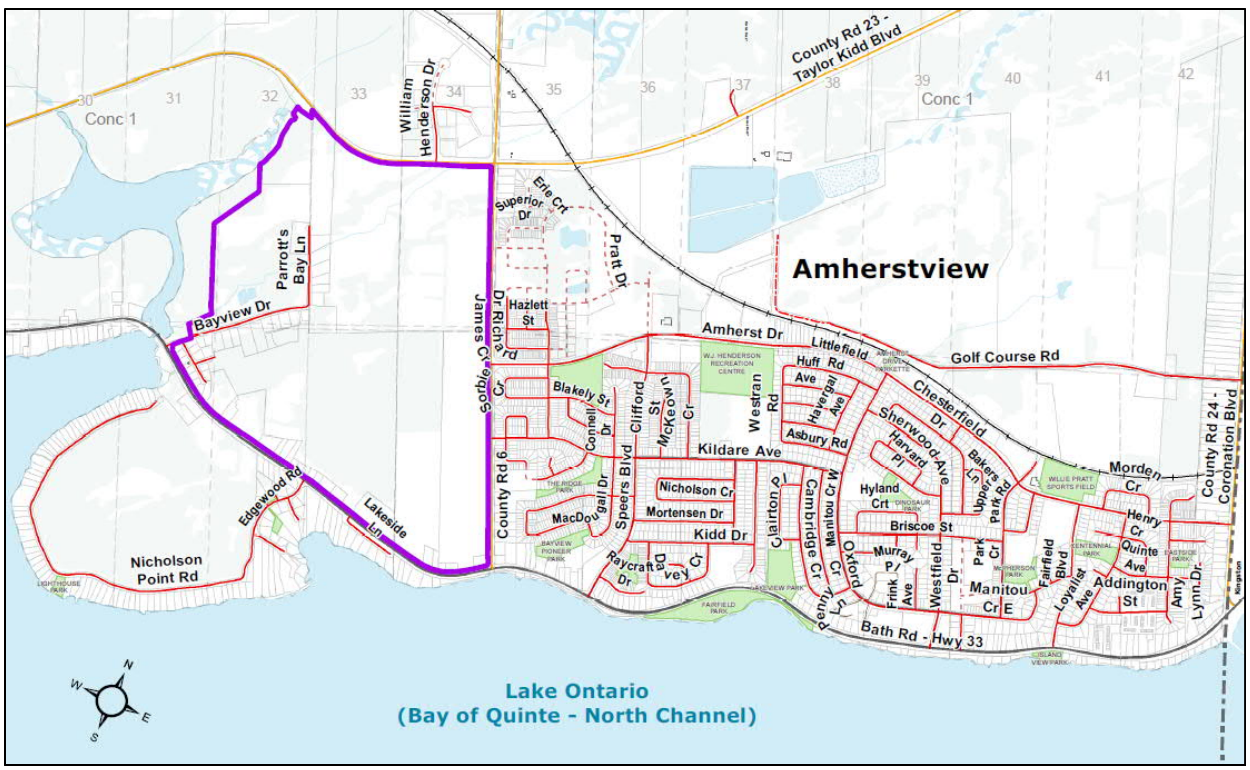
Amherstview West Secondary Plan

Natural Hazards and Master Stormwater Management Report

OCTOBER 11, 2024 FINAL



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Natural Hazards and Master Stormwater Management report

Loyalist Township

FINAL

PROJECT NO.: 211-01353-00
DATE: OCTOBER 11, 2024

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Revision History

First issue

2022-01-31	DRAFT REPORT			
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2022-12-12	FINAL DRAFT REPORT			
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2023-05-17	FINAL DRAFT REPORT Rev 1			
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2023-07-14	FINAL DRAFT REPORT Rev 2			
Prepared by	Prepared by	Reviewed by	Reviewed by	Approved by
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2023-11-13	FINAL DRAFT REPORT Rev 3			
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2024-07-22	FINAL DRAFT REPORT Rev 4			
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2024-10-11	FINAL REPORT Rev 5			
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1 Introduction

1.1 Background

The Loyalist Township is a lower-tier municipality located in the County of Lennox and Addington in Eastern Ontario. It has a land area of approximately 341.02 km^2 (2016 Census) and consists of several communities, including Amherstview; Bath; Amherst Island; Odessa; the hamlets of Millhaven, Morven, Stella, Violet, and Wilton; and surrounding agricultural, rural, and residential communities.

The Loyalist Township is undertaking a Secondary Plan for Amherstview West. The Secondary Plan will provide a policy and implementation framework to guide the future growth and development of this area for the next 25 years. The Secondary Plan will address the extension of Amherstview to the west, to accommodate future growth and development in the community for the next 25 years. It will consider future needs and priorities for the new community, including housing types, urban design, community amenities, protection of the natural environment, and transportation, as well as active transportation. As shown in Figure 1-1, the Secondary Plan study area is located to the west of County Road 6 and the existing built-up area in Amherstview. In addition, the study area is situated between Taylor-Kidd Boulevard (County Road 23) to the north and Bath Road (Highway 33) to the south.

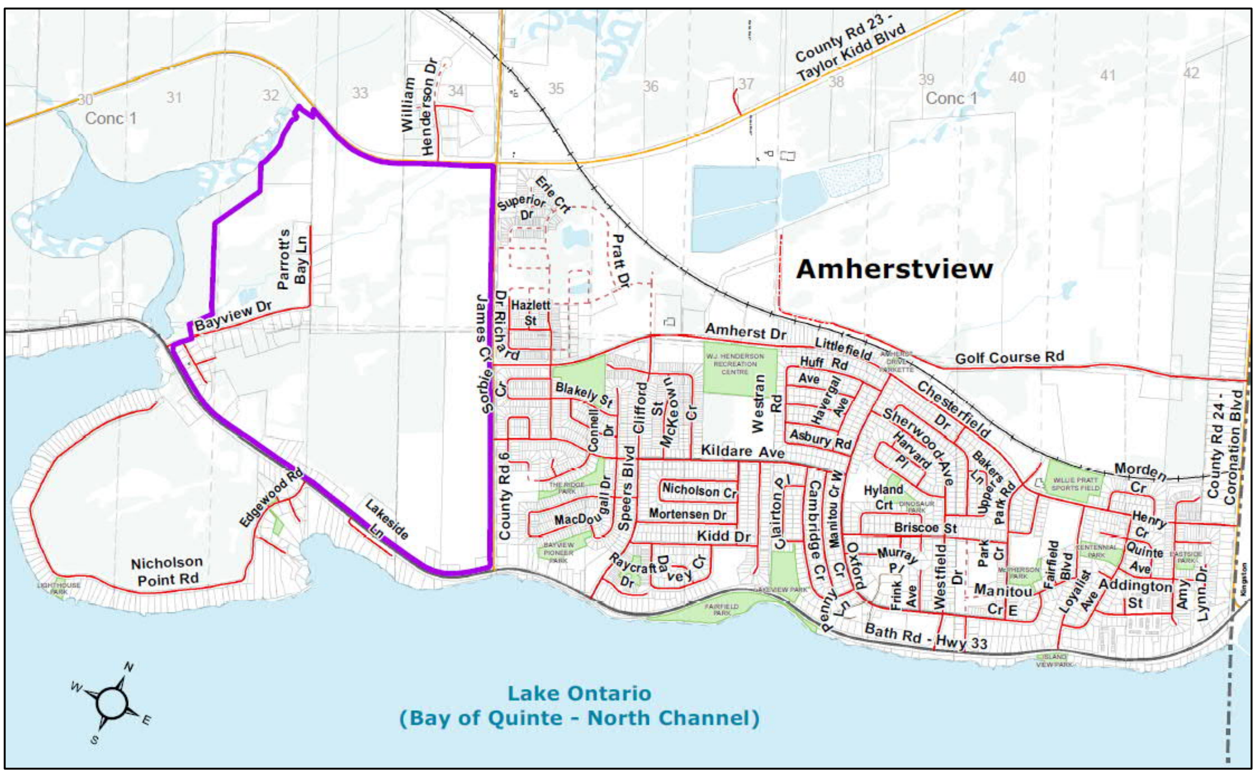

Figure 1-1: Amherstview West Secondary Plan – Study Area

1.2 Report Scope

The Secondary Plan study is being carried out in five phases:

- Phase 1 - Project start-up, data collection, and completion of background studies
- Phase 2 - Public engagement (ongoing over the course of the study)
- Phase 3 - Identification of land use concept options and identification of a preferred option
- Phase 4 - Preparation of urban design standards and Official Plan Amendment
- Phase 5 - Preparation of the implementing zoning by-law amendment

This report includes an assessment of Natural Hazards pertaining to stormwater management for the purposes of reviewing master stormwater management (SWM) options for servicing. The report provides a comprehensive assessment of the existing storm drainage patterns within the study lands, supported by hydrologic analysis to determine current peak flow rates at key locations through the site and at discharge points into offsite/downstream systems such as Lost Creek which discharges into Parrots Bay and The Edgewood Municipal Drain which ultimately discharges into Lake Ontario. This analysis of existing conditions informs the target SWM criteria for the planned development, which was developed on a regional basis for quantity and quality control of storm events up to and including a 100-year return period. The report also highlights where the provision of erosion control measures to protect receiving systems is warranted and the applicable municipal and agency SWM targets which are to be incorporated into the planned works.

To test the impact of the proposed works from a hydrologic perspective and to ensure robust SWM strategies are in place to support the proposed works the report includes the conceptual storm servicing options & hydrologic modelling to identify opportunities for SWM facilities and to ensure adequate land (in terms of area and location) is allocated for SWM features through the planning process. Typically, best practices favour consideration of Low Impact Development (LID) approaches to work towards target SWM criteria; however, it is acknowledged that within the study area, shallow overburden conditions coupled with impermeable bedrock and/or karstic conditions may limit future opportunities to incorporate LID features. These concerns were reviewed and validated as part of the study in conjunction with Geotechnical and Hydrogeological studies, which are currently ongoing in the area.

The report also includes reviews of additional “climate change impacted” storm events in the hydrologic modelling of the site (existing and proposed conditions), to test the sensitivity of the system to anticipated future changes in rainfall patterns.

As part of the assignment, WSP reviewed the CRCA guidelines to develop a thorough understanding of the current condition and capacity of the “Lost Creek” within the study area and to ensure that future development proposals respond appropriately to this existing natural feature. Hydrologic and hydraulic review was undertaken to support the assessment and inform SWM targets for any future runoff discharge to this area.

1.3 Study Area

The study area of Amherstview West is located on the west edge of County Road 6, south of Taylor-Kidd Boulevard (County Road 23), north of Bath Road (Highway 33), and east of Parrott's Bay Conservation Area. The study area is primarily undeveloped with the exception of Parrot's Bay Lane, Bayview Drive, Brooklands Park Avenue, and Harrow Court.

Figure 1-2 highlights the watershed, delineated by the orange border, which contributes significant runoff flow during significant rain events within the study area. Catchment area delineation is based on Cataraqui Region Conservation Authority (CRCA) and Ontario Flow Assessment Tool (OFAT) GIS data.

Figure 1-2: Study Area and Watershed

1.4 Provided Data

The following documents have been provided by Loyalist Township to complete the review for SWM and to perform an information gap analysis. These documents include:

- 2006 Central Cataraqui Region Natural Heritage Study Report
- 2014 County of Lennox and Addington Official Plan
- 2014 County of Lennox and Addington Transportation Master Plan Update (Completed by AECOM)
- Loyalist Township Building By-law
- 2014 Loyalist Township By-law 2001-38
- 2015 Loyalist Township Development Charges Background Study (Completed by Hemson Consulting)
- 2020 Loyalist Township Draft Official Plan
- 2019 Loyalist Township Growth Projection Study (Completed by Hemson Consulting)
- 2020 Loyalist Township Interim Development Charges Study (Completed by Hemson Consulting)
- 2019-2023 Loyalist Township Strategic Plan
- 2019 Loyalist Township Water and Sewer User Rates Study
- 1430 Sanitary sewer design chart
- 1999 Harewood-Brooklands Watermain Extension Highway 33 (Bath Road) As-builts
- 2002 KoSa Hwy 33 (Bath Road) Watermain Extension As-builts
- 1998-2019 Building Permit Summaries
- 2014 County Transportation Master Plan (Completed by AECOM)
- 2015 DC Background Study
- 2019 Drainage Report (Completed by Robinson Engineers)
- 2014 Lennox and Addington - Official Plan (Completed by Meridian Planning)
- 2019 Population Housing and Employment Projections (Completed by Hemson)
- Sanitary Design - County Road 6
- Sanitary Design – Taylor-Kidd to SPS

1.5 Data Requests

The following related information was requested and provided from the Township to complete the background study:

- Township Base Mapping (CBM)/ GIS Background Information in ArcGIS geodatabase (including Storm, Sanitary, and Water Pipe Material Information)
- Existing GIS storm and sanitary sub-catchment area mapping if available
- Central Cataraqui Natural Heritage Study - 2006 by the Cataraqui Region Conservation Authority - GIS layers
- Edgewood Municipal Drain Study (July 2019 by Robinson Consulting)
- Any available drainage studies for the study area or adjacent lands, including sub-catchment drainage details or flood plain mapping if available
- ResLienT Loyalist Township - Climate Action Plan (2021 – Loyalist Township)

2 Legislative Review

The following Federal and Provincial legislation apply to the establishment and expansion of water and sanitary linear networks in Ontario, and apply to any development within the Secondary Plan area.

2.1 Federal Legislative Requirements

2.1.1 Canada Water Act (1985)

The Canada Water Act, passed in 1970 and revised in 1985, provides for the management of water resources in Canada. The purpose of the Act is to provide a framework for cooperation with the provinces & territories regarding research, planning, and implementation of programs linked to water use, conservation, and development. The federal government has outlined regulations under the Canada Water Act including policies for fisheries, navigation, and the conduct of external affairs.

2.1.2 Fisheries Act (1985)

The Fisheries Act contains habitat and pollution protection provisions that apply to all levels of government and the public. Subsection 35(1) of this Act states “no person shall carry out any work or undertaking that results in the harmful alteration, disruption, or destruction (HADD) of fish habitat” unless authorized by the Minister of Fisheries and Oceans Canada. A subsection 35(2) Fisheries Act authorization may be issued when adverse effects cannot be avoided.

2.1.3 Canadian Environmental Protection Act (1999)

The Canadian Environmental Protection Act is intended to provide for the protection and conservation of the natural environment, by controlling discharges to air, land, and water. Regulations made under the Act propose limits on what can be discharged to the environment and allow for fines & other penalties when unauthorized discharges occur. This Act affects how a community can dispose of materials and approach its construction activities to ensure that there are no harmful effects on the environment.

2.2 Provincial Legislative Requirements

2.2.1 Drainage Act (1990)

The Drainage Act provides a procedure for municipalities to review and design drainage infrastructure after a valid petition of landowners in the "area requiring drainage”. The act provides a legal outlet for surface and subsurface waters not attainable under common law including ‘municipal drains.’ When developing the municipal drain system an engineer must first provide design information and maintenance schedules from information obtained in the field and from conversations with landowners. An engineer's experience with similar projects is valuable in preparing the design, determining necessary structures, specifying materials, writing a comprehensive description of work requirements, estimating costs, determining a cost share based on traditional drainage engineering concepts, and preparing necessary tender documents. The drainage report forms a basis for further discussion of a drainage proposal.

Under the Drainage Act, the municipality is responsible for maintaining the drainage works after construction. The municipality may appoint a drainage superintendent to supervise maintenance work on all municipal drains within the municipality. When the drainage report is "current", maintenance work can be undertaken without preparing a new drainage report. The drainage superintendent is responsible to the municipality and the landowners for inspecting the drain or local problems on the drain, discussing necessary maintenance with landowners, and supervising the maintenance work. The costs for maintenance are distributed amongst the landowners in the watershed according to the maintenance clauses contained in the current report.

2.2.2 Cataraqui Region Conservation Authority (CRCA – 2015) – Guidelines for Stormwater Management

A copy of the CRCA guidelines is presented as **Appendix A** to this report which is based on the CRCA Environmental Planning Policies (2015). The CRCA Environmental Planning Policies, as well as municipal stormwater guidelines, have been prepared to encourage the design process of SWM systems to determine design criteria requirements required for effective water quality and quantity control. The guidelines refer to Stormwater management as a very important aspect of any site development. When implemented correctly, it minimizes downstream hazards such as flooding and erosion, as well as maintains and improves water quality by capturing site pollutants before they reach receiving waterbodies such as lakes and streams.

