50 mm caliper (ball & burlap) native tree stock to promote shading.

13. References

Canada Land Inventory – *Soil Capability for Agriculture Map and Land Capability for Waterfowl Production Map*. 1966. Queens Printer, Ottawa.

Chapman, L. J. and D. F. Putnam. 1984. *The Physiography of Southern Ontario*. Ontario Ministry of Natural Resources, Ontario Geological Survey Special Volume 2. 270 p.

Coker, G.A., C.B. Portt, and C.K. Minns. 2001. *Morphological and Ecological Characteristics of Canadian Freshwater Fish*. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2554: iv + 89p.

Dillon. 2004. *Quinte Regional Groundwater Study* Dillon Consulting Limited, London, ON.

Doolittle, A., Mandrak, N. E., Ming, D., Bakelaar, C., and Brunette, P. 2007. *Development of a web mapping tool and distribution maps of Ontario fishes with emphasis on species at risk.* Canadian Technical Report of Fisheries and Aquatic Sciences 2699: x + 45 p.

Hogg, W.D. 1980. *Time distribution of short duration storm rainfall in Canada.* Proc. Canadian Hydrology Symposium: 80, NRCC, Ottawa. Pp. 53-63

Hogg, W.D., 1982. *Distribution of rainfall with time: design considerations.* Paper presented at the American Geophysical Union Chapman Conference on Rainfall Rates, April 27-29, Urbana, IL.

Gillespie, J. E., and R. E. Wicklund. 1962. *Soil Survey of Hastings County*. Report No. 27 of the Ontario Soil Survey. Research Branch of the Canada Department of Agriculture, and the Ontario Agricultural College.

Ministry of the Environment. 2003. *Stormwater Management Planning and Design Manual.* Queen's Printer for Ontario, Toronto, ON.

Ministry of Transportation (Ontario). 2004. Transportation Environmental Study Report: Highway 401 – County Road 41 Interchange Improvements (W.P 31-99-00).

Napanee Region Conservation Report – Salmon River Section. 1967. Ontario Department of Energy and Resources Management, Toronto.

Napanee Valley Conservation Report. 1957. Ontario Department of Planning and Development, Toronto.

Natural Heritage Information Centre, Ontario Ministry of Natural Resources. Queens Printer for Ontario, 2008. http://nhic.mnr.gov.on.ca/MNR/nhic/queries/geographic.cfm.
Accessed: August 19, 2008.

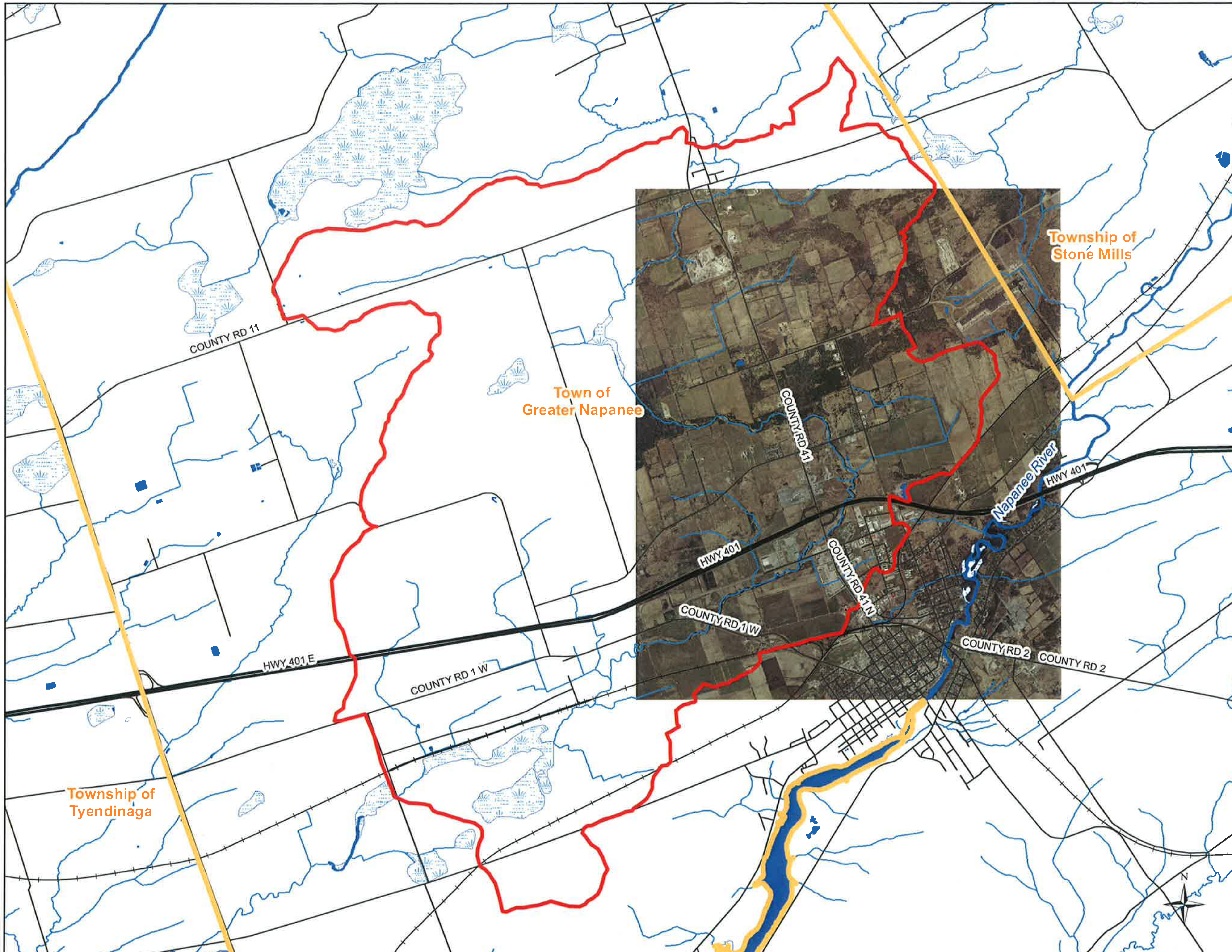
Ontario Ministry of Natural Resources. 1985. *Flood plain management in Ontario: technical guidelines. Conservation Authorities and Water Management Branch*, Toronto, ON.
Ontario Department of Planning and Development.

QRAP. 1993. *Bay of Quinte Remedial Action Plan Stage 2 Report.*

Schueler, T. R. 1987. *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs.* Metropolitan Washington Council of Governments, Washington, DC

Watt, W.E. and Chow, K.C.A. 1985. A General Expression for Basin Lag Time. ***Canadian Journal of Civil Engineering***, 12(2), 294-300.

Map 1.1
Study Area



Legend

- Study Area
- Townships
- Major Roads
- Minor Roads
- Railways
- Watercourses
- Waterbodies
- Wetlands

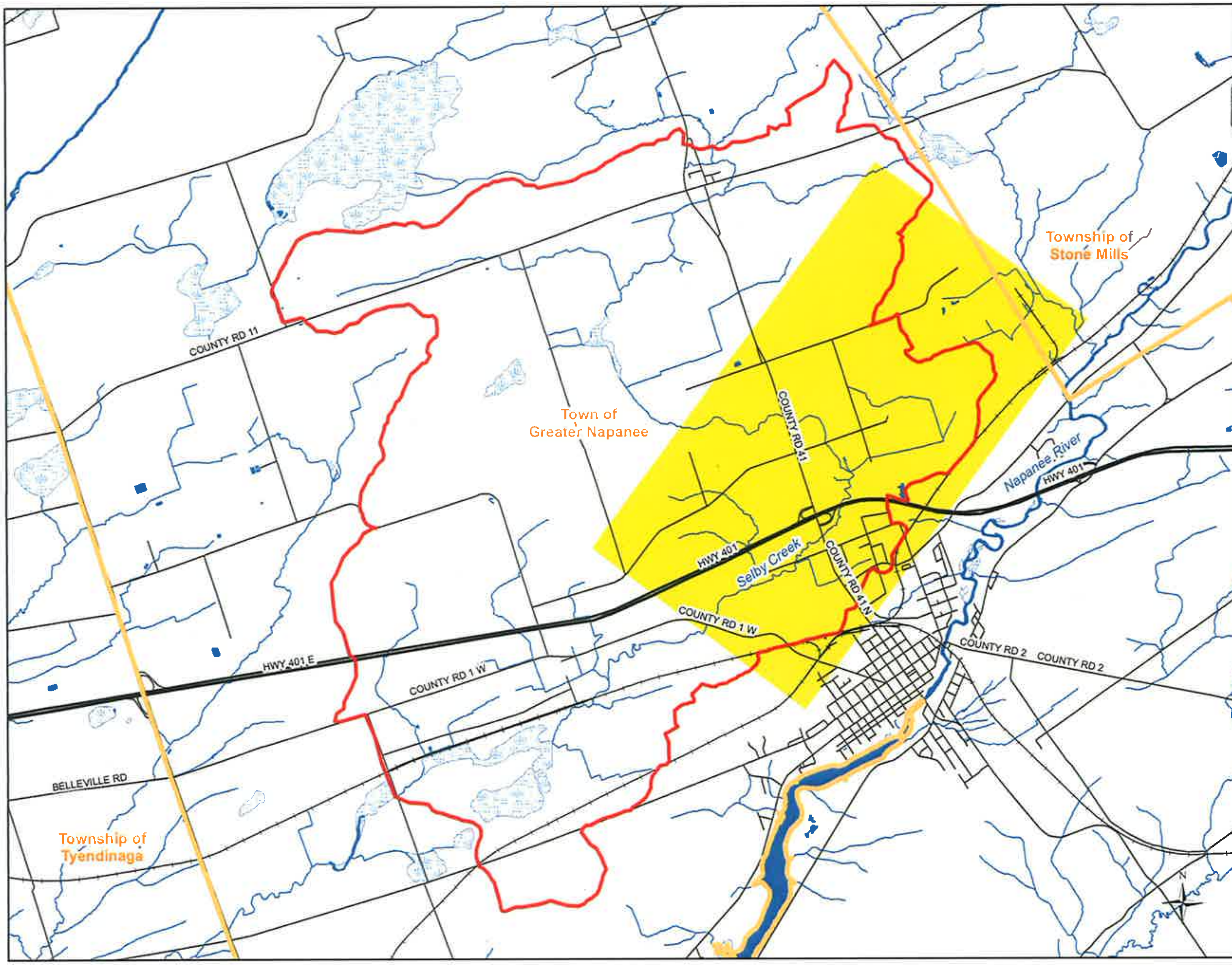
1:42,000

0 0.5 1 2

Kilometres

Digital Mapping Sources:
Base Map - Ministry of Natural Resources
1m Contours produced using LiDAR data
Watershed Boundary produced using LiDAR data

Map 3.1 LiDAR Coverage



Legend

- Study Area
- Townships
- Major Roads
- Minor Roads
- Railways
- Waterbodies
- Wetlands
- Watercourses
- LiDAR coverage

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0 0.5 1 2
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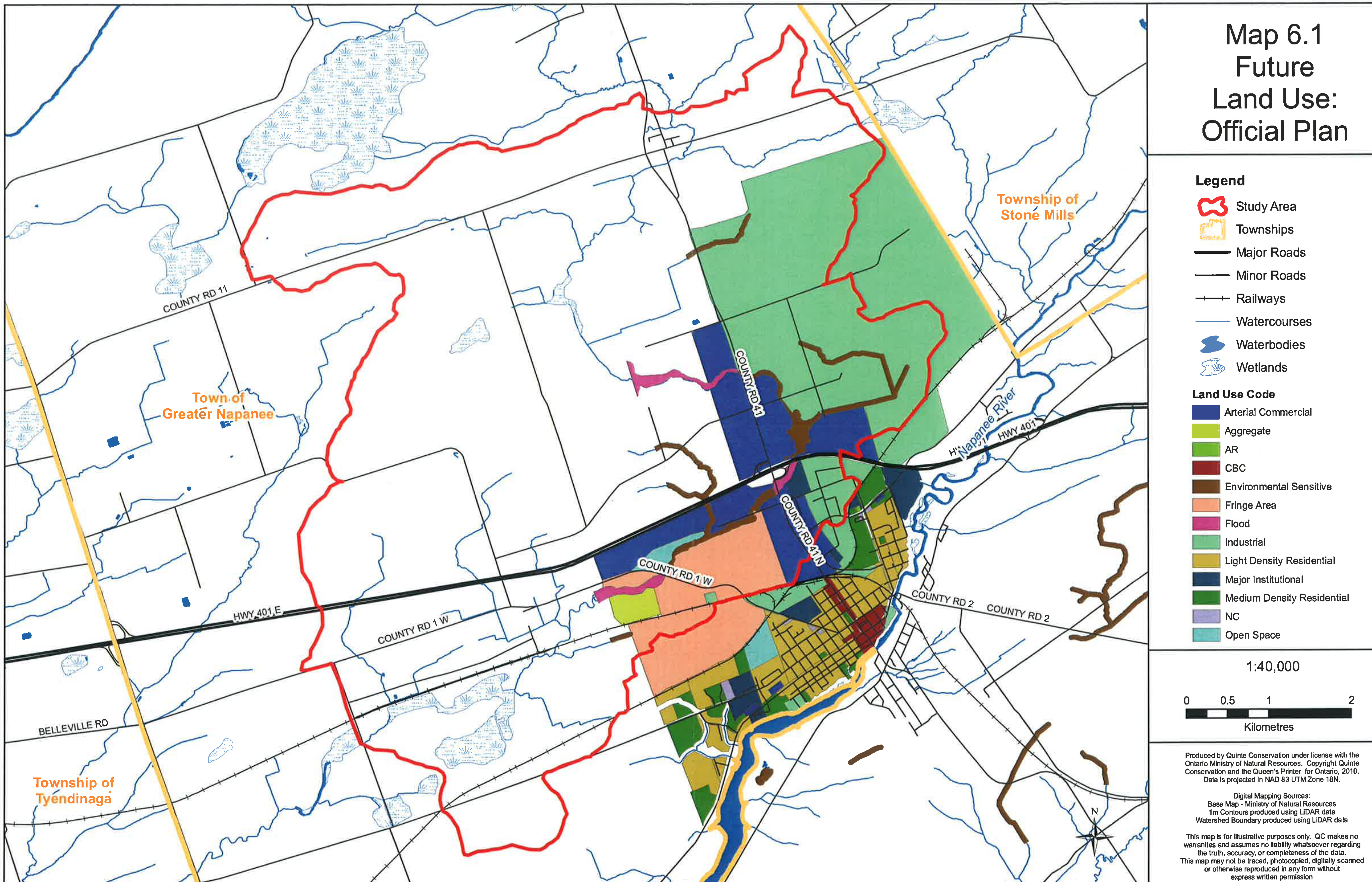
Data is projected in NAD 83 UTM Zone 18N

Digital Mapping Sources:
Base Map - Ministry of Natural Resources
1m Contours produced using LiDAR data
Watershed Boundary produced using LiDAR data