2.2.3 The Planning Act (1990)

The Planning Act, R.S.O. 1990, as amended, is the primary legislation governing land-use planning in Ontario. It outlines matters of provincial interest and enables the province to issue Policy Statements to provide direction to municipalities on these matters. The Planning Act enables municipal Councils to pass tools to plan and regulate the use of land and the location of buildings and structures on a lot. Under Section 16 of the Act, most municipalities, including Lennox and Addington County (upper-tier) and Loyalist Township (lower-tier), are required to prepare and adopt Official Plans in accordance with the Act. Official Plans contain a vision, objectives, and policies to guide decision-making on land-use planning matters. Municipal decisions, by-laws, and public works are required to conform to the policies of the Official Plan (Section 24(1)). The Act also enables municipalities to provide more detailed land use policy direction for specific areas or neighbourhoods, by way of a Secondary Plan, which is added to an official plan by amendment (Section 22(1)(1)).

2.2.4 Ontario Water Resources Act (1990)

The Ontario Water Resources Act was passed for the purpose of conservation, protection, and management of Ontario waters. The act identifies requirements for water works, including wells, and sewage works in relation to planning, design, siting, public notification and consultation, establishment, insurance, facilities, staffing, operation, maintenance, monitoring, and record-keeping. The Act is a general water management statute which applies to both groundwater and surface water. This Act specifies the requirements that the community must satisfy in order for the provincial government to grant approval for establishing, altering, extending, or replacing water and wastewater system components.

2.2.5 Clean Water Act (2006)

Ontario's Clean Water Act is intended to ensure that communities are able to protect their municipal drinking water supplies through the development of collaborative, locally driven, and science-based protection plans (source water protection plans). The Act requires that local communities evaluate existing and potential threats to their water source(s) and subsequently implement the required actions to reduce or eliminate these threats. The community can use this information to make choices about the size and locations of water & wastewater servicing elements (e.g., treatment plants, pumping stations, transmission mains, and collection mains).

2.2.6 Safeguarding and Sustaining Ontario's Water Act (2007)

The Province of Ontario passed the Safeguarding and Sustaining Ontario's Water Act to enable implementation of the Great Lakes – St. Lawrence River Basin Sustainable Water Resources Agreement and other amendments to the Permit to Take Water program.

The principles of the Great Lakes – St. Lawrence River Basin Sustainable Water Resources Agreement include the Premiers of Ontario and Quebec, as well as the Governors of Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin. This agreement recognizes the following:

- The water of the Basin are a shared public treasure and the parties to the Agreement have a shared duty to protect, conserve, and manage the waters.
- Conserving & restoring the waters and water dependent natural resources of the Basin will improve them.
- Continued sustainable, accessible, and adequate water supplies for the people and economy of the Basin are important.

2.2.7 Provincial Policy Statement (2020)

The Provincial Policy Statement (PPS) is an integral part of Ontario's planning system. The PPS sets policy direction on matters of provincial interest related to land use planning, growth management, environmental protection, public health, and public safety while aiming to provide a stronger policy structure that guides communities in Ontario toward a higher quality of life and a better long-term future.

The PPS establishes the various municipalities' roles in planning for growth, intensification, and redevelopment. New settlement area policies will only permit expansions where it is demonstrated that opportunities for growth are not available through intensification, redevelopment, or in designated areas. The PPS also requires municipalities to coordinate and provide direction on policies with cross municipal boundaries, such as natural heritage systems and resource management. The PPS provides the basis or context for all Provincial Plans and Municipal Official Plans.

The PPS outlines policies and policy reviews related to water, sewage, and stormwater infrastructure planning. These policies are based on addressing long-term population projections while creating sustainable, reliable, and financially feasible resources for the Province.

2.3 Ontario Environmental Assessment Act

The Ontario Environmental Assessment Act, and the associated Codes of Practice, require proponents to examine and document the environmental effects that might result from major projects or activities. The purpose of the Act is the betterment of the people of the whole or any part of Ontario by providing for the protection, conservation, and wise management of the environment in the Province (RSO1990, c. 18, s.2).

The Act sets a structure for a systematic, rational, and replicable environmental planning process that is based on five key principles, as follows:

- Consultation with affected parties: Consultation with the public and government review agencies is an integral part of the planning process. Consultation allows the proponent to identify and address concerns cooperatively before final decisions are made. Consultation should begin as early as possible in the planning process.
- Consideration of a reasonable range of alternatives: Alternatives to include functionally different solutions to the proposed undertaking as well as alternative methods of implementing the preferred solution. The “do nothing” alternative must also be considered.
- Identification and consideration of the effects of each alternative on all aspects of the environment: This includes the natural, social, cultural, technical, and economic environments.
- Systematic evaluation of alternatives in terms of their advantages and disadvantages, to determine their net environmental effects: The evaluation shall increase in the level of detail as the Study moves from the evaluation of alternatives to the proposed undertaking to the evaluation of alternative methods.
- Provision of clear and complete documentation of the planning process followed: This will allow traceability of decision-making with respect to the project. The planning process must be documented in such a way that it may be repeated with similar results.

2.3.1 Municipal Class Environmental Assessment (2023)

The EAA allows for certain “classes” of routine projects that have predictable environmental effects that can be readily managed to follow a streamlined Environmental Assessment process, referred to as a Class EA. Provided the approved process is followed, projects and activities included in a Class EA do not require individual review and approval under the EAA. This project is being conducted in accordance with the MCEA process, described in the MCEA guide prepared by the Municipal Engineers Association (MEA) (October 2000, as amended in 2007, 2011, 2015, & 2023).

The Class EA planning process requires the integration of sound engineering judgement, prudent long-term planning and protection of all aspects of the environment (natural, social, economic, and cultural). This includes consultation with the public and affected agencies, to obtain comments and input throughout the decision-making process before identifying a preferred alternative. The overall result of the Class EA process is the identification of a recommended plan that considers and minimizes impacts on the environment.

The MCEA process is made up of five phases: (1) definition of problems/opportunities; (2) development and evaluation of alternative solutions; (3) development and evaluation of alternative design concepts; (4) preparation of an Environmental Study Report for public review; and (5) implementation. Since projects undertaken by municipalities can vary in their environmental impact, projects are classified under the MCEA in terms of "Schedules." The project Schedule dictates which phases of the MCEA process must be completed before proceeding to implementation. The following provides a high-level overview of the current MCEA Schedules:

Exempt Projects

On March 3, 2023, the Government of Ontario enacted Amendments to the MCEA process approved under the Ontario Environmental Assessment Act. Under the amendments, projects that were formerly Schedule A and A+ projects, including various municipal maintenance, operational activities, rehabilitation works, minor reconstruction or replacement of existing facilities and new facilities that are limited in scale and have minimal adverse effects on the environment are now exempt from the requirements of the *Environmental Assessment Act* under the amended MCEA process. These projects may now proceed without fulfilling the process requirements of the MCEA.

Schedule B

Schedule B projects have the potential for some adverse environmental effects. As such, the proponent is required to undertake a screening process, involving mandatory contact with directly affected public and relevant review agencies, to ensure that they are aware of the project and that their concerns are addressed through the planning and decision-making process.

Schedule B projects must complete Phases 1 and 2 of the MCEA process to proceed to implementation. At the completion of the Schedule B MCEA process, a Project File Report is made available for public and stakeholder review for a period of 30 days. During this time, a request may be made to MECP to require a higher-level of study (e.g., an individual or comprehensive EA approval before being able to proceed) or that conditions be imposed (e.g., require further studies) on the grounds that the project could introduce adverse impacts on constitutionally protected Aboriginal or Treaty rights. This was previously known as a "Part II Order" or "bump up" request.

Schedule B projects generally include improvements and minor expansions to existing facilities. Examples include the construction of new water storage facilities and water/wastewater conveyance facilities (pumping stations), among others.

Schedule C

Schedule C projects have the potential for significant environmental effects and must proceed under the full planning and documentation procedures specified by the MCEA process. Schedule C projects require that an Environmental Study Report be prepared and filed for review by the public and review agencies.

Schedule C projects must complete Phases 1, 2, 3 and 4 of the MCEA process to proceed to implementation. At the completion of the Schedule C MCEA process, an Environmental Screening Report is made available for public and stakeholder review for a period of 30-days. During this time, requests may be made to MECP for a higher-level of study or that conditions be imposed, as described above for Schedule B projects.

Schedule C projects generally include the construction of new facilities and major expansions to existing facilities. Examples of a Schedule C project include construction of a new water system including water supply & distribution system and expansion of a wastewater treatment plant.

Agreements or commitments to further study and mitigation measures identified as part of the MCEA process must be followed through and implemented during later stages of design and construction.

Eligibility for Exemption

Under the 2023 MCEA amendments, projects that are identified as "eligible for screening" in the Project Tables of the MCEA may be exempt from the requirements of the *Environmental Assessment Act* based on the results of the Archaeological Screening Process and/or the Collector Roads Screening Process. Proponents must fully and accurately complete the screenings for a project to be considered exempt. Completing the screening process is voluntary and proponents may choose to proceed with Schedule B or C instead.

The Class EA process flowchart is provided in Figure 2-1.

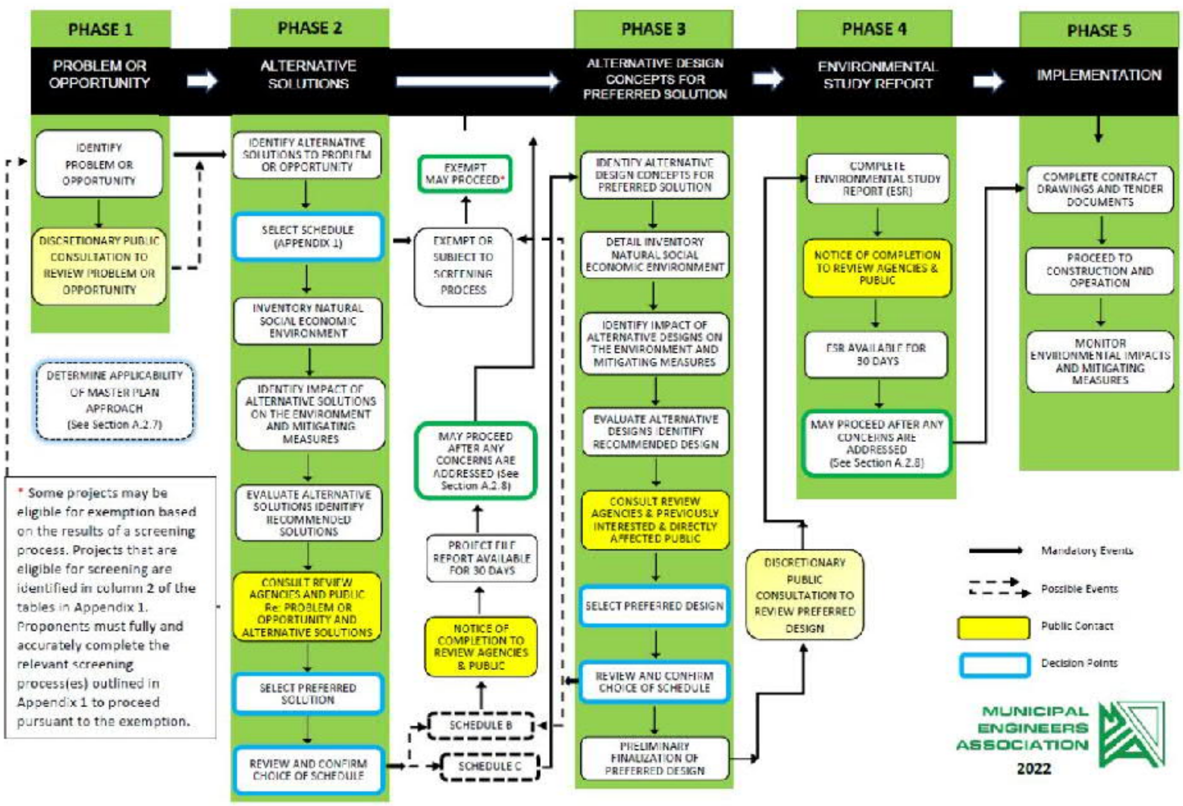

Figure 2-1: Municipal Class EA Process (Municipal Class EA Document, October 2000, as amended in 2015 and 2023)

2.3.1.1 Master Plans

The MCEA planning and design process applies primarily to municipal works considered on a project-by-project basis, the MCEA allows for a "Master Plan" approach when it is beneficial to considering a group of related projects or an overall system (e.g. water, wastewater and/or roads network) or a number of integrated systems (e.g. infrastructure master plan). By planning in this way, the need and justification for individual projects and the associated broader context are better defined.

Master Plans are long-range plans which examine infrastructure systems or groups of related projects to outline a framework for planning of subsequent projects and/or development.

The following are distinguishing features of Master Plans:

- Their scope is broad and usually includes a system-level analysis to outline a framework for future works. Plans are typically not focused on a site-specific problem.
- Plans typically recommend a set of works which are distributed geographically throughout the study area and which are to be implemented over an extended period of time.
- Plans provide the context for the implementation of specific projects which make up the plan and satisfy, as a minimum, Phases 1 and 2 of the Class EA process. Notwithstanding that these works may be implemented as separate projects, collectively these works are part of a larger management system. Master Plan studies, in essence, conclude with a set of preferred alternatives and, therefore, by their nature, Master Plans limit the scope of alternatives which can be considered at the implementation stage.

The MCEA document (Appendix 4) outlines several approaches to conducting Master Plans, including an approach that is integrated with Planning Act approval. This approach is also applicable for Secondary Plans which fall under the 'Master Plan' MCEA process.

2.4 Background Report Review

2.4.1 Edgewood Municipal Drain Study (July 2019 by Robinson Consulting)

A Municipal Drain Study was completed on Edgewood Road by Robinson Consultants in 2019. The purpose of the study was to review drainage of Highway 33 and conveyance of flows from adjacent lands to have a sufficient outlet. Downstream of Highway 33, private properties experienced flooding which led to the preparation of this report.

A large inlet structure was installed beside Highway 33 (across from Edgewood Road) to prevent flooding the subject site. The reason for the design was to convey flow into the subsurface, thereby preventing the flow from accumulating on the surface.

The stormwater sewer along Edgewood and Compton Roads outlets directly into Lake Ontario and is sized to convey minor and major flows from the identified catchment area. Figure 2-2 shows the extent of the catchment area in relation to the study area (see blue cross hatch). The stormwater management facilities for the noted catchment area are to be designed to the existing system capacity. Any future development planned in the catchment area will be subject to a review of the impacts on the Edgewood municipal drain catchment area and storm sewer system. Stormwater management for future development is required to ensure that the sewer capacity is not compromised.

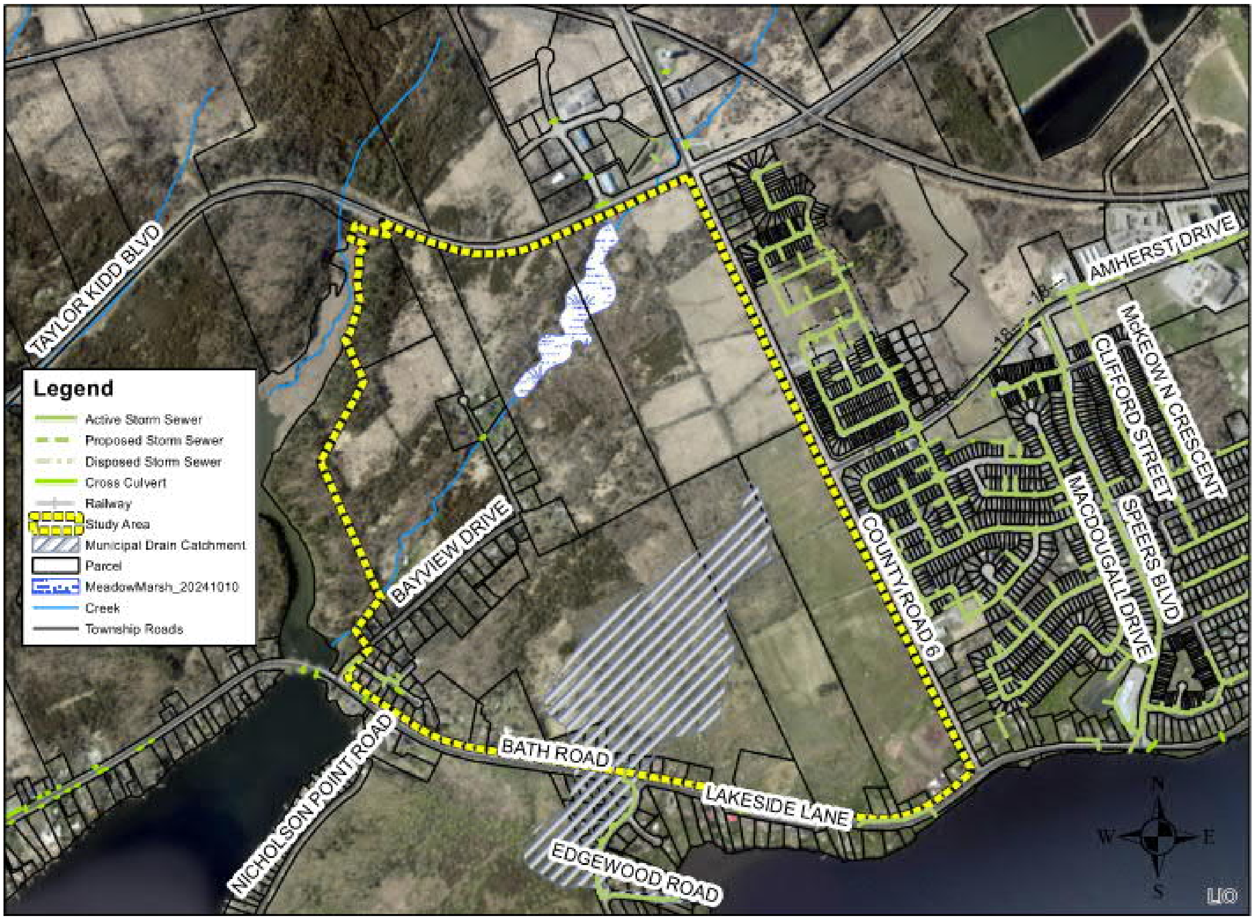

Figure 2-2: Edgewood Municipal Drain Catchment Area

Three (3) servicing alternatives for future development within the Municipal Drain area were presented in the report:

> ***Alternative 1****: Maintain existing culvert and provide for drainage conveyance to the outlet. In this alternative, the existing Highway 33 centreline culvert would be removed and replaced ‘like-for-like’ as part of the overall highway improvement project. In conjunction with a potential storm sewer system, drainage would discharge through a manhole structure at the culvert outlet. The storm sewer system would convey drainage easterly to the Highway 33/Edgewood Road intersection, then southerly along Edgewood Road approximately 200 m, and then easterly approximately 190 m through the existing Loyalist Township easement for Harewood Village Park. A second option would be to convey drainage along Compton Road, which would reduce the overall system length by approximately 100 m. In both scenarios, the system would outlet to Lake Ontario.*

Alternative 2*: Plug and abandon the existing culvert and convey drainage easterly within the MTO right-of-way. In this alternative, the existing Highway 33 centreline culvert would be plugged and abandoned, and a closed system would be installed on the north side of Highway 33 to convey the drainage easterly to the existing roadside ditch on the north side of Highway 33. This scenario would require the installation of three (3) ditch inlets and approximately 243m of 900mm diameter storm sewer on the north side of Highway 33 to convey drainage easterly to the existing roadside ditch. This alternative would require a full assessment of existing ditch capacity, hydraulic review of entrance culverts, and design for the storm system and outlet. Potential impacts to the environment as well as adjacent property would have to be assessed. Further, this work could temporarily impact Highway 33 driving lanes as well as property owners on the north side of the highway."*

Alternative 3: *Provide storage within lands to the north. This scenario would require acquiring property from the property owner(s) north of Highway 33 and designing & constructing a stormwater management facility to retain surface drainage and minimize peak flows to the existing Highway 33 centreline culvert. A preliminary review of this scenario indicated that the footprint of the facility (including the pond, 5:1 sloping to avoid fencing, an access road for maintenance, and a setback) would be approximately 8,000*m^2.

2.4.2 ResLienT Loyalist Township - Climate Action Plan (2021 – Loyalist Township)

The 2021 Loyalist Township Climate Action plan was developed by the Climate Action Working Group, consisting of township staff and Councillors, with input from Community supporters, to develop the plan under the Federation of Canadian Municipalities' (FCM) Partners for Climate Protection Program (PCP). The plan follows a commitment to climate action by setting goals for Greenhouse Gas (GHG) emission reductions across various sectors and sets high-level goals to achieve the targets. The goals for the sectors identified are projected to be implemented over a 10-year period. Table 2-1 Table 2-1summarizes the primary goals.

Table 2-1: ResLienT Loyalist Township – Climate Action Plan Sector Goals Summary

Priority Sector	Goals
Sustainable Land Use	Meet the current and future needs of the Loyalist Community while incorporating practices that will protect the environment and support local agriculture.
Waste Reduction	Divert waste away from landfill and promote a circular economy.
Transportation	Provide residents with enhanced transit services and promote the uptake of low-carbon fuels in vehicles, all while maintaining expected levels of service.

Buildings	Increase the energy efficiency of existing residential, commercial, and municipal buildings. Promote the construction of new buildings designed to exceed existing energy standards.
Water and Wastewater	Reduce residential water usage and the amount of energy required to treat, distribute, or collect water and wastewater.
Other	Undertake initiatives which may not have a direct and quantifiable impact on GHG emissions in Loyalist, but that will contribute to a culture of climate action while promoting community resiliency and financial sustainability.

Based on the sector analysis completed in the development of the plan there is a set target reduction of tCOe2 between 2016 and 2030 with a focus on transportation, buildings, waste, and wastewater sectors. The combined commitments are expected to decrease emissions by 25% of current estimated levels from 874,949 to 652,066 tCO2e.

2.4.3 Natural Heritage Existing Conditions Report (2021)

A Natural Heritage Study was completed in August 2006 by the Cataraqui Region Conservation Authority. The Natural Heritage Study was performed to ensure the municipalities, in consultation and partnership with the community, might develop a strategy to protect and enhance the habits and biological diversity of the system.

Natural heritage features and functions of provincial significance that were found in the study area (Kingston and Loyalist) include:

- Wetlands, such as the Little Cataraqui Creek Wetland and Parrott's Bay.
- Areas of Natural and Scientific Interest (ANSI) such as the Collins Lake Upland Forest and the Asselstine Alvar.
- Environmentally Sensitive Areas, such as the Abbey Dawn Forest and the Kingston Mills Gorge.
- Significant Woodlands, such as the Leo Lake Forest.
- Significant Valleylands such as those along Wilton Creek and the Little Cataraqui Creek.
- Significant Wildlife Habitat areas, including the Owl Woods on Amherst Island.
- Areas of fish habitat.
- Areas of Significant Habitat for Threatened and Endangered species, such as Black Rat Snakes, Five-lined Skinks, and Eastern Loggerhead Shrike.

These significant features and functions will need be investigated prior to any development to protect and ensure negative impacts due to development are removed or limited.

A new Natural Heritage Existing Conditions Report (2021) was completed by WSP as part of the Amherstview West study with the main objective of conducting an ecological assessment to characterize a baseline/preliminary evaluation of the natural heritage features within and adjacent to the Amherstview

West Secondary Plan. This work was carried out to identify the natural heritage constraints of the Secondary Plan and to document sensitive natural features that may impact the future development of the Study Area. This process used the following three (3) elements to evaluate the ecological constraints within the secondary plan area:

- A desktop background review of available online biodiversity databases to determine which wildlife/SAR have a record/likelihood of occurrence within the Study Area, as well as any significant natural heritage features.
- An ecological field survey to confirm the presence or absence of wildlife/SAR habitat and record any direct observations of wildlife within the Project Study Area.
- A risk level assessment (High, Medium, Low) for each SAR with the potential to conflict with future development plans based on field survey results and a habitat suitability analysis.

Note: Further detailed ecological assessments should be considered as part of the Municipal Class Environmental Assessment process, once infrastructure requirements and development plans are established in greater detail.

The identification of potential Significant Wildlife Habitat (SWH), candidate Species at Risk (SAR) habitat, provincially & regionally significant natural heritage features, and associated environmental setbacks provides the necessary framework to identify areas that should be considered a constraint to development. These areas are illustrated in Figure 2-3 Figure 2-3 and depict a range in the level of constraint from Minimal to High constraint dependant on its significant feature, likelihood of SAR, or connectivity to adjacent ecologically significant areas.

Figure 2-3: Natural Heritage Constraints and Opportunities (2021, WSP)

Note: The secondary plan schedules based on the Natural Heritage Constraints and Opportunities were updated in 2024 to include the Meadow Mash located on the Lost Creek. Refer to the latest land-use schedules included in the Secondary Plan for details.

2.5 Natural Hazards with Climate Lens

2.5.1 Context And Objective

A Climate Lens Assessment is a process created by Infrastructure Canada to help address climate change impacts and GHG emissions of infrastructure projects. By incorporating climate and natural hazard considerations during the planning and design of infrastructure projects, the strategy is intended to help assess the impact of projects, influence the design process, address operation and maintenance strategies once constructed, and inform funding decisions. The effort is an essential part of the federal and provincial government's strategy to achieving Canada's mid-century goals of a clean growth low-carbon economy and the creation of resilient communities.

The scope of this background analysis study is to identify the opportunities and constraints of the Climate Lens Assessment in context of the Secondary Plan area to provide guidance for future design of development that will be completed at a later stage in the planning process.

2.5.2 Natural Hazards and Climate Change Resilience Assessment

The Climate Change Resilience Assessment is used to identify, assess, mitigate, and manage potential risks associated with climate change during a project's design, construction, and operation. The scope of work should be conducted in accordance with the ISO 31000:2018, Risk management – Guidelines standard by qualified climate change adaptation experts. The approach (outlined below) are the steps which align with the Climate Lens Guidance and includes our experience of completing other Climate Lens Assessments.

2.5.2.1 Vulnerability Assessment

Prior to detailed design development of the subdivision, a vulnerability assessment may be conducted to determine how to focus the analysis by identifying broad climate and weather-related hazards to which the project is likely vulnerable. During the vulnerability resilience assessment, the following is usually performed:

- **Context scoping**: Definition of the spatial and temporal boundaries of the assessment, creation of a project description, determination of asset and sub-asset categories, setting of design lifetimes of the project assets, establishment of climate parameters, and collection of climate data.
- **Vulnerability assessment**: Climate vulnerability is the degree to which a system is susceptible to and unable to cope with the adverse effects of climate change. It is assessed by determining sensitivity and exposure (both current and future).
    - Sensitivity is the susceptibility of the project elements to extreme weather events & climate variations and is determined primarily from historical events.
    - Exposure is the nature & degree to which the project elements are exposed to extreme weather events and climate variations. It is determined from historical weather data (as available), an analysis of scenarios for projected future climate, and a literature review of climate hazards, taking into consideration the associated uncertainty.

To undertake a Climate Lens Assessment, a proponent would be required to receive and review the following but not limited to:

- The latest version of design drawings, preliminary layout, and a Photovoltaic (PV) System or energy yield assessment.
- Design reports including any environmental or geotechnical work.
- Copy of the grant application or relevant sections.
- Information on municipal service connections including water, storm, and sewer.

The vulnerability of the project elements to climate and weather hazards is then determined. High and Medium vulnerabilities are then taken forward into the risk assessment stage.

2.5.2.2 Risk Assessment

The purpose of the risk assessment is to identify the risks & opportunities associated with the identified climate & weather vulnerabilities (or natural hazards) and to develop preliminary mitigation & adaptation measures that may reduce these vulnerabilities. Details about the steps undertaken are described below:

- **Risk analysis**: In this stage, risks are identified and described based on the climate & weather effects and vulnerabilities assessed in the vulnerability assessment. The output of this stage is an initial risk register.
- **Risk mitigation already in place**: In this stage, the effect of control measures already implemented and the level of adaptive capacity to mitigate risks are investigated. An assessment is made to evaluate the likelihood of an actual impact on infrastructure components and to determine a level of residual risk.
- **Risk evaluation**: In this stage, the residual risks (after having considered the control measures already in place) are compared and the likelihood and consequence of each risk are systematically rated. The risks are evaluated to determine their severity, with particular attention given to unacceptable risks (Moderate and higher). The result of this stage is a risk rating for each risk and phase of the project.
- **Adaptive measures:** In this stage, the proponent identifies preliminary adaptation measures to reduce risks that are considered too high to confirm the climate resilience of the infrastructure; these may include measures such as remedial engineering actions, monitoring activities, management actions, or operation and maintenance recommendations.

2.5.2.3 Climate Change Resilience Report

The Climate Change Resilience Report to support a Climate Lens Assessment for detailed design of subdivisions includes the following but is not limited to:

- An attestation that the report and the resilience analysis results were prepared in compliance with Climate Lens and the ISO 31000 standard.
- An executive summary.
- An overview of the project.
- A description of the scope and timescale of the project, the methods for identifying and assessing climate hazards, the methods for assessing impacts, and their consequences.
- Climate resilience assessment results, including hazard analysis, consequence matrix, and risk matrix.
- Conclusion and References.

3 EXISTING CONDITIONS ANALYSIS

This section provides details of the data and methodology used to develop the hydrologic SWM model simulating the existing stormwater collection hydrology and hydraulics.

3.1 Data Gap Analysis

To fully understand the existing drainage patterns, data was obtained from several sources and was analyzed. Any remaining gaps identified were closed through use of appropriate modelling assumptions, which are detailed in the report.

3.1.1 Existing Drainage System Inventory

The existing drainage system for the Amherstview West Secondary Plan area was sub-divided into two (2) primary drainage areas. To the north and northeast, runoff drains directly into Lost Creek as part of the Lost Creek Watershed that outlets into Parrott's Bay. The remaining Secondary Plan area to the south drains towards Lake Ontario directly or via direct outlets that cross Bath Road (Hwy 33). A large portion of the secondary plan area drains into the Edgewood Municipal Drain to the south.

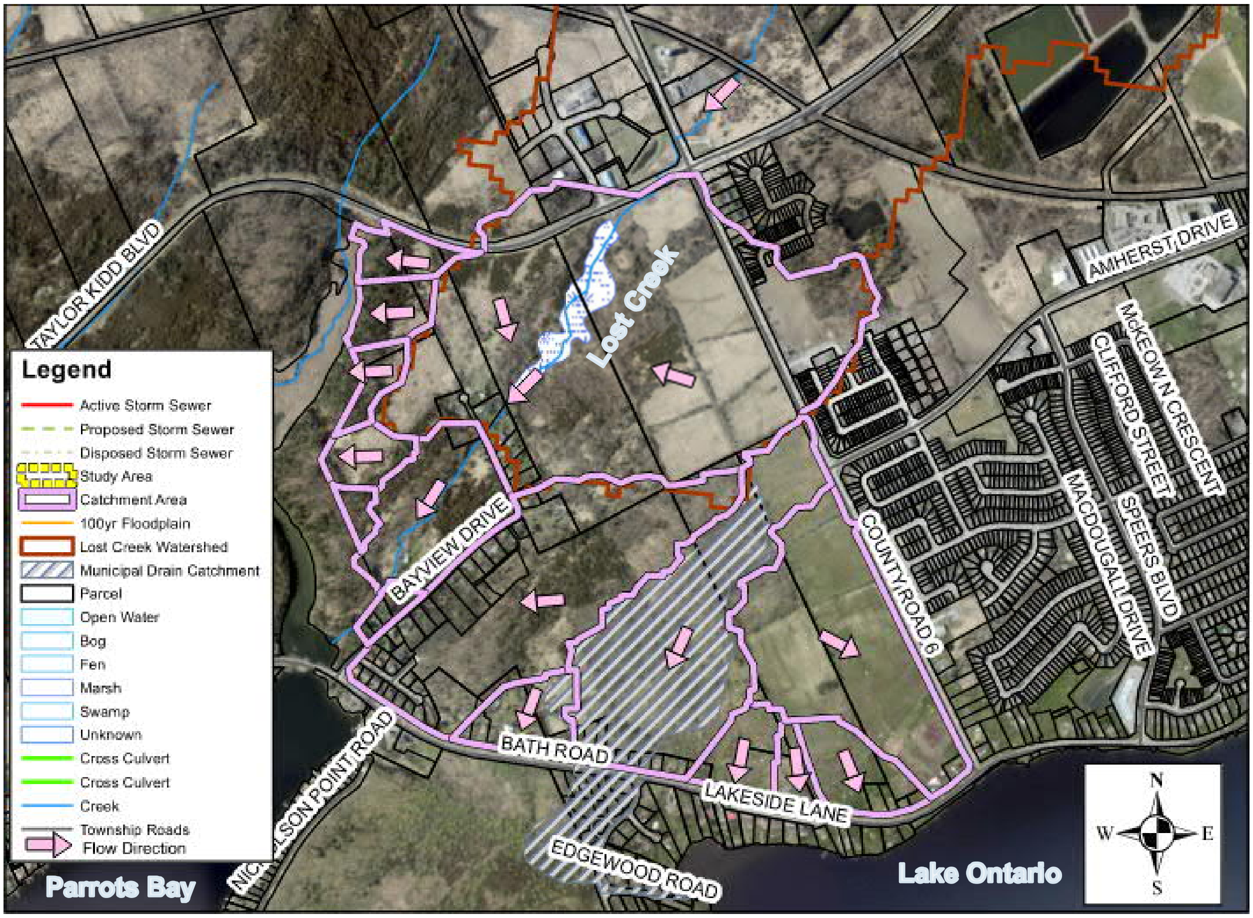

Figure 3-1: Amherstview West Existing Drainage System

Surrounding the catchment areas are a few municipal drainage features and structures including sewers and culverts located along Bayview Drive and twin culverts located on Parrott's Bay Lane at the Lost Creek Crossing.