Map 6.1 Future Land Use: Official Plan



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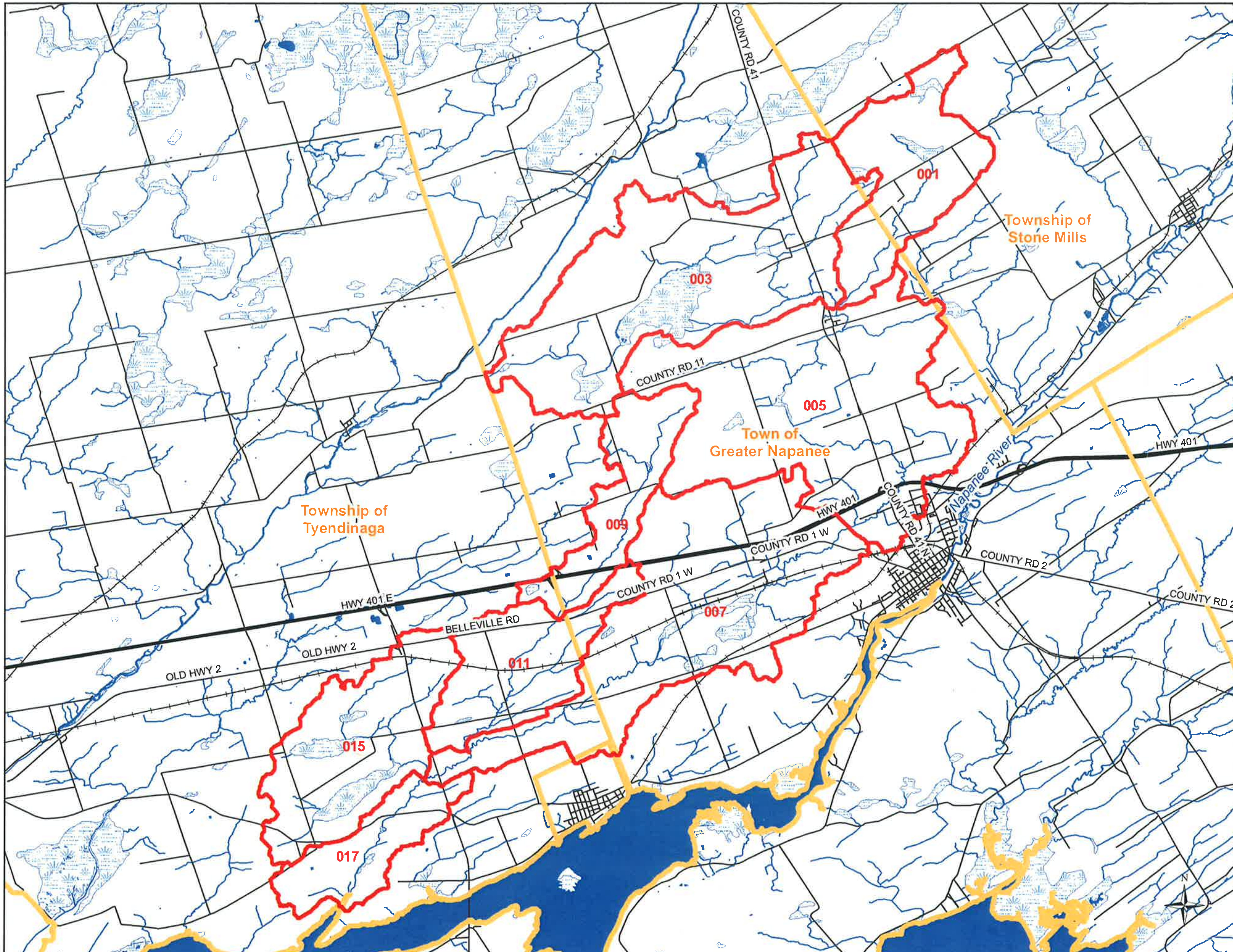
Digital Mapping Sources:
Base Map - Ministry of Natural Resources
1m Contours produced using LiDAR data
Watershed Boundary produced using LiDAR data

Map 7.1 Crysler & Lathem (1981) Sub-Basin Discretization



Legend

- Sub-Basins
- Townships
- Major Roads
- Minor Roads
- Railways
- Waterbodies
- Wetlands
- Watercourses

1:85,000

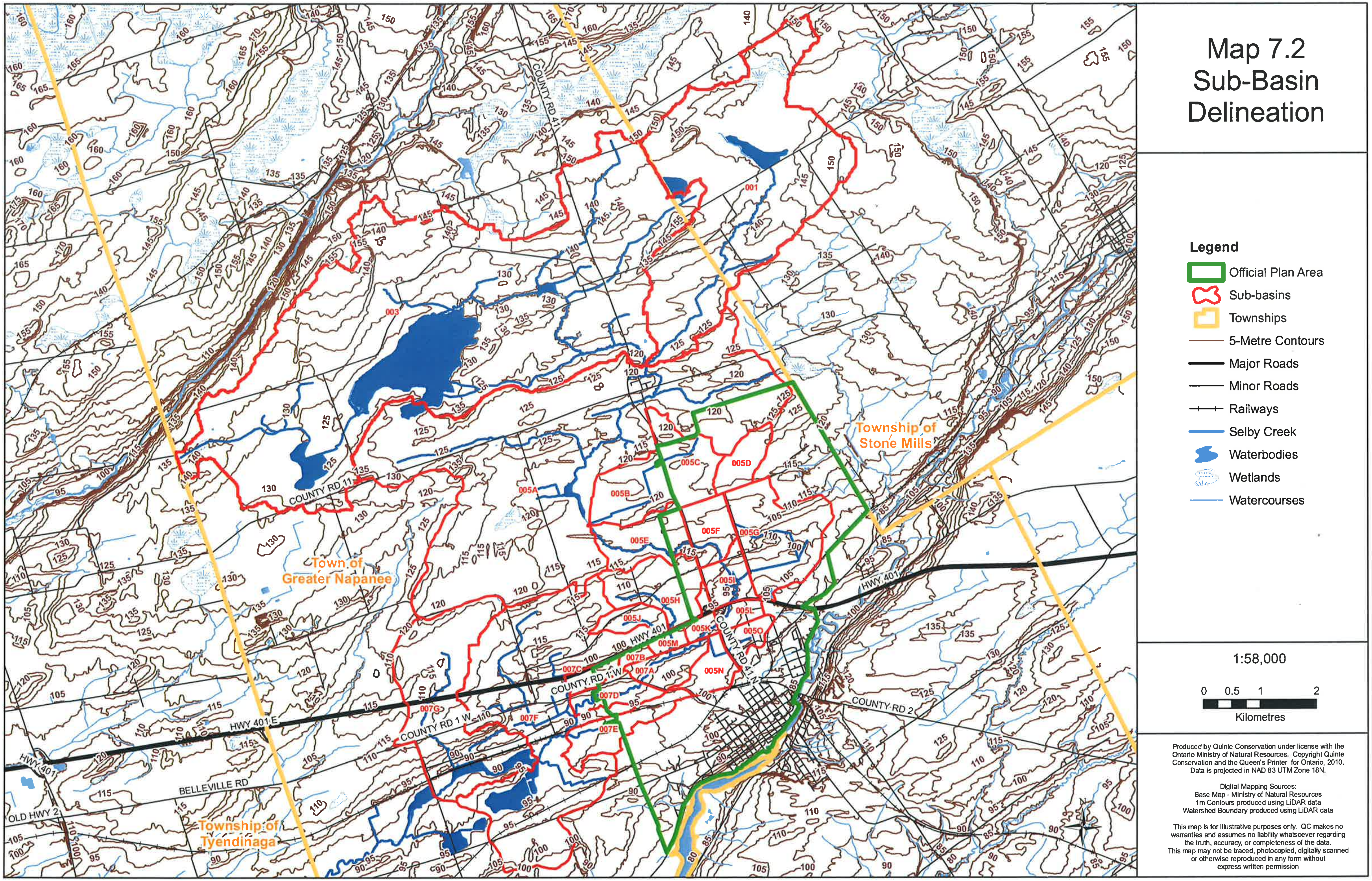
0 0.5 1 2 3 4

Kilometres

Data is projected in NAD 83 UTM Zone 18N.

Digital Mapping Sources:
Base Map - Ministry of Natural Resources
1m Contours produced using LiDAR data
Watershed Boundary produced using LiDAR data

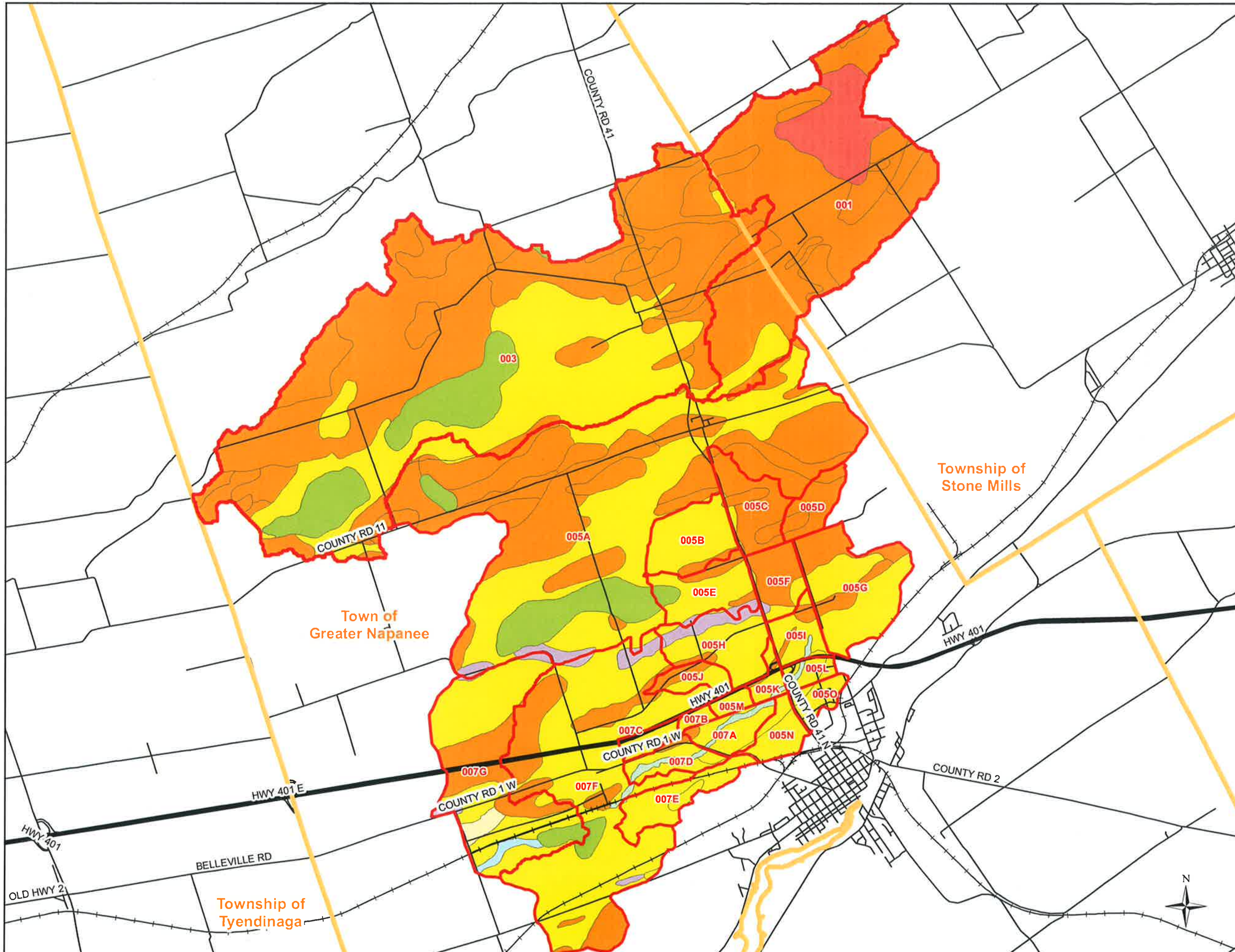
Map 7.2 Sub-Basin Delineation



Data is projected in NAD 83 UTM Zone 18N.

Digital Mapping Sources:
Base Map - Ministry of Natural Resources
1m Contours produced using LiDAR data
Watershed Boundary produced using LiDAR data

Map 7.3 Surficial Soils



Legend

- Sub-basins
- Townships
- Major Roads
- Minor Roads
- Railways

WaterHP

- BOTTOM LAND
- CLAY
- CLAY LOAM
- LOAM
- MUCK
- Sandy Loam
- MARSH

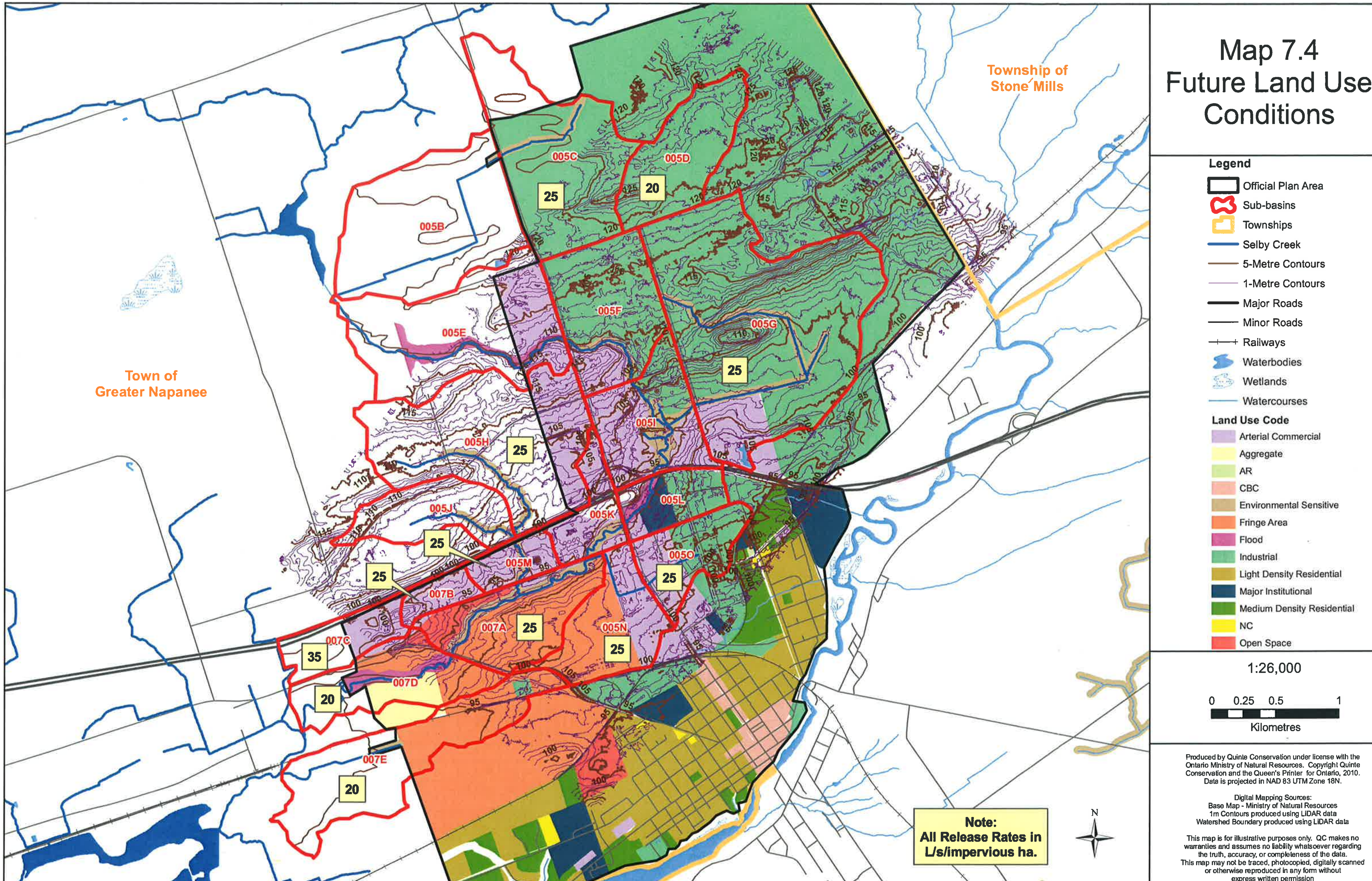
1:58,000

0 0.5 1 2

Kilometres

Data is projected in NAD 83 UTM Zone 18N.