Aside from the storm structures located within the Amherstview West Secondary Plan area, there are also culvert crossings located along the perimeter of the study area. To the north, Lost Creek crosses under Taylor-Kidd Boulevard into the Amherstview West Secondary Plan area next to the intersection with County Road 6. The catchments along County Road 6 also drain into the municipal ditch with areas south of Amherst Drive draining south towards Lake Ontario and areas north of Amherst Drive draining north towards Lost Creek and the Meadow Marsh. Also located along the perimeter are dedicated stormwater sewer systems that service other subdivisions for the Village of Amherstview, however, these sewers do not convey flows back into the Lost Creek System, with the exception of the subdivision located across Country Road 6 at the intersection with Taylor-Kidd Boulevard.

A model to assess the existing stormwater collection hydrology and hydraulics was developed using SewerGEMS (EPA-SWMM5 Solver) by Bentley software. Further details on the model development and methodology are included in Section 4.

3.1.2 Design Documents

The following SWM and servicing design reports were provided to WSP as part of the data gap analysis assignment and have been reviewed to extract details for modelling purposes:

- Cataraqui Region – Natural Heritage Study Report Central
- County of Lenox and Addington – Official Plan
- County of Lenox and Addington – Transportation Master Plan
- Loyalist Township – 'Draft' Technical Design Guidelines
- Loyalist Township – Building By-law
- Loyalist Township – By-law 2001-38
- Loyalist Township - Development Charges Background Study
- Loyalist Township – Official Plan Draft
- Loyalist Township – Interim Development Charges Study
- Loyalist Township – Recreation Master Plan
- Loyalist Township – Strategic Plan 2019-2023
- Loyalist Township – Water and Sewer User Rates Study
- Loyalist Township – Edgewood Road Municipal Drain
- Loyalist Township – Population, Housing and, Employment Projections to 2046
- Township of Ernestown – Official Plan Schedules
- Loyalist Township – Hydraulic Water Model Update
- Lakeside Ridge and Lakeside Ponds – Hydrogeological and Geotechnical Reports (2007)
- Analysis of Stormwater Management Requirements for Lakeside Ponds Subdivision (Josselyn Engineering Inc., 2016)
- Bayview Bog Executive Summary - 2010

3.1.3 GIS Shapefiles and Surface Data

Access to the Loyalist Township GIS server was provided to WSP for use in this study. Figure 3-2 Figure 3-2 shows the LiDAR contours and Aerial Photography with locations of existing culverts within the study area. The information was field verified through the completion of an unmanned aerial vehicle (UAV) survey of the Secondary Plan area (study area) and supplemented with Ontario Base Mapping (OBM) data for wetlands. Refer to **Appendix C** figure C-4 for additional contour mapping details of the existing conditions. The UAV survey data was primarily used for the study area, while all other areas were supplemented using GIS and other surface data.

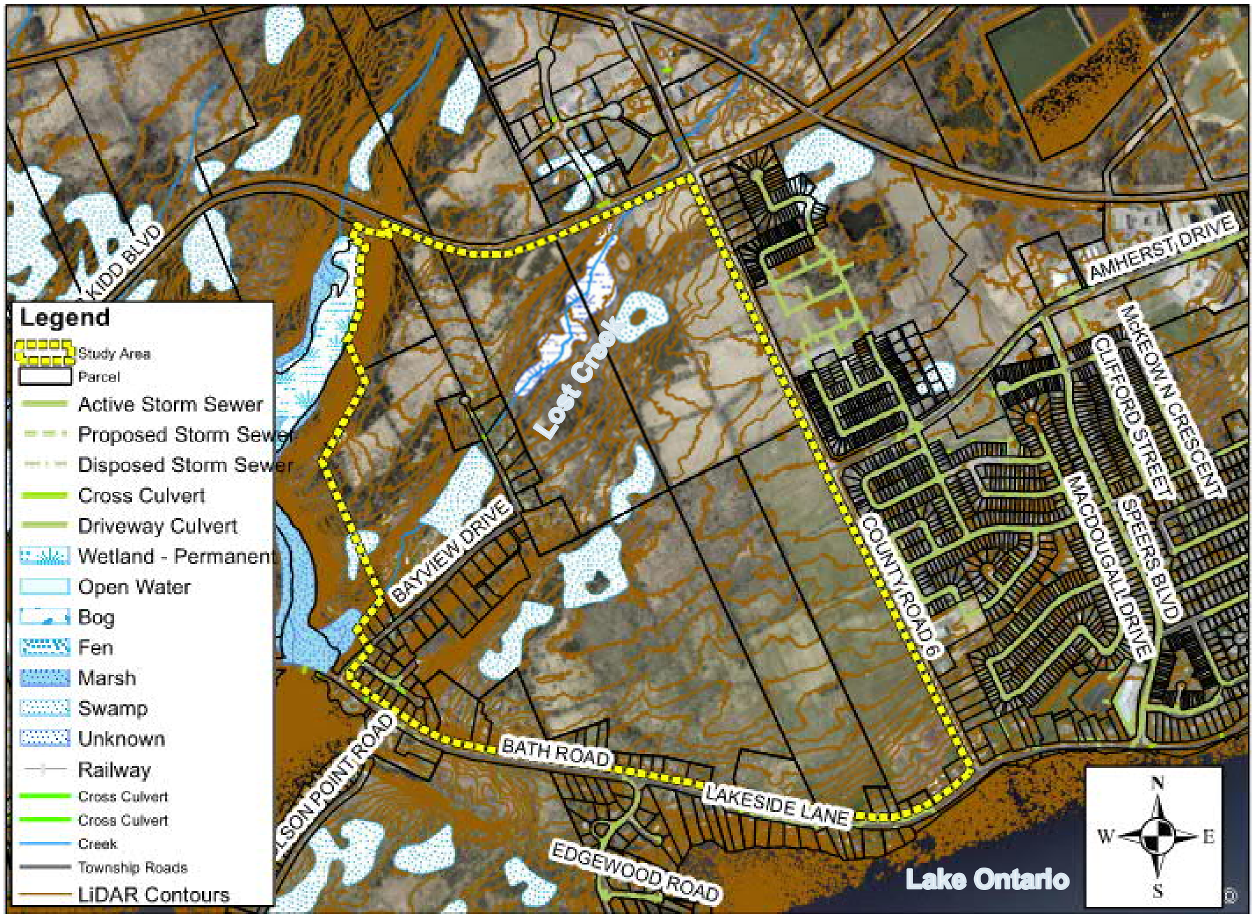

Figure 3-2: Amherstview West - LiDAR Contours

3.2 Field Verification, Survey, and Filling Data Gaps

WSP retained AG UAV Consultants to conduct a photogrammetric survey of the Secondary Plan area utilizing a UAV equipped with a high-resolution camera and GPS control in November 2021. The work included the installation of survey control targets consisting of 200mm x 600 mm rectangles laid out in crosses and “Ls” across the study area at strategic locations. These control targets were surveyed in real-time with a GPS unit coordinates in NAD83 (CSRS), CGVD1928:1978. The UAV took high-resolution imagery with overlapping images. The digital data was then processed to generate a complete orthorectified high-resolution mosaic of the area. The data included a 3D point cloud with a typical vertical accuracy of +/- 100mm and horizontal accuracy of +/- 50mm. Trees and structures were filtered out from the point cloud data in order to generate a digital terrain model (DTM) of the existing ground. The DTM was used to generate contour plans for the purposes of catchment area delineation of the Secondary Plan area. The high-resolution imagery was also used as a background for CAD and GIS to layout fences, lot lines, property limits, trails, and other features.

Additional field verification was completed at the Lost Creek crossing at Parrott's Bay Lane to review the recently installed twin culverts to validate the SWM Hydrologic and Hydraulic Model to represent flow conditions.

4 MODELLING METHODOLOGY

4.1 Stormwater Management Drainage Model

The intent of the SWM modelling strategy and methodology is to develop scenarios suitable for the analysis of wet weather conditions for storm events in order to characterize the existing pre-development conditions and anticipated magnitude of stormwater runoff flows for the purposes of supporting the review/recommendations of land requirements for SWM facilities for the Secondary Plan. The model is a hydrologic and hydraulic representation of the Lost Creek watershed and topography within the Secondary Plan study area. The model is limited to the analysis of overall downstream flow analysis and was not developed to review HGL in existing sewers as they are located outside of the study area. The model was used to primarily assess the pre-development existing conditions for the Lost Creek Watershed and secondary plan area, while subcatchment analysis was completed for 25-year post-development projection based on the latest preferred land use concept as detailed in **Section 5**.

The standard SWM modelling methodology includes the following key components:

- Definition of a minor and major systems (culverts and outfalls)
- Delineation of subcatchments and assignment of appropriate parameters to these areas to allow the model to accurately simulate runoff and connect each subcatchment area to appropriate major system nodes (i.e. "loading" the major system). EPA-SWMM5 was selected as the hydrologic and hydraulic method used within SewerGEMS
- Running simulations with geographically suitable rainfall data, for a range of return periods, to develop a thorough understanding of the performance of the system.
- Considerations for Climate Change sensitivity analysis and model scenario development was also reviewed and is further detailed in **Section 6** of this report.

The following section sets out the approaches being followed for each of these aspects and specific assumptions being used for development of the SWM model in Amherstview West. It's to be noted that assumptions presented are based on engineering judgement of the CRCA Guidelines for Stormwater management, MOE (now MECP) 2003 Stormwater Management Planning and Design Manual best management practices, and the townships draft 'Technical and Development Guidelines' currently being developed.

4.1.1 SewerGEMS Model Build Process

SewerGEMS (EPA-SWMM5 Solver) by Bentley Inc. was selected for the hydrologic and hydraulic model development using the assumption indicated within this section. The model build includes scenarios for Minor and Major Storms using AES Method and sensitive analysis scenarios were created for climate change considerations. The primary intention of the model build process was to characterize the existing stormwater conditions and to use the tool to review effective stormwater management objectives for the Amherstview West Secondary Plan area, including the provision of stormwater management facilities and the selection of dedicated catchment areas to meet water quantity and water quality design criteria.

4.1.2 Design Requirements

The following requirements were requested by the Loyalist Township in the draft “Technical and Development Guidelines”:

- All minor systems must be designed to convey, at a minimum, the 5-year storm event.
- For new developments, stormwater designs are required to control and attenuate all major storm events including the 100-year design storm to pre-development conditions and safely convey 20% above the 100-year design via overland flow routes. The additional 20% accounts for the increase in surface runoff flow rates attributed increased rainfall volumes from projected climate change.
- A general erosion control storage of 40 m^3/ha, which shall be applied to stormwater management facility outlets to storm sewers or ditches.
- For on-site water quality treatment, 80% Total-Suspended Solids (TSS) removal (per typical provincial requirements).

It should be noted that the townships draft ‘Technical and Development Guidelines’ guidelines are still in development and subject to review and changes under the Township’s separate Infrastructure Master Plan project. Guidelines have been reviewed in for concurrence with the Cataraqui Region Conservation Authority (CRCA) requirements for development.

4.1.3 Existing Minor Systems

The existing minor system shapefiles, consisting of nodes (representing existing manholes and catch basin manhole locations), minor system polylines (representing the existing storm sewer pipes), and associated elevation data, were provided by the township and additional data was gathered based on survey information (sewer inverts, maintenance hole data). Existing minor systems are primarily located along the perimeter of the Secondary Plan area and located outside of the modeled catchment but have been reviewed as tie-in locations for outlets.

4.1.4 Existing Major Systems

The existing major system has been modelled to represent the existing overland flow paths in the study area. The Lost Creek system has been represented by the use of transects and conduits in the model.

Loyalist Township provided LIDAR data, supplemented by UAV survey data, has been processed and converted into a Digital Elevation Model (DEM) using ArcMap. The DEM was then analyzed using automated GIS-based tools to identify low points and streamlines (i.e., concentrated, overland flow paths), and channel cross-sections. These low points, streamlines, and sections informed definition of the major system elements, along with other pertinent information and application of engineering judgement.

Refer to **Appendix C** for more details

4.1.5 Existing Subcatchment Delineation

The DEM data referenced above (generated from LIDAR data provided by Loyalist Township, supplemented by UAV Survey) has been analyzed with GIS-based tools to delineate subcatchment areas for both Lost Creek and the study area. These delineated areas have been used, in conjunction with a visual inspection of contour data and field survey observations, to accurately define how the major system should be loaded. Assumptions on rooftop slope directions and the major system low points (identified as part of the major system definition process) have also informed subcatchment extents. Refer to **Appendix C** for additional mapping showing the subcatchment extents. As part of the modelling exercise, this catchment area has been split into multiple subcatchments to best represent where runoff from each subcatchment will load the major system.

External area flows (such as the watershed) have been examined to ensure that the model incorporates all pertinent inputs.

4.1.6 Modelling Parameters / Assumptions

Given limitations in available data, development of the model requires certain assumptions to be made to ensure that the numerical model reasonably reflect real-world conditions. The following sections present the model parameter assumptions that have been made throughout the development of the model to close data gaps. These assumptions are based on best practice approaches and reasonable engineering judgement.

4.1.6.1 Subcatchment Parameter Assumptions

- The Horton Infiltration Model has been used to simulate infiltration losses for the Amherstview urban basins for pre-development conditions. Rainfall that reaches pervious ground surfaces will initially infiltrate into the upper layer of the soil. With extended periods of dry weather, the infiltration capacity of the soil will approach its maximum capacity; however, this capacity will diminish as the storm progresses and the soil becomes saturated. The Horton Method provides a hydrologic based approach to calculating infiltration rates and is commonly applied in urban drainage models. The Horton Method is one of the most widely used methods for estimating infiltration rates in urban basins. Assumptions are based on judgement of provided documents, topographic studies and the Hydrogeological and Geotechnical study (WSP, 2022) conducted for the Secondary Plan.
- Infiltration values for Horton’s Equation were taken as follows using inputs from the Hydrogeological and Geotechnical study conducted for the study area:
    - Initial Infiltration Rate: 76.20 millimeters (mm)/hour (hr):
        - Maximum infiltration rate values range from 1 inch (in)/hr for clays to 5 in/hr for sands. An average was taken to obtain a value of 3 in/hr which was then converted to 76.20 mm/hr.
    - Final Infiltration Rate: 59.82 mm/hr:

        - Minimum infiltration rate values range from 0.01 in/hr for clays to 4.7 in/hr for sands. An average was taken to obtain a value of 2.35 in/hr which was then converted to 59.82 mm/hr.
    - Decay Constant: 0.00125 seconds $(s)^{-1}$:
        - Typical values for the decay constant range between 2 and 7 hr^{-1}. An average was taken to obtain a value of 4.5 hr^{-1} which was then converted to 0.00125 s^{-1}.
- Depression storage values:
    - Pervious Depression Storage: 7.62 mm
        - Typical value for forested areas 0.3 in converted to 7.62 mm
    - Impervious Depression Storage: 1.27 mm
        - Typical value for forested areas 0.05 in converted to 1.27 mm
- All surfaces both pervious and impervious within the watershed and study area have some depression storage.
- Characteristic width was taken to be the longest flow path of overland flow to a maximum of 500m..-
- Subcatchment mean slope was calculated using Google Earth Pro contour information which is unique to each catchment.
- Percent impervious was estimated based on ariel imagery..
- Percent impervious zero storage was set to 25% for all Pre- Development Subcatchments.
- Rear yard recreational pools have been ignored with respect to imperviousness calculated for each Pre-development subcatchment.
- Impervious for post-development subcatcments for the 25-year analysis – Refer to Section 5 and Appendix C for details. Based on review of similar land use designation and existing areas withing the village of Amherstview.