Digital Mapping Sources:
Base Map - Ministry of Natural Resources
1m Contours produced using LiDAR data
Watershed Boundary produced using LiDAR data


Map 7.4
Future Land Use Conditions
Legend
Official Plan Area
Sub-basins
Townships
Selby Creek
5-Metre Contours
1-Metre Contours
Major Roads
Minor Roads
Railways
Waterbodies
Wetlands
Watercourses
Land Use Code
Arterial Commercial
Aggregate
AR
CBC
Environmental Sensitive
Fringe Area
Flood
Industrial
Light Density Residential
Major Institutional
Medium Density Residential
NC
Open Space
1:26,000
0 0.25 0.5 1
Kilometres
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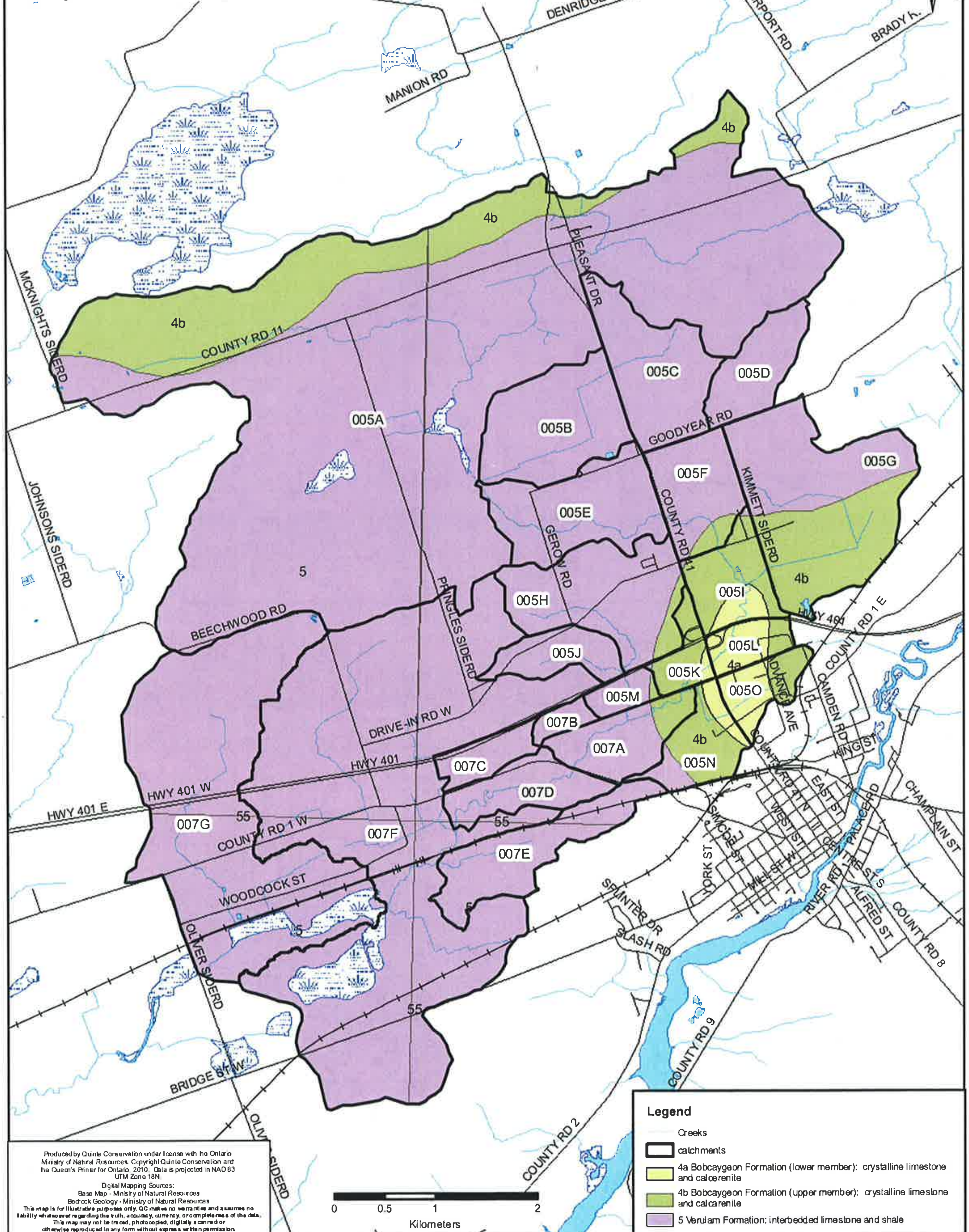
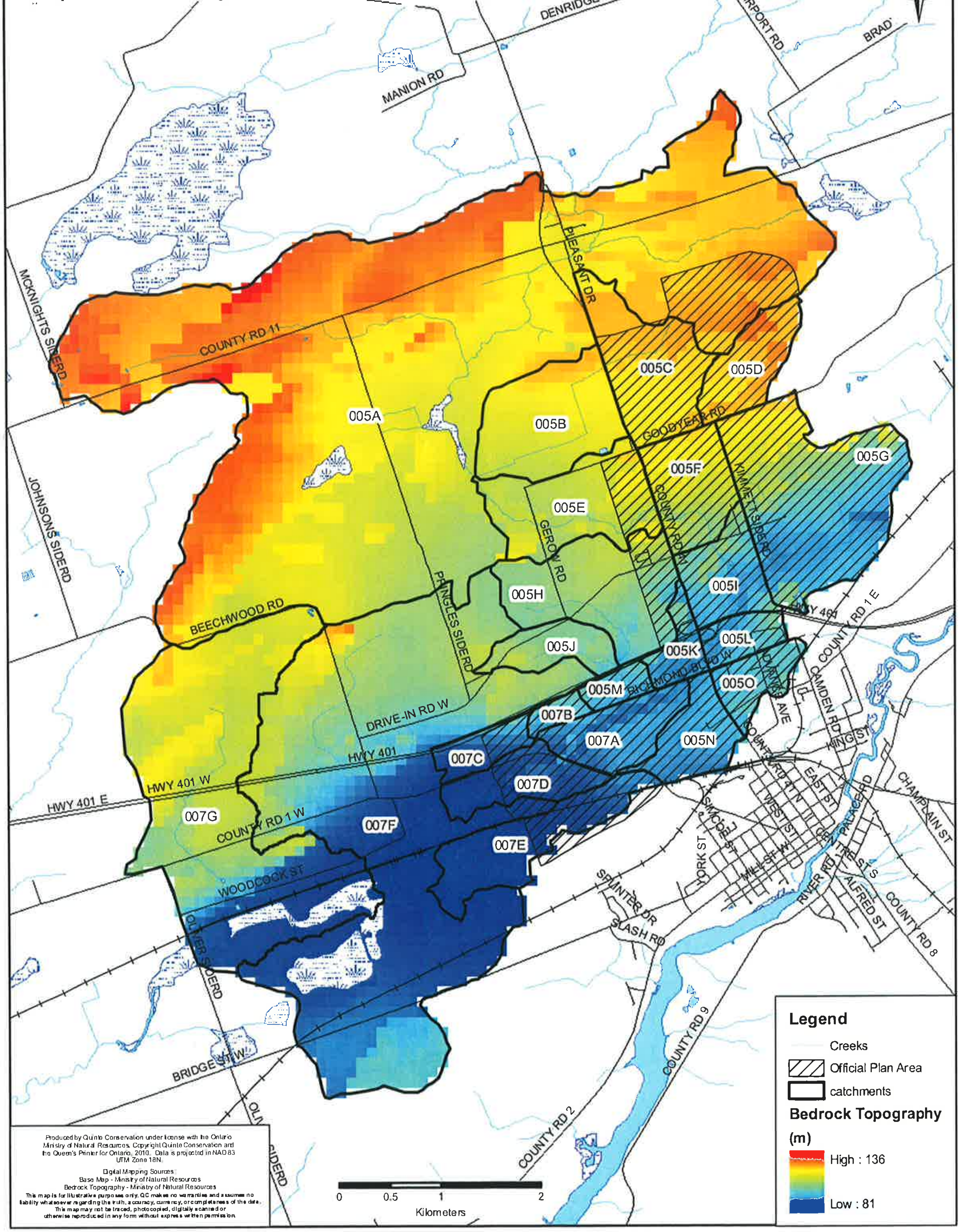
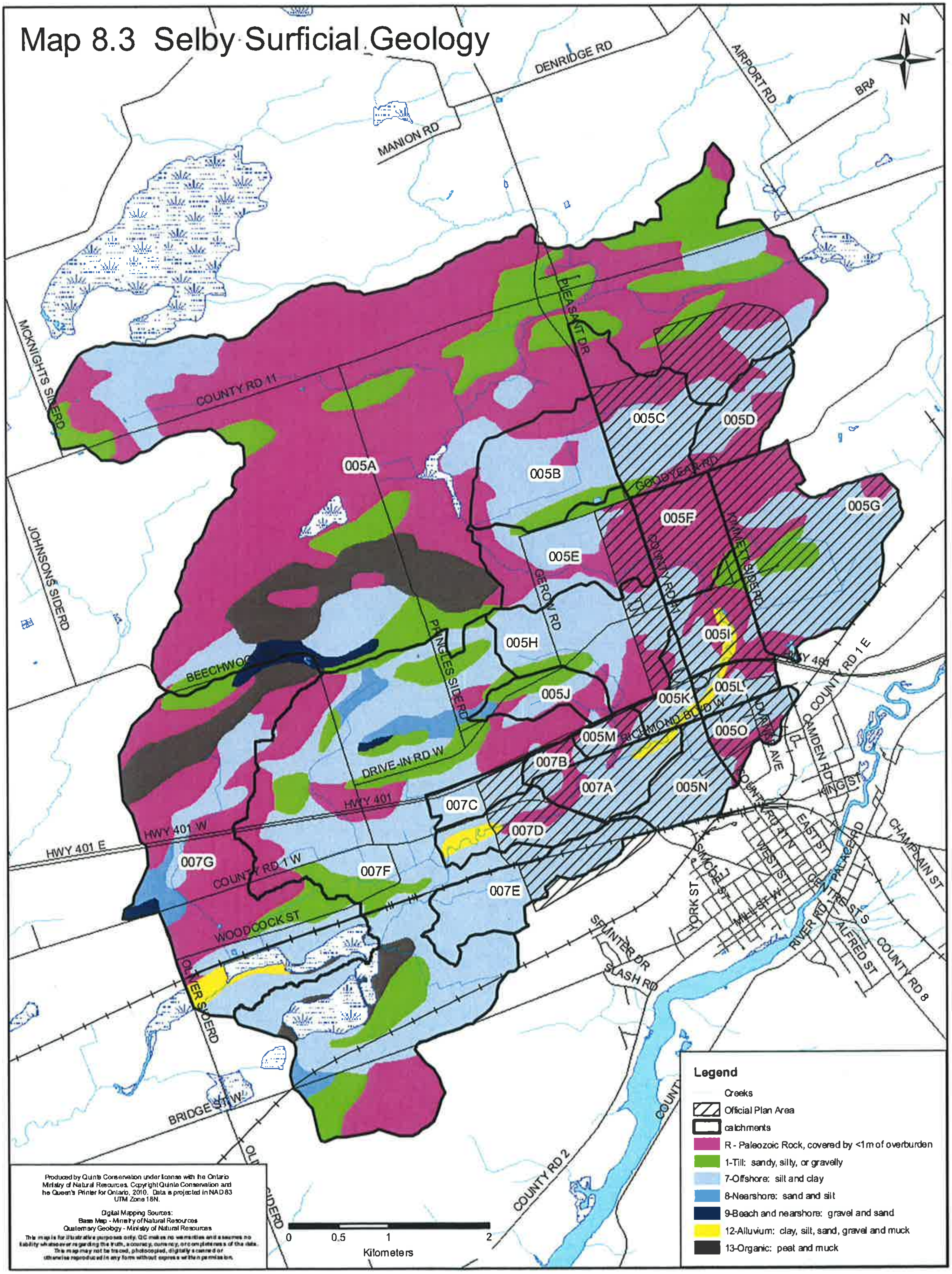
Township of Stone Mills
Town of Greater Napanee
Note:
All Release Rates in L/s/impervious ha.
N
005B
005C
005D
005E
005F
005G
005H
005I
005J
005K
005L
005M
005N
005O
007A
007B
007C
007D
007E
25
20
35

Map 8.1 Selby Bedrock Geology



Map 8.2 Selby Bedrock Topography




Map 8.3 Selby Surficial Geology
N
DENRIDGE RD
AIRPORT RD
BRA
MANION RD
MICKNIGHTS SIDERD
COUNTY RD 11
PLEASANT DR
005A
005B
005C
005D
005E
005F
005G
005H
005I
005J
005K
005L
005M
005N
005O
007A
007B
007C
007D
007E
007F
007G
GOODYEAR RD
COUNTY RD 41
KIMMETT SIDERD
JOHNSONS SIDERD
GEROW RD
PRINGLES SIDERD
BEECHWOOD
HWY 401
COUNTY RD 1 E
RICHMOND BLVD W
DAIRY AVE
CAMDEN RD
DRIVE-IN RD W
KING ST
HWY 401 W
HWY 401 E
COUNTY RD 1 W
EAST ST
WEST ST
CENTRE ST
PALACE RD
CHAMPLAIN ST
SIMCOE ST
YORK ST
MILL ST W
RIVER RD
ALFRED ST
COUNTY RD 8
WOODCOCK ST
SPLINTER DR
SLASH RD
OLIVER SIDERD
BRIDGE ST W
COUNTY RD 2
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Quaternary Geology - Ministry of Natural Resources
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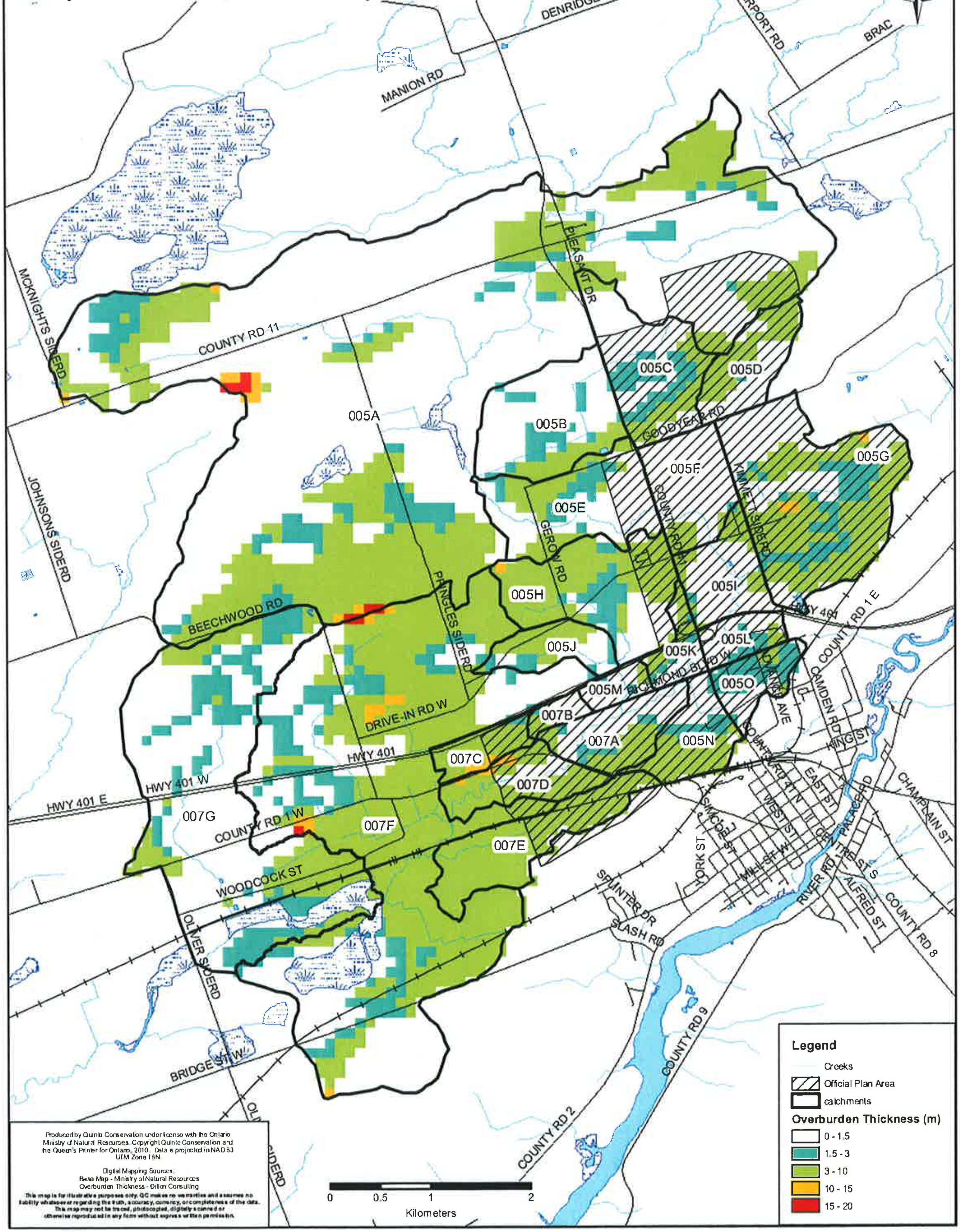
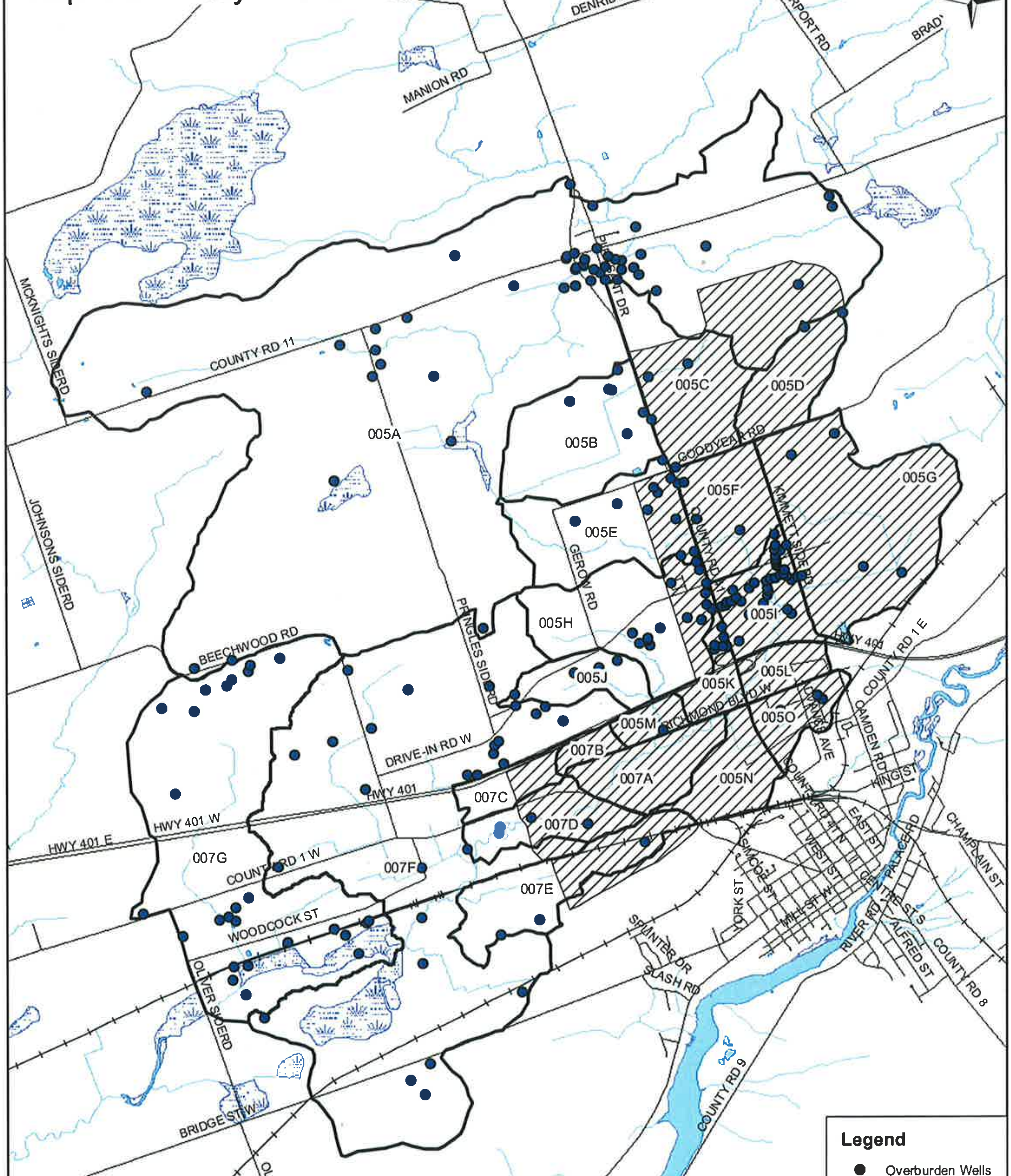
0
0.5
1
2
Kilometers
Legend
Creeks
Official Plan Area
catchments
R - Paleozoic Rock, covered by <1m of overburden
1-Till: sandy, silty, or gravelly
7-Offshore: silt and clay
8-Nearshore: sand and silt
9-Beach and nearshore: gravel and sand
12-Alluvium: clay, silt, sand, gravel and muck
13-Organic: peat and muck