4.1.6.2 Manning's Roughness Assumptions (Subcatchments & Conduits)

- The Manning's n roughness coefficient of 0.013 has been assigned for both Concrete and PVC pipes.
- Manning's n for subcatchment pervious area is assumed to be 0.08 for grassed/wooded areas.
- Manning's n for subcatchment pervious area is assumed to be 0.012 for asphalt/granular areas.

4.1.6.3 Major / Minor System Connection Assumptions

- Catch basins were identified by using the catch basin point shapefile supplied by the Township.
- The Major System includes Lost Creek culvert crossing locations using information from UAV surveys and Township provided information to portray the flow through these Major System components limited to inlet/outlet configurations, diameter and material.

4.1.6.4 Existing Major System Transect Assumptions

- Each transect represents the cross-sectional area of major drainage systems, such as the Lost Creek drainage basin. The system includes areas upstream of the Amherstview West Secondary Plan area to accurately capture the runoff generation contributing to the Lost Creek. Refer to **Appendix C** for additional details.
- Transects represent 2%-3% crossfall on roadways (unless specified otherwise).
- Transects have been modelled using 2% bank slopes.

4.1.7 Hydrologic Input

Ontario Ministry of Transportation (MTO) Intensity-Duration-Frequency (IDF) curves were used as the primary hydrologic inputs for the area and these curves are appended under **Appendix B** of this report. The Atmospheric Environmental Service (AES) storm input method used and tested using the modelling software's built-in analysis tools for South-Eastern Ontario. . The IDF information was taken from the location closest to the Amherstview West study area and is presented in **Appendix B**. The IDF relationships were used to derive synthetic design storms for the 2-, 5-, and 100-year design events with durations of 3 and 6 hours and compared to Modified Rational Method catchment totals for pre-development and post-development analysis. Further to this input, Climate Change sensitivity scenarios as detailed in **Section 6** were also compared to analyze the single-event impacts.

4.2 Water Quality Analysis

4.2.1 Methodology

Catchments delineated from DEM data during modelling were aggregated into minor system outfalls from the study area. Sediment total loading was calculated from catchment imperviousness based on the relationship defined in the Ministry of Environment (MOE) Stormwater Management Planning and Design Manual (2003) Table 6.3 and reproduced herein as Table 4-1. Catchment areas with no available data on the minor system were omitted from this analysis.

Table 4-1: Annual Sediment Loadings (from MOE 2003, Table 6.3)

CATCHMENT IMPERVIOUSNESS	ANNUAL LOADING (KG/HA)
35%	770
55%	2,300
70%	3,495
85%	4,680

5 FUTURE CONDITIONS ANALYSIS

5.1 Overview

Based on the draft land-use concepts and discussions with the Township, future development is anticipated to primarily occur along the eastern extents of the study area along County Road 6. In 2024 the preferred land-use concepts were identified, and concept mapping was prepared showing the impacts to stormwater catchment areas. Overall strategy for post-development catchment areas were reviewed for the future conditions analysis. Refer to Figures D-2 and D-3 in **Appendix D** for two concept layouts being considered for the Secondary Plan, along with post development catchments and major flow routes. Figure 5-1 shows the general layout of the 25-year planning horizon land use designations while Figure 5-2 shows the general layout of the potential future development area based on land use for build-out conditions, including the location of potential collector road network expansion. Its to be noted that only the 25-year planning horizon was carried forward into detailed stormwater runoff analysis as detailed in **Appendix C**.

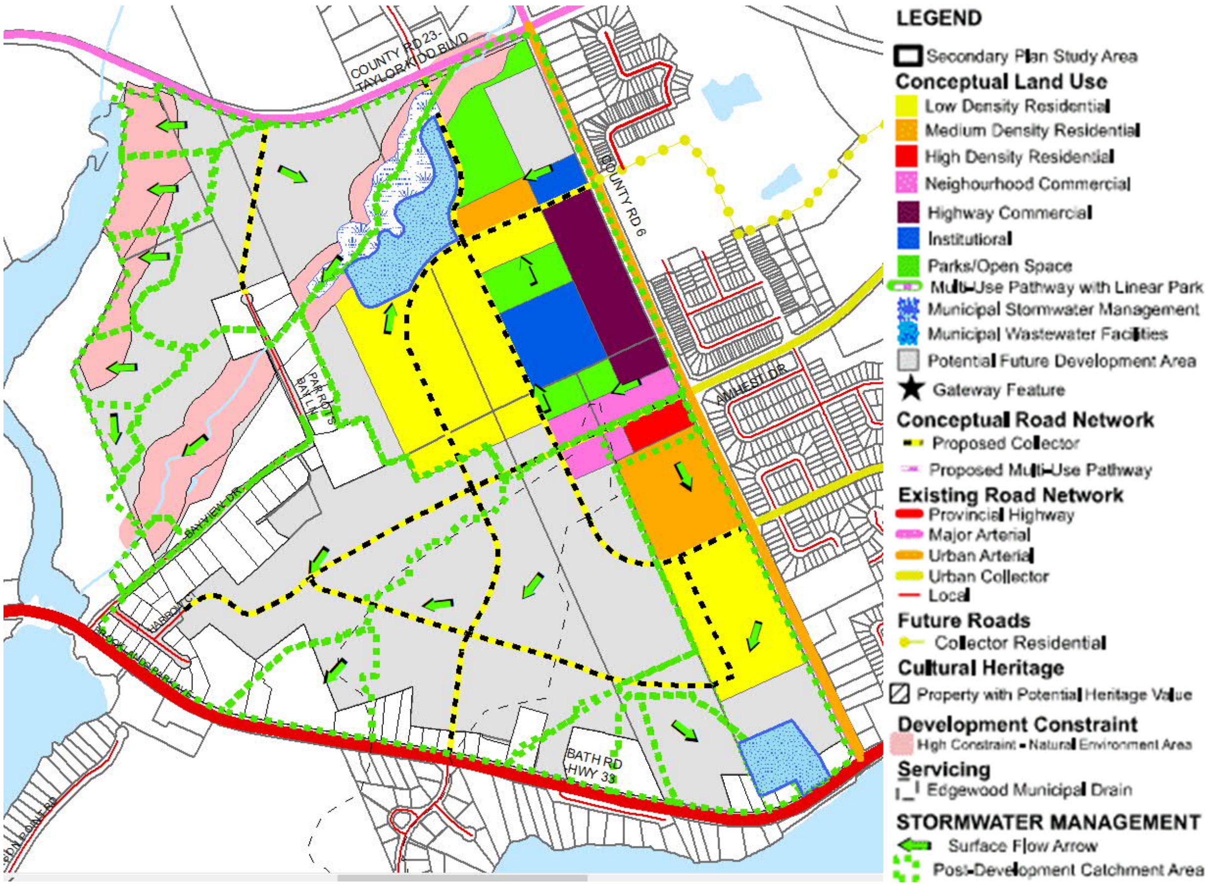

Figure 5-1: Land Use Amherstview West – 25-year Development

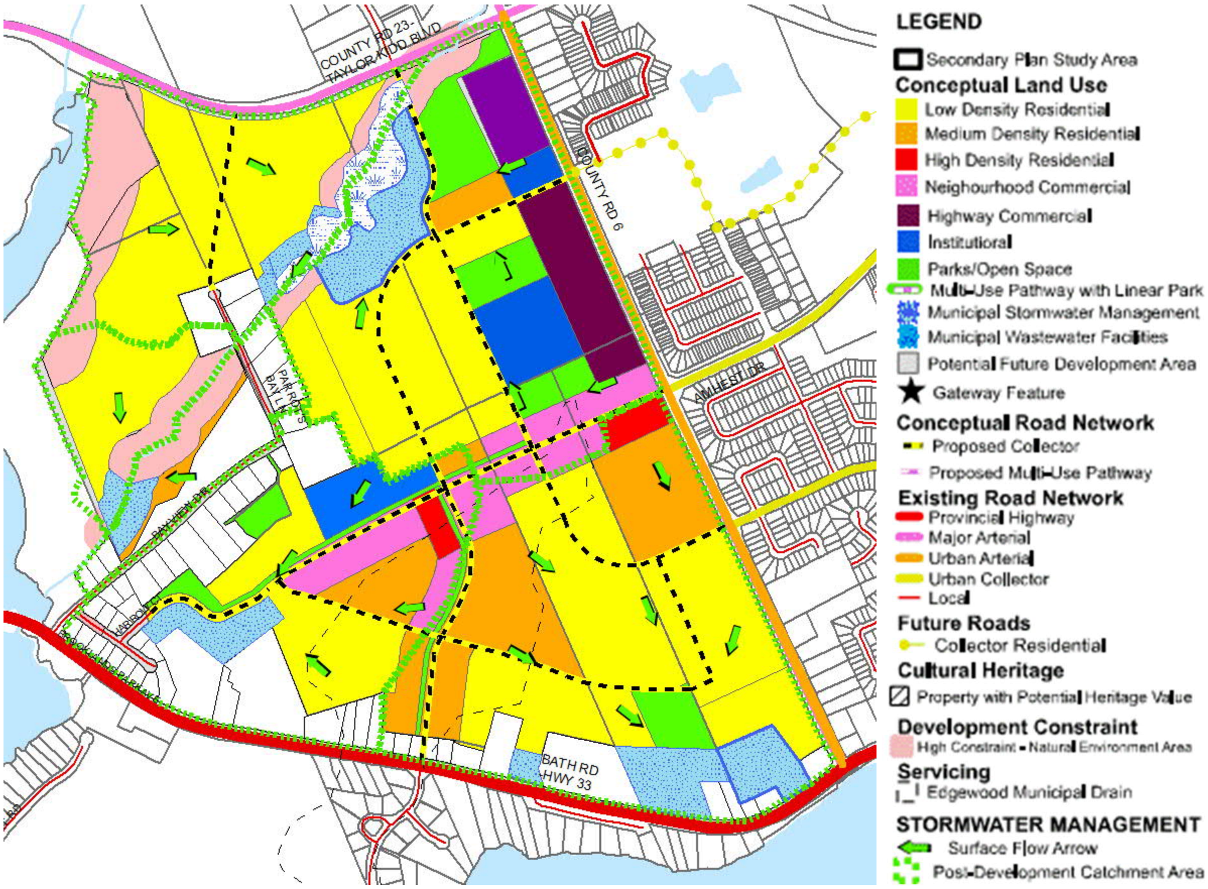

Figure 5-2: Land Use Amherstview West – Full Build-Out

Areas with existing wetlands, woodlands, and other natural heritage features will be subject to environmental protection and studies prior to development in these areas. The primary strategy for stormwater management under future conditions will be the provision of stormwater facility locations that capture and store the increase in runoff generated flow. This increase in runoff generated flow is a result of an increase in impervious areas and changes in grading due to planned development. The opportunity that new development provides is the strategic regrading of the land to direct stormwater runoff to controlled locations and to centralize the locations of larger stormwater management facilities which combined pre-development catchment areas. It was acknowledged that areas for development (where no design documentation is available), were not included in this study however general assumptions on the type of land (Residential, Commercial, and Institutional) have been made. This review includes an analysis of storm-related zoning bylaws or specific municipal design guidelines for new development and makes recommendations on policy updates to bring them in-line with best industry practices.

It is assumed that new development growth areas will be designed in accordance with SWM design criteria that will result in limiting impact on existing downstream storm sewer infrastructure, or natural receiving systems.

It is also assumed that the requirement for on-site water quality treatment to 80% Total-Suspended Solids (TSS) removal (per typical provincial requirements and current Consolidated Linear Infrastructure – Environmental Compliance Approval requirements), translating to limited impact on existing infrastructure from a quality perspective either.

To service new development in future growth areas, developers will need to construct storm sewer collection and conveyance systems, along with SWM facilities (ponds or other control features) to achieve the quantity and quality criteria, within their development lands and in conjunction with the designated municipal SWM facilities. These systems would typically then be assumed by the Township following any required maintenance period. Furthermore, the creation or designation of lands and stormwater management facilities/areas are recommended to be identified to allow for general catchment and storage of rainwater for all assumed municipal road networks, parks or, lands designated to remain under the township's control. These common SWM facilities and lands will need to be sized to account for collective SWM management within the Secondary Plan area, given a phased development approach. It's to be noted that the two (2) proposed SWM facilities within the 25-year plan are further identified in Section 7 and these locations shown in by the blue 'Municipal Stormwater Management' areas shown if figures 5-1 and 5-2.

It's to be noted that the preferred land use concept reviewed during the secondary plan process, Figure 5-2, includes projected land use designations beyond the 25-year growth horizon which would be subject to amendment during development approval stages. This land use option provides the opportunity to eliminate the Edgewood Municipal Drain area within the Secondary Plan study area through development and interception of stormwater by splitting drainage to dedicated stormwater management facilities.

5.1.1 Sanitary and Storm Catchment Areas in Post-Development Conditions

As means of improving sanitary servicing potential, the development presents an opportunity (through general terrain regrading) to change topography such that sanitary gravity servicing is more achievable for select areas. This includes facilitating the gravity drainage of sanitary flows to the north to the Taylor-Kidd Pumping Station Sanitary catchment area, thereby eliminating the requirement for a new sanitary pumping station within the 25-year growth horizon. To accommodate this, the post-development sanitary and SWM catchment areas need to include surface regarding as well which is an opportunity to redirect flows away from the north-eastern extents of the Edgewood Municipal Drain toward the Lost Creek Watershed. From a SWM perspective, this provides an added benefit of reducing runoff to the Edgewood Municipal Drain outlet, if the SWM facilities and LID features proposed for the Lost Creek catchment area are sufficiently sized to accommodate. This approach is considered the preferred option for the Amherstview West Secondary Plan servicing furthered by analysis.

5.2 Future Conditions Modelling Methodology

The existing conditions model was used as a base and modified to develop the future conditions model. Future development areas were simulated using a high-level approach to accurately represent the proposed SWM designs without the need to explicitly model every individual feature (considered beyond the scope of the assignment and unnecessary in this context). Modelling parameters are consistent with the summary presented in Section 4 with a summary of assumed parameters presented in **Appendix C.**

For the 25-year post-development scenario, the final built-form is not known at this stage and will vary by development. The methodology for assigning % impervious vs. pervious area was based on the review of existing properties located within Amherstview Village for similar land use designations. The assumed rates per percentage of total area are detailed in **Appendix C** and summarized in Table 5-1.

Table 5-1: Post-Development % Pervious vs. Impervious Assumptions per Land Use Designation - Total Area for 25-Year Development Catchments

	Open Space	Low Density - Residential	Low Density - Residential	Low Density - Residential	Institutional	Mixed-Use Commercial	Highway Commercial
Asphalt & Roofs	5%	50%	60%	80%	50%	75%	80%
Granular	10%	20%	20%	15%	25%	15%	15%
Grassed Areas	85%	30%	20%	5%	25%	10%	5%

1- Based on review of existing properties of similar land use designation in village of Amherstview

5.3 Future Conditions Modelling Results and Findings

A summary of modelling results and findings has been prepared and documented in **Appendix C**. **Appendix D** has been prepared to include the Storm Infrastructure Improvement Areas as part of the stormwater recommendations presented in Section 7 of this report, which includes conceptual development areas and considerations for the future development areas located within the Secondary Plan study area. Refer to **Section 6** for details on Climate Change Single-Event sensitivity analysis methodology details.

In summary, Table 5-2 provides a results of projected stormwater runoff generated flows by design storm for the modified sub catchment areas projected from potential future development under existing conditions. This summary was used in comparison with the results summarized in Table 5-3 which details the post-development stormwater runoff generated flows for 25-year project development for the preferred land use concept detailed in **Section 5**. Refer to map figures C-4 and C-5 in **Appendix C** for drainage area details.

Table 5-2: Single Event Climate Change Model Output Flows - Amherstview West Secondary Plan Post-Development Sub-Catchments (1:2 year - 1:100 + 20% year)

Drainage Areas	Area (Ha)	1:2 Year (L/s)	1:5 Year (L/s)	1:100 Year (L/s)	1:00 Year + 20% (L/s)
B1-1	26.5	1,078	1,437	2,391	2,869
B1-2	46.6	1,835	2,443	4,066	4,880
B1-3	9.3	384	511	851	1,021
B1-4	9.5	397	529	880	1,056
B1-5	37.3	1,674	228.77	3,709	4,451
B1-6	51.6	1,996	2,657	4,423	5,307

Table 5-3: Single Event Climate Change Model Output Flows - Amherstview West Secondary Plan Post-Development Sub-Catchments (1:2 year - 1:100 + 20% year)

Drainage Areas	Area (Ha)	1:2 Year (L/s)	1:5 Year (L/s)	1:100 Year (L/s)	1:00 Year + 20% (L/s)
C1-1 Lost Creek SWM	26.5	4,114	5,480	9,119	10,944
C1-2 Areas to the South-East of the Secondary Plan area Along County Road 6.	17.9	1,740	2,318	3,858	4,630

1- Based on review of existing properties of similar land use designation in village of Amherstview

6 Climate Change

6.1 Future Climate Projections

The ResiLient Loyalist Township plan summarized the local context of climate change impacts which are also applicable across Canada and specifically to the Amherstview West Secondary Plan area given its proximity to Lake Ontario.