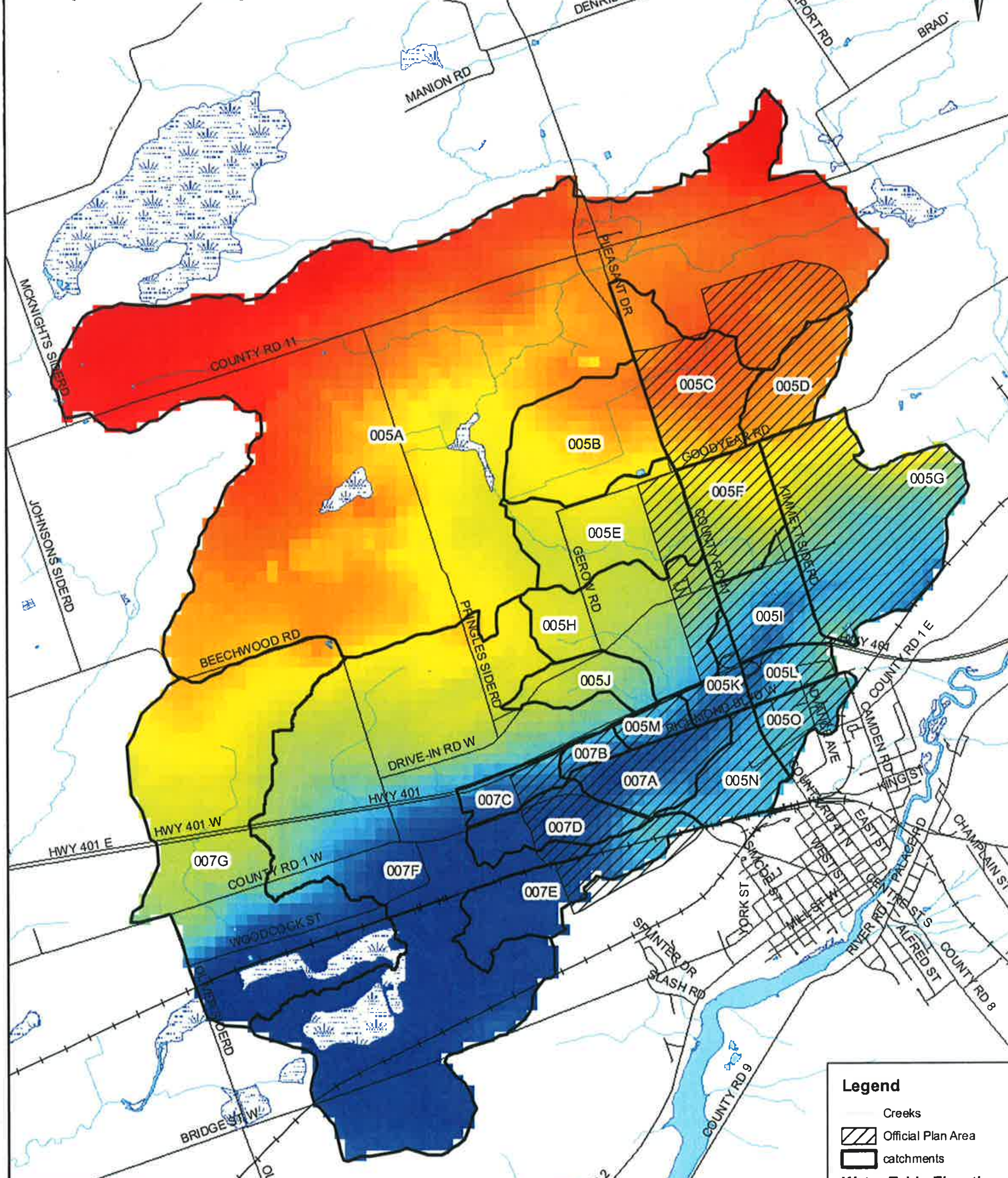
Map 8.4 Selby Overburden Thickness



Map 8.5 Selby Wells



Map 8.6 Selby Water Table Elevation



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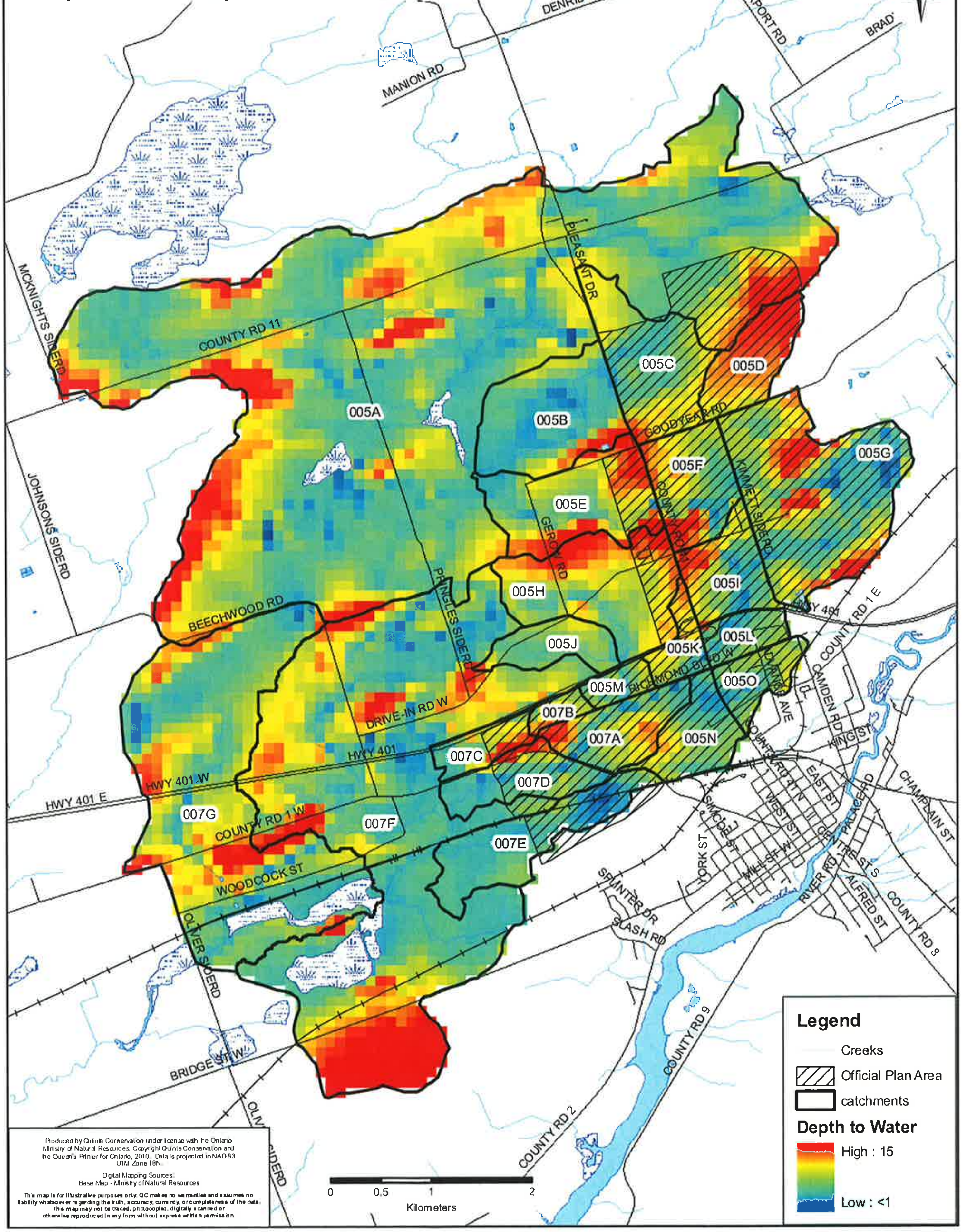
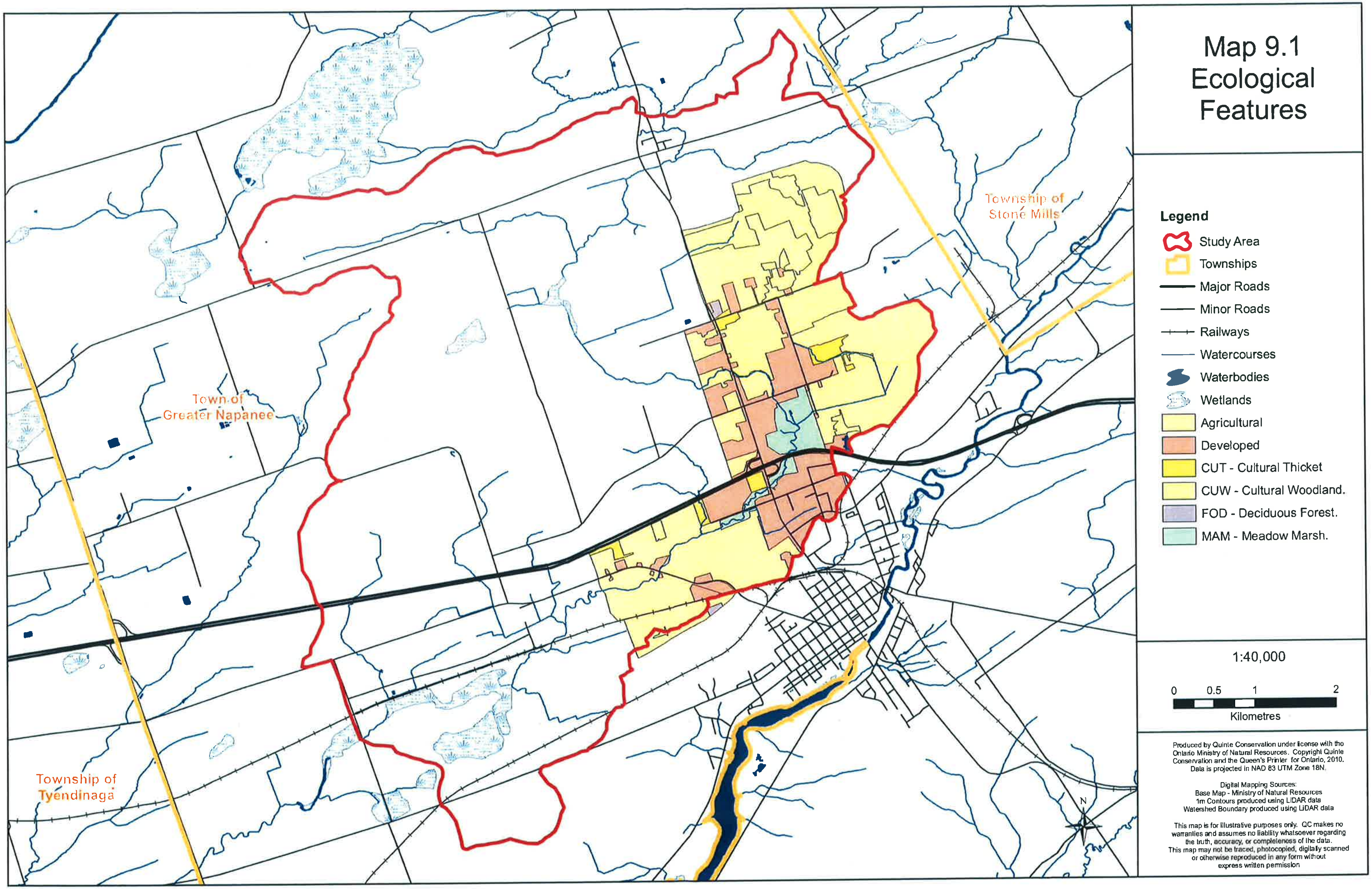
Digital Mapping Sources:
Base Map - Ministry of Natural Resources
Water Table Elevation - Dillon Consulting

Map 8.7 Selby Depth To Water




Map 9.1
Ecological
Features
Legend
Study Area
Townships
Major Roads
Minor Roads
Railways
Watercourses
Waterbodies
Wetlands
Agricultural
Developed
CUT - Cultural Thicket
CUW - Cultural Woodland.
FOD - Deciduous Forest.
MAM - Meadow Marsh.
1:40,000
0
0.5
1
2
Kilometres
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Township of
Stone Mills
Town of
Greater Napanee
Township of
Tyendinaga
N