Extreme weather events can impact the livelihood of Canadians, causing harm to properties and homes alike through floods, fires, declines in water supplies, or reduced agricultural yields. More importantly, negative impacts on human health and quality of life have also been linked to climate change due to factors such as decreased air quality, higher frequencies of heat waves, or the increased transmission of vector-borne diseases, among others. These consequences are more likely to disproportionately affect vulnerable and marginalized populations such as children, seniors, people living in poverty, or Indigenous peoples. This can be attributed to increased exposure and susceptibility of these groups to the impacts of climate change, along with a decrease in their ability to cope and recover from damages.

From the Climate Atlas Resource, the following Table 6-1 summarizes the local weather climate change projections anticipated in Loyalist Township from 2021-2050. These findings are presented in the ResLienT Loyalist Township Plan.

Table 6-1: Climate Atlas Projections for Loyalist Township (from ResiLienT Loyalist Report, 2021)

		1976-2006	2021-2050		
Variable	**Period**	**Mean**	**Low**	**Mean**	**High**
Precipitation (mm)	Annual	875	779	934	1100
Mean Temperature (°C)	Annual	6.7	7.5	8.9	10.2
Mean Temperature (°C)	Spring	5.6	5.2	7.5	10
Mean Temperature (°C)	Summer	19.2	19.9	21.3	22.8
Mean Temperature (°C)	Fall	8.7	9.3	10.9	12.6
Mean Temperature (°C)	Winter	-6.9	-7.4	-4.5	-1.6
Tropical Nights	Annual	4	5	13	24
Very hot days (+30°C)	Annual	9	10	26	42

Variable	Period	1976-2006	2021-2050		
		Mean	**Low**	**Mean**	**High**
Very cold days (-30°C)	Annual	1	0	0	1
Last Spring Frost (date)	Annual	May 1	Apr 6	Apr 22	May 6
First Fall Frost (date)	Annual	Oct 8	Oct 6	Oct 20	Nov 3
Frost-Free Season (days)	Annual	156	156	178	203

Based on the summary from the Climate Atlas it is anticipated that a potential increase of flooding and drought activity is expected given the mean increase in precipitation and temperatures, respectively. The overall impacts due to weather are applicable specifically to the Amherstview Secondary Plan area with potential implications to local Stormwater Management and farming operations currently in place.

The projected changes in climate (precipitation and temperature) were combined with the historical record(s) to generate synthetic climate change records. The records served as input into the SewerGEMS model to facilitate the drainage system performance assessment using both continuous and event-based simulation. The simulation output will help develop an understanding of how drainage system performance may evolve over time, under a range of potential future climate scenarios.

6.2 System Performance Evaluation

The performance of the Amherstview West drainage systems was evaluated using a single-event approach to review performance in terms of operational level-of-service. Continuous simulation approaches will also be used to assess performance against the risk-related criteria of reliability (frequency of failure), resiliency (duration of failure), and vulnerability (magnitude of failure). See subsequent sections for further details.

As documented previously, the existing conditions performance of the Amherstview West drainage system was assessed using a single-event approach in SewerGEMS based on available data including rainfall data from MTO IDF curves as detailed in section 4.1.7.

The three (3) parameter IDF equation is provided below, where i is the intensity (mm/hr), td is the storm duration (in hours), and A, B, & C are constants. A summary of the historical IDF information for the 2-, 5-, and 100-year return periods are provided in Table 6-2 below.

$$i = \frac{A}{(t_d + B)^c}$$

Climate scenarios for Low, Mean, and High conditions were incorporated into the single-event approach using the MTO online IDF tool. The use of the revised climate change IDF curves allow for drainage system performance assessment under a range of potential future climates projected for the short-term and long-term planning horizons. The scenarios supplement the methodology described in **Section 4**.

6.2.1 Single-Event Analysis

The climate change assessment undertaken using a single-event analysis approach is an extension of typical design/assessment methodologies but using revised storm data as input to the model to represent potential future changes in rainfall intensities.

Table 6-2: Rainfall Depths (Historical Analysis)

Historical	Return Period			
Storm Duration	2-year	10-year	50-year	100-year
10 minutes	12.2	18.8	24.5	26.9
1 hour	20.9	32.2	42.0	46.1
6 hours	35.8	55.2	72.0	79.1
12 hours	44.2	68.0	88.7	97.4
24 hours	54.4	83.8	109.3	120.0

6.2.2 Single Event Climate Change Model Output and Findings

Model outputs and summaries are found in **Appendix C** which includes the results of one climate sensitivity scenario based on the flows generated by the 1:100yr design storm +20%. This scenario represents the impacts regarding the increase in the severe weather anticipated in the region in comparison to existing conditions. Refer to **Section 5** which includes a summary of results for the 25-year development scenario in comparison to post-development existing conations for the single-event climate change scenario.

6.2.3 Climate Change Assessment Recommendations

Based on the projected increase in more frequent minor and major storms an overall increase in precipitation is projected in the next 25-30 years as presented in the ResLienT Loyalist Township Plan. Design storms selected for design should consider these impacts when designing stormwater management systems, especially for quantity control, when detention or retention systems are involved. To account for this, conservative design storms distributions, such as AES may be considered. In addition to this, policies which aim to reduce the target runoff for post-development flows below pre-development flows (up to 20%) provides additional resiliency and is being implemented in other Municipalities across Ontario.

7 Stormwater Recommendations

7.1 Alternative Servicing Strategies

7.1.1 Methodology

Future condition model results were reviewed to identify areas within the study area where there are opportunities for stormwater infrastructure improvements for the overall servicing strategy. The areas reviewed helped focus efforts on the development of remedial measures in areas that are worst affected by poor hydraulic performance of existing storm infrastructure, areas referred to as “Storm Infrastructure Improvement Areas” in the map figures presented in **Appendix D**. The improvement areas are grouped into three primary catchments

- Lost Creek
- Edgewood Road Municipal Drain and Areas to the South-East of the Secondary Plan area Along Country Road 6.
- Areas to the West and South of Lost Creek that Discharges Towards Parrots Bay

Recommendations depend on the nature of the issues identified in each area (as listed in the following section), and with regard to approaches that are available to designers to help resolve specific types of storm drainage problems, including but not limited to:

- Inlet Control Devices: ICDs can be installed in existing catch basin/manhole structures to help limit flow into the below ground pipe systems and therefore improve HGL conditions within the minor system. This can help mitigate basement flooding risks for properties in areas with high minor system HGL issues. The use of ICDs must be balanced with respect to the effects they can have on additional major system flows due to bottlenecks and backwater impacts.
- Pipe System Upgrades: where model results are indicating insufficient conveyance capacities (or “bottleneck” conditions), consideration should be given to upsizing storm sewers.
- Low Impact Development design measures: soft materials such as mulch or turf may be incorporated to assist with drainage issues due to shallow bedrock or the identification of Bioretention areas may be considered for all future developments. These development alternatives incorporate water retention measures without the deep footprint of traditional stormwater retention systems, such as ponds. Additional Low Impact development design measures are summarized in **Appendix E**.
- Potential for a traditional stormwater facility, such as a stormwater management pond, at the south portion of study area in close proximity to the lake to curb excessive drainage within the Lost Creek and Edgewood Municipal Drain area.

Final recommendations will target standard storm drainage design criteria for the Township currently being prepared as part of the Infrastructure Master Plan.

Although not explicitly included in the recommendations made in the Storm Infrastructure Improvement Area summary below, the Township may also want to consider a protective plumbing program in locations where existing residential homes are connected to local storm sewers along the perimeter (Bayview Drive and Parrott's Bay Lane) or in areas where no storm sewer upgrades are planned/executed for that specific storm sewer network/drainage system. Educating residents about the performance of the existing system and recommending (and/or financially supporting) the installation of backflow prevention devices, sump pumps (and other hydraulic disconnection approaches) for individual properties.

To investigate the issues in each area, the future conditions model, using the 5-year return period event as a design target and Single-Event climate change scenario, was used to test alternatives and develop a preferred approach in each location. The following sequence of analysis was applied:

- Simulating ICDs in existing culverts and catch basins were considered first (in the right-of-way with curbs only), since they can typically help improve the level of service of an existing storm sewer system while being cost-effective, requiring relatively low installation effort and disruption. Note that ICDs were only investigated in areas considered suitable for ICD implementation (i.e., locations where the major system ponding depths (above the catch basin) did not exceed 0.30 m in existing conditions for the 100-year climate change event). The ICDs were generally modelled to cap the flow at 15 l/s per catch basin lead. Where the simulated ICDs resulted in ponding depths greater than 0.30 m (with some exceptions) in the ROW during a 100-year climate change event, they were removed from the model and not recommended.
- Based on the analysis of the ICD program in each Storm Infrastructure Improvement Area, there were three (3) outcomes:
    - ICDs addressed high HGL conditions within the minor system and no further analysis was considered.
    - ICDs improved conditions and additional servicing alternatives were then investigated in addition to the ICDs.
    - ICDs did not provide significant improvements and as such, alternate servicing alternatives were explored.
- Identification of cost-effective stormwater management solutions, such as stormwater management facilities at centralized locations, that provide the least amount of disruption.

A high-level approach was applied to modelling each applicable servicing alternative (i.e., the existing inverts have been used and pipe size updates were made without necessarily optimizing slope for conveyance purposes). Where servicing alternatives are adopted, considerations for review during detailed design have been included. Furthermore, for a robust system, some systems may need to be dropped/raised to improve conveyance and risk of potential basement surcharge. Attention should also be paid to minimum cover requirements for any new/improved storm infrastructure, typically a minimum of 1.0 m (with insulation), or 2.0 m (without insulation) as required by soil conditions. In areas where the storm system is shallow, simply upsizing pipes to improve system performance (without modifying pipe inverts) may reduce the depth of cover to less than acceptable limits. These issues would need to be considered during any detailed design exercise.

Details of the conceptual servicing alternatives developed in each Storm Infrastructure Improvement Area are provided in the following section.

7.1.2 Storm Infrastructure Improvement Areas

7.1.2.1 Lost Creek

The Lost Creek watershed located within the Amherstview West Secondary Plan area will need to maintain the current conveyance of water upstream of the study area and limit increased flows to not compromise the existing infrastructure conveyance capacity. Within this watershed, the Parrott's Bay twin culvert crossing acts as an ICD and backwater during minor and major storm events pond spills withing the surrounding lowlands around the creek and into existing fields & wetlands which act as a buffer. To mitigate any negative impacts due to flooding caused to the neighboring lands and to reduce the overall risk of flooding locally, the lands surrounding the creek should be protected from infilling or provisions should be made to develop cut areas (ponds) where infilling occurs to counteract the existing flooding buffers created by the topography in this area. To minimize the requirement for cut/infill areas, a new stormwater management area may be designated adjacent to the Lost Creek bordering private and Township lands along the south side of the Creek as shown in Figure D-1 of **Appendix D**.

The provision of a least 3.75 ha of land will provide sufficient area to house stormwater management ponds that will store water for water quantity and quality control. The additional area designation may also allow for future development to propose offsite stormwater retention from their designated development area using municipally owned, operated, and maintained land that accounts for roadway drainage. This form of development will allow for denser and mixed forms of development to occur. The final size of the stormwater management facility should be based on the degree of low impact development measures designed with a target to reduce stormwater runoff flows by 20% as compared to existing conditions to align with the Township's draft Technical Design Guidelines currently under development.

One additional consideration is an increase in Lost Creek Catchment if the south-east extents closer to the County Road 6 and Amherst Drive area are modified for Sanitary System gravity sewer redirection to the north. This option to adjust the high point in this area is possible for approx. 5-10 Ha of land to redirect flow towards the Lost Creek watershed, the result would be a reduction in the Edgewood Municipal Drain Catchment SWM facility requirements.

7.1.2.2 Edgewood Road Municipal Drain and Areas to the South-East of the Secondary Plan area Along County Road 6.

The Edgewood Municipal Drain Report by Robertson Consulting identifies the best opportunity for stormwater management for lands within and surrounding the municipal drain is a collective stormwater management pond(s) or storage facility that includes provisions for water quality and quantity control. This aforementioned opportunity to regrade the area during future development (to redirect sanitary/stormwater flows north by gravity) means that the municipal drain can be mitigated within the secondary plan area. The development of these facilities would require property north of Highway 33 at two locations at the west and east extents. The storage facilities may be designed for catchment of areas outside of the Edgewood Road municipal drain catchment area south of Amherst Drive. These structures are treated as ICDs. The provision of at least 4.5 ha of land will provide sufficient area to house stormwater management ponds that will store water for quantity and quality control of this area. Refer to Figure D-2 of **Appendix D** for more details.

As with the Lost Creek area, this form of stormwater management will allow for denser and mixed forms of development to occur. The final size of the stormwater management facility should be based on the degree of low impact development measures designed with a target to reduce stormwater flows by 20% as compared to existing conditions to align with the Township's draft Technical Design Guidelines currently under development. Areas located south of the Lost Creek catchment area and east of the Edgewood municipal drain currently include farmland that conveys surface runoff towards existing ditches along County Road 6 and south towards Lake Ontario. County Road 6 ditching and modifications should continue to accept stormwater flows from these portions of the land until designated development is identified. Dedicated stormwater management (by development) is to be designed to mange flow from their respective catchments to ensure no additional runoff flows will be directed to County Road 6 or Hwy 33 ditches from the development.

One additional consideration is a reduction in the Edgewood Municipal Drain Catchment stormwater contributions would be if the north-east extents closer to the County Road 6 and Amherst Drive area are modified for Sanitary System gravity sewer redirection to the north. This option to adjust the high point in this area is possible for approx. 5-10 Ha of land to redirect flow towards the Lost Creek watershed, the result would be a reduction in the Edgewood Municipal Drain Catchment SWM facility requirements.

7.1.2.3 Areas West and South of Lost Creek That Discharge into Parrots Bay

Areas located west of the Lost creek catchment area are subject to stormwater runoff flows being directed west towards Parrots Bay in an uncontrolled manner to the north. While areas directly south-east of Bayview Drive also direct flows westward towards the Parrots Bay. This discharge for these locations cross Bayview Drive at a few locations via culverts and sewers located along Harrow Cr. and Brookland's Parge Ave. These located structures are treated as ICDs. Storage facility (by development) should be designed for their respective catchment of areas within these areas depending on the catchment area delineation. Refer to Figure D-1 of **Appendix D** for more details and summary of existing features.

7.2 Recommended Asset Management Processes and Additional Recommendations

7.2.1 Storm Servicing Infrastructure

All newly proposed storm sewer infrastructure will be subject to the Environmental Compliance Approval process under the Ministry of the Environment, Conservation, and Parks (MECP) are and should be sized in accordance with MECP Stormwater Management Design Guidelines and applicable Township Technical Design Guidelines currently in development.

In Ontario, LIDs are currently the primary recommended approach for quality control, where soil and hydrogeological conditions are appropriate. It is recommended that policies are in place to limit or eliminate all proposed connections of sump pumps or drainage pipe systems for roof-tops and weeping tiles into municipal sewer systems, in order to promote overland drainage allowing for stormwater to infiltrate into the ground or enter enhanced swale networks which provide the ability treat water for quality control.

Any conditions imposed on developments that limit storm sewer servicing may be reviewed on a case-by-case basis when reviewed against the other proposed Storm Infrastructure Improvement Area benefits.

The establishment of a new storm sewer collection and management network, complete with quantity and quality control measures, will be subject to MCEA Schedule B environmental assessment.

Table 7-1 provides an overview of the project recommendations to implement the preferred storm servicing infrastructure strategy, the year when the project(s) would be required to be completed, and the corresponding MCEA Schedule.

Table 7-1:Storm Servicing Infrastructure Project(s)

Project	Year Required	MCEA Schedule	Trigger
Low Impact Development Systems	Within 25-year planning horizon Full Build Out	EXEMPT Schedule 'B' If 'Land Acquisition is Required'	Implementation and construction of stormwater management for low impact development required as a condition of Site Plan, Plan of Subdivision or Condominium under the Planning Act are EXEMPT. Schedule 'B' for establishment of 'new' collection systems is only triggered when additional Land Acquisition is required dedicated to stormwater low impact development infrastructure.
New Servicing Infrastructure including ponds, tanks, sewers and ditches.	Within 25-year planning horizon Full Build-out	EXEMPT Schedule 'B' if 'Land Acquisition is required'	Establishing new or replacing/expanding existing stormwater infrastructure including sewers and ditches are EXEMPT when infrastructure is located within an established utility corridor, or road allowance where property acquisition is not required. Schedule 'B' for establishment of 'new' collection systems is triggered when additional Land Acquisition is required dedicated to stormwater collection infrastructure.

7.2.2 SWM Facilities

SWM facilities should be designed according to MOE (now MECP) 2003 Stormwater Management Planning and Design Manual (as amended). It's to be noted that the province periodically reviews and updates best management practices.

SWM facilities will be subject to the Environmental Compliance Approval process and should be sized in accordance with MECP Stormwater Management Design Guidelines and applicable Township Technical Design Guidelines currently in development.

LID facilities and traditional SWM facilities should be periodically inspected for performance and treated as assets for regular operational maintenance. Additional LID best management design practices have been summarized in **Appendix E** for additional details. It's to be noted that with pending changes to the MECP best management design practices that the implementation LID is highly recommended. As a result of these changes the design of LID will be prioritized when hydraulic conductivity and hydrological conditions are suitable for their use over traditional SWM facilities and this will have an impact on pond sizing, layout and requirements for localized water quality treatment.

Areas designated as snow collection will be subject to increased risk of surface water quality degradation. These sites should be planned and reviewed during the site plan application process as part of the detailed design of development areas.

For SWM facilities which include the establishment of a new stormwater management pond or stage-storage control facilities which incorporate quality control, the requirement for an MCEA Schedule B environmental assessment will apply.

Table 7-2 provides an overview of the project recommendations to implement the preferred storm management facility infrastructure strategy, the year when the project(s) would need to be completed, and the corresponding MCEA Schedule.

Table 7-2: Stormwater Management Facility Project(s)

Project	Year Required	MCEA Schedule	Trigger
Lost Creek SWM Facility	Within 25-year planning horizon	Schedule 'B'	The Lost Creek SWM facility is proposed within the 25-year planning horizon and is to be established once development is proposed within the catchment. This facility includes stormwater detention/retention ponds and appurtenances and includes establishing of a new outfall to Lost Creek where property acquisition is required.
Edgewood Road Municipal Drain and Areas to the South-East of the Secondary Plan Area and Along County Road 6	Within 25-year planning horizon Full Build-out	Schedule 'B'	Within 25-years the areas to the south-east of the Secondary Plan Area and along County Road 6 are to be developed which will trigger the establishment of a new SWM facility. This facility includes stormwater detention/retention ponds and appurtenances and includes where property acquisition is required. Expansion of the SWM facility is not required until full build-out when the Edgewood Road Municipal drain area is planned for development.

Project	Year Required	MCEA Schedule	Trigger
			To construct new or modify, retrofit or improve existing retention/detention facility or infiltration system for the purpose of stormwater quality control and quantity control that includes property acquisition will trigger the Schedule 'B' process.
Areas to the West and South of Lost Creek that Discharge Towards Parrot's Bay	Full Build-Out	Schedule 'B'	The areas West and South of Lost Creek that discharge towards parrot's dedicated SWM facilities are not triggered until full build-out of future development lands. These facilities include stormwater detention/retention ponds and appurtenances and includes establishing of a new outfall to Lost Creek where property acquisition is required.

7.2.3 Flow Monitoring

Flow quantity monitoring is recommended at ICDs for existing & proposed locations in coordination and cooperation with the Cataraqui Region Conservation Authority to ensure that stormwater servicing objectives are met and outflow to Lake Ontario may be monitored for impacts. Water quality flow monitoring may be considered on a case-by-case basis to confirm the performance of installed facilities.

7.2.4 Future Considerations and Phasing

SWM facility development would start with the land acquisition and a phased development of SWM pond infrastructure based on the rate of development within the Secondary Plan area. The Lost Creek SWM facilities would need to be developed first and consideration for the build-out of the collector road system is to be considered for connecting ditches/swales and/or storm sewers systems which are to direct flows toward any proposed SWM pond inlets. The collector roads are to be designed such that ponds are not intersected or act to divide catchment areas with the installation of storm sewer and/or culvert infrastructure. It's to be considered during design development that any existing topographic areas that currently subdivided portions of main catchment area in pre-development conditions are consolidated during post-development when re-grading is an option for any proposed subdivisions. The re-grading along the Amherst Drive extension, for example, should aim to redirect flows currently draining south towards the Edgewood Municipal Drain area back towards the Lost Creek watershed to the North to delay the build-out of the SWM facilities for the Edgewood Municipal Drain area into a future planning horizon. The SWM facilities proposed for the Edgewood Municipal Drain will need to be developed, (as soon as this catchment area is to used) to prevent any adverse downstream impacts for any area topography that may not be redirected. The 25-year planning horizon represents a buildout which include the establishment of a new stormwater management pond or stage-storage control facilities which incorporate quality control, the requirement for an MCEA Schedule B environmental assessment will apply.

7.2.5 Additional Recommendations

Given the opportunity to develop new municipal road networks and open space park areas, the following additional recommendations may be considered for future development:

- Rural roadway and multi-use trail networks may be considered which could include enhanced grassed swales for stormwater conveyance and water quality treatment.

Low Impact Development features may be considered as part of the proposed right-of-way development and could include Bioretention ponds/areas, enhanced swales, or perforated pipe systems. Opportunities and constraints for such systems require input from dedicated hydrogeological studies tailored to the proposed design of such systems which review the available hydraulic conductivity and suitability of soils. In localized cases, soft materials such as mulch or turf may be incorporated for drainage across shallow bedrock. A summary of additional details on LID best management practices and considerations in context of the Secondary Plan area have been included as part of **Appendix E**.

Appendix

A CRCA GUIDELINES

Appendix I: Guidelines for Stormwater Management

1 Introduction

This document is Appendix I to the Cataraqui Conservation Environmental Planning Policies (2015). It should be read in conjunction with the Cataraqui Conservation Environmental Planning Policies, as well as municipal stormwater guidelines where they have been prepared. These guidelines will be updated from time to time. Cataraqui Conservation staff encourage consultation early in the design process to determine specific requirements, coordinated through our Planning Office.

Stormwater management is a very important aspect of any site development. Where it is implemented correctly, it minimizes downstream hazards such as flooding and erosion, and maintains and improves water quality by capturing site pollutants before they reach receiving waterbodies such as lakes and streams.

The need for stormwater management is established by various legislation and policies, including the Canada Fisheries Act (protection of fish habitat), the Ontario Lakes and Rivers Improvement Act (in-stream works), the Ontario Water Resources Act (water quality and hydrologic performance), and the Ontario Planning Act and the associated Provincial Policy Statement (water quantity and quality). Conservation Authorities provide input on stormwater management requirements, and also apply regulations under the Ontario Conservation Authorities Act regarding work within, and near, waterbodies. Additionally, the riparian rights doctrine of common law requires consideration of impacts to upstream and downstream users.

The Ministry of Environment has prepared the Stormwater Management Planning and Design Manual (SWMPDM) (2003), which contains useful information to assist with design and construction of stormwater management controls. Some municipalities in the Cataraqui region have stormwater management design standards that are also used to review development plans.

The following outlines the guidelines of the Cataraqui Region Conservation Authority for stormwater management in the region.

2 General Guidelines

The goals of stormwater management are:

1. to protect waterways from increasing/excess erosion, increasing flows and flooding, decreasing flows and drying up, water takings and diversions. This is implemented by attempting to mimic the pre-development condition hydrograph in the post-development condition hydrograph.

2. to maintain the water balance and groundwater recharge.

3. to maintain or improve water quality.

Cataraqui Conservation encourages master drainage planning for all development areas. Master drainage plans are prepared on a subwatershed basis and identify the approach to meet targets for the area, specify methods of stormwater control, and outline the general location and size of stormwater facilities.These plans should be structured so as to account for a variety of implementation scenarios, in terms of: the order and timing of development, the type and form of development, and land tenure. Master drainage plans need to be reviewed and updated to reflect current standards on a regular basis, at least once every five years.

All stormwater management plans should be consistent with existing watershed plans, subwatershed plans or master drainage plans. The development proponent is responsible for checking with the local municipality and with Cataraqui Conservation to determine if any such plans exist. If so, then the development proponent is required to demonstrate that the proposed development's drainage system is consistent with those plans. If a master drainage plan has been prepared but is no longer considered valid, then the preferred approach is for the master drainage plan to be updated in light of the proposed development.

The size and complexity of a proposed development often decides the size and complexity of the stormwater report.

In general, Cataraqui Conservation will encourage the preparation of master drainage plans and other major stormwater management reports for plans of subdivision (e.g. neighbourhood scale development with multiple landowners) and in support of site plan control for large scale residential, commercial, industrial, or institutional developments.

Standard stormwater management reports will generally be recommended for plans of subdivision, and in support of site plan control for small or medium scale residential, commercial, industrial, or institutional developments.

At the discretion of Cataraqui Conservation staff, an abbreviated (brief) stormwater management report, may be allowed in certain circumstances.

2.1 Quantity

While the rational method and the matching of pre and post development peak flows at various event return periods have been used together as an estimation tool for hydrograph matching, they should not be used as the sole method of analysis. The rational method was developed in the 19th century as a method for sizing storm sewers, and is not appropriate for pond design. There are drainage area limitations for the rational method, but may be considered adequate in some situations (e.g. - very small sites).

A hydrologic/hydraulic model is the best way to compare undeveloped and developed site runoff characteristics. Pre-development and post-development hydrographs should also be examined in an attempt to provide a match. While exact hydrograph matching is generally not possible due to an increase in the volume of water in the post-development condition, the goal is to match as closely as possible to protect streams from increased flow, erosion and flooding, as well as decreasing flows to the point of drying up the stream.

If the development proponent proposes post-development peak flows which exceed predevelopment peak flows, then the proponent will be responsible for conducting all necessary hydrologic and hydraulic studies to prove that the post peak flows can be released from the site without any adverse upstream or downstream impacts on flood risk or watercourse erosion. These studies must show this to the satisfaction of planning and regulatory authorities including the local municipality and Cataraqui Conservation. Prior to making any such submission, the proponent should consult with the Cataraqui Conservation to determine the specific technical analyses that will be required to support higher site release flows.

2.2 Quality

In terms of quality control, capturing the more frequent, smaller events and the start of larger events (called the first flush) that typically wash contaminants off the hard surfaces, and holding them for a minimum of 24 hours, has been shown to reduce the volume of sediments and contaminants in the water.

Quality controls need to be based on watershed studies, master drainage plans, or master stormwater management plans, where they exist. Where such plans do not exist, Normal (level 2) protection, as defined by the Ontario Ministry of the Environment, will generally need to be achieved. Some receiving waterbodies that are coldwater streams or lakes, wetlands, the Bay of Quinte, or other environmentally-sensitive waterbodies will require enhanced protection. Consult with Cataraqui Conservation for the level of protection necessary for the receiving waterbody.

Further, quality storage should be designed to provide a minimum of 24 hours of detention for settling of particles, and provide a sediment forebay at the SWM inlet to collect additional sediment.

2.3 Treatment Options

Treatment options should be considered, in order of preference, by lot-level and conveyance control, and end-of-pipe treatment. Low Impact Development (LID) techniques should be considered where suitable conditions exist. Credit Valley Conservation (CVC) and the Toronto Region Conservation Authority (TRCA) have produced a very useful guideline for Low Impact Development Stormwater Design that is available on their websites (http://www.creditvalleyca.ca/ and http://trca.on.ca/).

Best management practices (BMPs) are a stand alone stormwater management option for small sites, and are encouraged for all sites. Some BMPs, which are typical low impact development (LID) techniques, include:

- Reduce lot grading
- Grassed swales
- Vegetative buffer strips
- Infiltration pits/trenches/basins
- Sand filters
- Previous pipe systems

Supporting sizing calculations are to be included in the design reports where these or other types of controls are proposed.

New developments should be designed to incorporate all reasonable and practical means of minimizing direct surface runoff, including:

- Minimizing the amount of impervious area
- Maximizing the amount of existing vegetated area (treed areas, grassed areas) that is retained within the development design, to help maximize opportunity for infiltration of surface water
- Diverting roof drainage to vegetated areas to give the water opportunity to soak into the ground

Cataraqui Conservation encourages, and is open to, new and innovative ideas where they are shown (through scientific research and monitoring) to be reasonable, effective and environmentally sound for the Cataraqui Conservation area.

3 Report Content

Cataraqui Conservation reviews stormwater management reports with respect to the legislation and policies identified above. Reports which do not meet the basic Cataraqui Conservation requirements for breadth of content may not be reviewed until modifications have been made to fulfill these requirements. All reports should be typed, clearly legible, use SI (metric) measurements, and include applicable, legible maps and plans with sufficient, identified scales appropriate for review.

Stormwater management reports shall include the following:

Title Page

- Development name and name of proponent
- Date of issue and revision number
- Consultant contact information

Introduction

- Development location (with key map), municipality (existing and geographic), Lot,
- Concession, civic address
- Size of property (ha)
- Size of development (ha)
- Type of development
- Existence, date of creation, and phase of development in a Master Drainage Plan, where applicable
- Proposed development phasing, and its impact on the effectiveness of the stormwater system as a whole

Background

- Site history
- Information on existing development/land use
- Plan layout of existing, and proposed site
- Areal extent and description of all types of pervious and impervious surfaces present including:
    - Buildings
    - Asphalt
    - Gravel
    - Landscapes including lawn, long grass, trees, etc
    - Ponds
    - Waterways
- Runoff coefficients
- Site constraints
- Receiving waterbodies: identification, location relative to the site, existing condition/issues
- Any geotechnical properties of the local soil including permeability, depth to bedrock, water
- table levels, etc.

Analyses

Quantity Control Analyses

- Quantity control provided for the minor through regulatory (2 year through 100 year) return periods.
- Hydrologic/hydraulic matches assessed so that post-development peak flows equal predevelopment peak flows, and in addition that the post-development hydrograph matches the pre-development hydrograph.

- Appropriate calculations and tables. These should be sufficient for Cataraqui Conservation review and should conform to the guidelines outlined by the municipality.
- Appropriate storm, runoff coefficients, assumptions and equations that conform to the guidelines outlined by Cataraqui Conservation and the municipality. Intensity Duration Frequency (IDF) curves are available for Kingston and Brockville and should be used.
- An examination of more than one storm distribution (and duration) including a worst-case scenario. The Chicago storm distribution was designed for extreme rainfall in Chicago and surrounding areas of Illinois, it is not appropriate for eastern Ontario. It overestimates peak flows, and thereby does not properly match the pre and post hydrographs, and may result in oversizing of ponds, and oversizing of pond outlet structures. Instead, a storm distribution created from specific Canadian data is more appropriate, such as an AES (Atmospheric Environment Service) or Hydrotek storm distribution.
- The runoff coefficient (C) and time of concentration (t_c) values used in the calculations shall be appropriate for the existing site (or Ontario) and the proposed *development.*
- Equations, assumptions and units used.
- For stormwater management reports that are prepared in support of the redevelopment of a site, an assessment of runoff for the state of the land prior to any development (predevelopment condition), and also for the state of the land with existing development.
- The method of control (e.g., BMPs, dry pond, wet pond, wetland, infiltration, enhanced catch basin)
- Calculations to support open channel, flow control, and major flow path designs.
- Examination of the impact of the control method on groundwater recharge.

Quality Control Analyses

- Quality control for the 25 mm storm held for 24 hours, with Normal Protection (MOE, 2003) is generally required. Some locations on coldwater streams or lakes, wetlands, waterbodies draining toward the Bay of Quinte, or other environmentally-sensitive waterbodies will require more stringent protection. Consult with Cataraqui Conservation for the level of protection necessary for the receiving waterbody.
- Sample calculations for each equation used.
- Naming of all variables, constants, units and equations.
- The method of control.
- Properly designed sediment forebay to capture sediment at the inlet to the SWM facility.

Controls

- Stage-storage-discharge table.
- Detailed drawings, plan view, elevation view, cross-section through outlet structure.
- Minimum freeboard of 0.3 m at regulatory event must be used.
- Outlet(s) location are to be shown.
- Emergency overflow outlet to convey major event flow if normal outlet becomes blocked (or larger than major event is received).
- Sediment forebay(s).
- Planting plan: native, non-cultivar species appropriate for frequency of inundation are to be used whenever possible. The use of *persuasive planting* (e.g. rose bushes, hawthorns) shall be preferred over perimeter fencing, especially where the facility has been designed with safety features (i.e. a shallow permanent pool, benching, gentle sideslopes, etc.).
- Safety concerns.
- Extent of parking lot and roadway storage at 5 year and regulatory (100 year) return period events - maximum depth should be 0.25 m.
- Snow storage location(s) for all parking facilities and private (internal) roads. Snow storage areas must be located as far as possible from the intended stormwater outlet and/or an adjacent *waterbody* and/or an identified *groundwater* recharge or discharge area, and be designed so as not to impair the function of stormwater management facilities.
- Maintenance access
- Maintenance and operations plan - including inspection and cleanout frequency
- Method of conveyance/outlet between site controls and receiving waterbodies to demonstrate that sufficient capacity exists
- Conveyance details: longitudinal slope, cross-section, subsurface drainage, rock check dams, etc.

Erosion and Sediment Control Measures

- Temporary and permanent measures:
    - prior to site construction (grubbing, pre-grading)
    - during construction
    - post-construction
- Location plan drawing.
- Appropriate Ontario Provincial Specification Drawings (OPSD) included in drawing set.
- Monitoring plan addressing monitoring provisions and frequency of monitoring of erosion and sediment control measures.
- Removal plan for accumulated sediments.

Recommendations and Conclusions

- Recommendations with descriptions, based on the analyses performed.
- Long term maintenance and monitoring plan addressing monitoring provisions and frequency of stormwater controls.
- Recommended notices to purchasers, or on title, regarding special setback or building freeboard provisions.
- Signature.
- Professional Engineer's Seal.

Appendices

- Computer model input and output files
- Additional drawings
- Full calculation sheets
- Agencies consulted

4 Design Parameters

4.1 Applicable Storms

An applicable storm for the Cataraqui Region should be used for modeling purposes. As noted above, the examination of multiple storm distributions and durations should be conducted by consultants, and the most appropriate should be selected. Environment Canada has kept records and completed statistical analyses on historical rainfall events. The text Hydrology of Floods in Canada (Watt, 1989) recommends the Atmospheric Environment Service (AES) or Hydrotek storm distributions for use in Canada. The Chicago distribution is much less suitable.

However, care should be taken to ensure that the best design storm is chosen and used properly within the range of its applicability (Marsalek and Watt, 1984).

The storm duration should be greater than the time of concentration of the site, and a variety of durations should be examined to determine the worst case scenario. Time of concentration should be calculated for each site, using the appropriate method. A time of concentration method based on Canadian, or better Ontario, data is the most appropriate option.

For urban design, typically a rain event will result in the largest flows, but larger watersheds, and rural watersheds, may experience higher flows due to a combination rain/snowmelt event.

Plans shall be based on climate data from Atmospheric Environment Service (AES) stations that are representative of the subject area or site.

4.2 Ponds

Stormwater management ponds are recommended for quality and quantity control on all new development. Planned development should make adequate accommodation for stormwater management facilities. Some sites (e.g. redevelopments and, potentially, infill sites) may be too small to accommodate a pond and will require alternative stormwater control, such as those discussed in Sections 4.3 and 4.6.

All stormwater management ponds are generally required to provide both quality and quantity control. In rare cases the removal of the requirement for a quantity control pond may be considered, for instance if a site has direct drainage to Lake Ontario or the St. Lawrence River. Consideration for removal of the quantity control aspect is due to the size of the receiving water body, and the minimal effect an increase in volume will have on the flood hazard in that water body. It should be noted that even though a site may ultimately drain to a large body of water such as Lake Ontario or the St. Lawrence River, the conveyance path from the site to the water body must be considered from a flood hazard perspective, and the removal of the quantity control pond requirement may not be an option. In all cases, quality control will be required. Calculation of this quantity of initial storm runoff should be discussed with Cataraqui Conservation staff.

The following list contains a number of other considerations for pond design.

- Quality ponds should be designed to include a sediment forebay (settling basins) located at each inlet into the pond, and a permanent pool or wetland component. These will serve to increase pollutant removal efficiency. The ponds should be designed as per the SWMPDM.
- Quantity ponds can take the form of dry extended detention basins, wet ponds, wetlands, etc.
- All pond inlet and outlet orifices should be a minimum diameter of 75 mm (3 in.) to minimize the potential for plugging with sediment and/or debris.
- The bottom of the pond is to be lined with a 0.5 m clay liner in areas with a high groundwater table, permeable soils or bedrock and/or where infiltration of groundwater is undesirable.
- Upstream drainage not affected by the *development* should bypass any ponds in order to provide maximum pond efficiency, unless the pond is intended to provide control for that upstream area.
- Ponds and larger conveyances should have a minimum freeboard of 0.3 m during major events.
- Pond embankments should have a maximum slope of 5:1.
- Ponds should preferably be designed to include plantings of native species of Eastern Ontario stock, especially where adjacent to a receiving waterbody or other natural area.

- Species and proposed planting locations should be considered with respect to moisture tolerance, frequency and duration of inundation.
- Ponds should be amenities that are integrated into public *open space*; however, designers should also consider the safety aspects of these locations.
- Ponds should be fully constructed and ready to accept water **prior** to development.
- For areas where more than one phase of *development* has been proposed, the pond outlet should be designed such that it can be modified as the catchment area continues to be developed.
- Infiltration should be explored and used where appropriate, at all levels of control: lot-level, conveyance, and end-of-pipe. Consideration of the potential for groundwater contamination will be required when infiltration is proposed.
- Stormwater management reports should include maintenance plans, expected cleanout frequency, recommended inspection frequency, etc.

4.3 Swales

We recommend that swales be designed as per the Stormwater Pollution Prevention Handbook (MOE, 2001):

- minimum 0.75 m flat bottom;
- maximum 0.15 m^3/s flow;
- maximum 0.5 m/s velocity;
- maximum 2 ha contributory drainage area;
- minimum 3(h):1(v) side slopes; and
- minimum 15 cm grass length (i.e., unmown vegetation).

The Ministry of Natural Resources Natural Hazards Technical Guides (MNR, 2001, 2002a and 2002b) recommend a velocity-depth product of less than 0.4 m^2/s (velocity multiplied by water depth), with a maximum depth of 0.8 m, or a maximum velocity of 1.7 m/s; this has been deemed safe for people to traverse. In addition, a freeboard of 0.3 m between the top of bank and the regulatory water level is recommended.

4.4 Buffer Strips

Buffer strips are encouraged for water quality protection, as this has been found to remove a significant portion of suspended sediments and pollutants. Additional information on buffer strips is provided in Appendix ‘F’ to the Cataraqui Conservation Environmental Planning Policies. A riparian buffer minimum of 30 m is recommended, with exceptions made for special circumstances. Steeper slopes, less porous soils, or other factors warrant an increase in buffer width. Wetlands are not considered buffers. The Cataraqui Conservation Riparian Buffer Guidelines recommend a buffer for protection not only of water quality, but of the general health of the stream, aquatic species and riparian zone.

4.5 Catch Basins

It is recommended that any catch basins being installed on a site be protected with sediment controls until the site has been stabilized. Examples include surrounding the catch basin with straw bales or placing geotextile underneath the catch basin grate, to keep sediment out of the storm sewer system and the receiving waterbody. Sediment should be removed, and properly disposed of, from around the catch basin once the site is stabilized, and then on a regular basis.

Where pipe/catch basin/parking lot storage is proposed, the maximum depth of ponding is to be no more than 0.25 m to facilitate safe vehicular access in parking lots.

Increased catch basin sump depth is recommended to increase sediment capture in the storm sewer network.

Regular sediment removal from catch basins is very important to the overall water quality protection aspect of this type of SWM control.

4.6 Other Types of Controls

Stormwater management methods such as enhanced catch basins (oil/grit separators), underground tanks, etc., will only be considered where there is not enough space to use other, more natural methods of management, in small redevelopment sites or infill projects, or where specific spill-control concerns are raised. Where these facilities are proposed, they should be designed as part of a treatment train approach including lot-level BMPs and conveyance controls.

Enhanced catch basins may be supported for spill control and as the primary method of quality treatment on small urban sites (i.e., generally less than 1.0 ha) such as refuelling stations, especially as part of infill *development* or the redevelopment of a site. On other sites, enhanced catch basins are generally not supported since new planned developments should make adequate accommodation for more natural forms of stormwater management (e.g., lot level, conveyance, and end-of-pipe facilities).

Cataraqui Conservation may support the use of underground storage tanks for quality control if used in conjunction with other proven measures to provide the necessary level of quality protection or where oversight would be provided by the Ministry of the Environment.

4.7 Cleaning, Maintenance and Monitoring

Temporary construction sediment and erosion control measures should be installed prior to any site disturbance, checked on a daily basis, remain in good working order until the site is stabilized, and should be cleaned on a regular basis. Once the site has been stabilized and excess sediment removed, these temporary sediment and erosion controls should be removed.

All sediment deposition, catch basins, sediment forebays, sediment fences, etc., should be cleaned prior to the municipality assuming ownership (for public facilities), or prior to the owner paying the final installment to the contractor (for private facilities). All permanent sediment and erosion controls should be in good working order prior to assumption, or final payment.

The stormwater report should include a section on maintenance, cleaning, and monitoring of the SWM facilities for the duration of their operation. It should specify when maintenance is required (e.g. forecast when a SWM pond would be x% full). This information will be included in the Site Plan or Subdivision Agreement, as applicable.

5 Approval Process

Application for approval of proposed drainage systems for land developments must be made to the local municipality as part of the overall development approval process administered by the municipality.

Cataraqui Conservation will review proposed development plans with respect to drainage and stormwater management requirements set out in these guidelines. Cataraqui Conservation will assess a cost-recovery fee for its review of a stormwater report, based on the approved Plan Review Service Fee Schedule, as amended from time to time. Straightforward reports will typically be reviewed at the staff level. However, depending on scope and complexity, reports may be subject to a peer review, at the expense of the proponent.

Additional approvals may be required depending on the specific design and type of drainage system being proposed, such as a permit under Ontario Regulation 148/06: Development, Interference with Wetlands, and Alterations to Shorelines and Watercourses.

The development proponent is responsible for obtaining any and all necessary approvals related to stormwater management. These approvals will include but are not necessarily limited to: Ontario Ministry of Environment approval (Section 53 approval under Ontario Water Resources Act); Ontario Ministry of Natural Resources approval (Sections 14 and 16 under the Lakes and Rivers Improvement Act); and Fisheries and Oceans Canada approval (Section 35(1) under the Fisheries Act). The development proponent is responsible for determining approval requirements through discussion with Cataraqui Conservation, the local municipality and the Ontario Ministry of the Environment.

The development proponent is responsible for completing any necessary environmental assessment (EA) that may be required under the Ontario Environmental Assessment Act or the Canadian Environmental Assessment Act. The development proponent is responsible for determining what EA requirements apply to the project.

References

Marselek, J., and W.E. Watt. 1984. *Design Storms for Urban Drainage Design*, Canadian Journal of Civil Engineering 11(3) pp. 574-584.

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Ontario Ministry of Natural Resources. 2001. Great Lakes - St. Lawrence River System and Large Inland Lakes: Technical Guides for Flooding, Erosion and Dynamic Beaches in Support of Natural Hazards Policies 3.1 of the Provincial Policy Statement. Queen's Printer for Ontario.

Ontario Ministry of Natural Resources. 2002a. Technical Guide – River and Stream Systems: Erosion Hazard Limit. Queen's Printer for Ontario.

Ontario Ministry of Natural Resources. 2002b. Technical Guide – River and Stream Systems: Flooding Hazard Limit. Queen's Printer for Ontario.

Watt, W.E. 1989. *Hydrology of Floods in Canada*.

For More Information

Please contact Cataraqui Conservation at 613-546-4228, info@crca.ca or visit our website at www.cataraquiconservation.ca.

Appendix

B MTO IDF CURVES

MTO IDF Curve Information

Location Used:

Active coordinate

44° 14' 15" N, 76° 40' 15" W (44.237500,-76.670833) Modify selection

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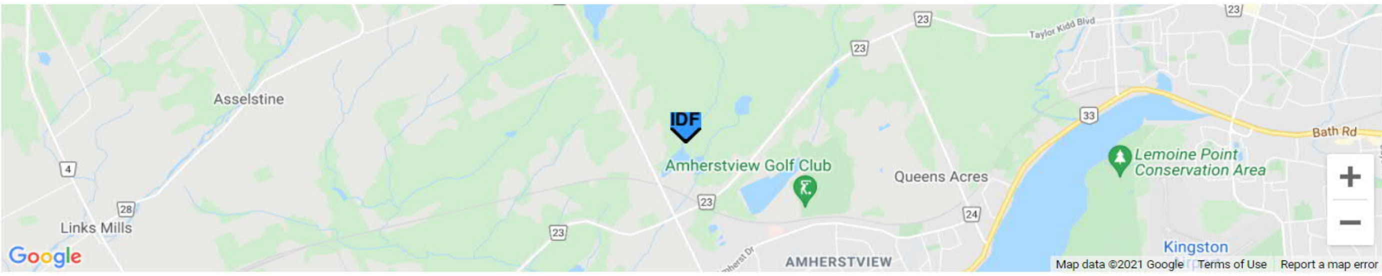
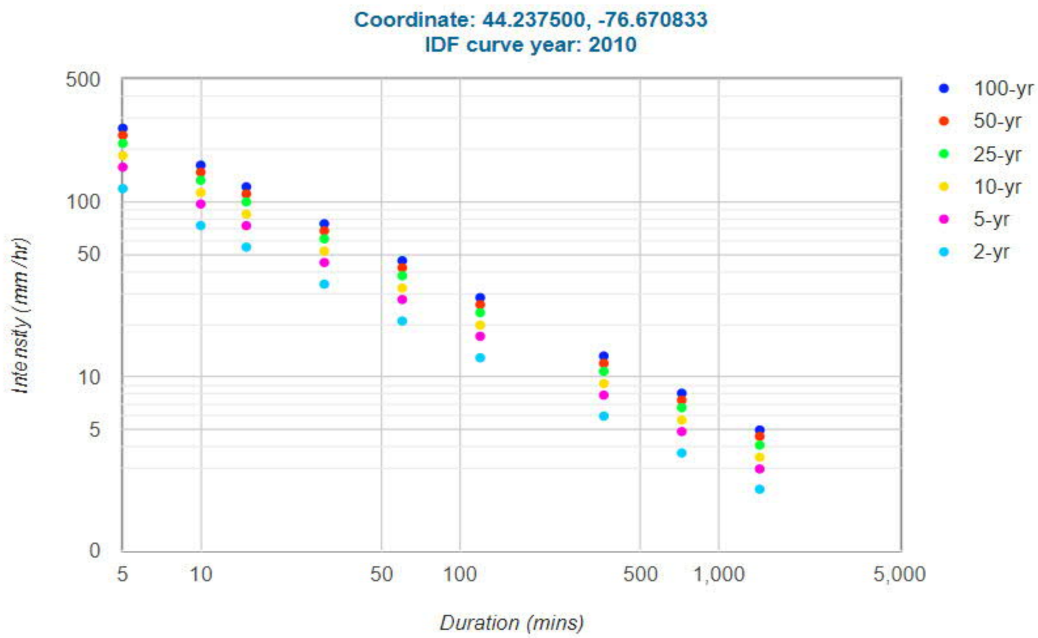


IDF Curve:



Coefficient Summary:

Return period	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
A	20.9	27.7	32.2	37.8	42.0	46.1
B	-0.699	-0.699	-0.699	-0.699	-0.699	-0.699

Rainfall Intensity:

Rainfall intensity (mm hr^{-1})

Duration	5-min	10-min	15-min	30-min	1-hr	2-hr	6-hr	12-hr	24-hr
2-yr	118.7	73.1	55.1	33.9	20.9	12.9	6.0	3.7	2.3
5-yr	157.3	96.9	73.0	45.0	27.7	17.1	7.9	4.9	3.0
10-yr	182.9	112.7	84.9	52.3	32.2	19.8	9.2	5.7	3.5
25-yr	214.7	132.3	99.6	61.4	37.8	23.3	10.8	6.7	4.1
50-yr	238.6	147.0	110.7	68.2	42.0	25.9	12.0	7.4	4.6
100-yr	261.8	161.3	121.5	74.8	46.1	28.4	13.2	8.1	5.0

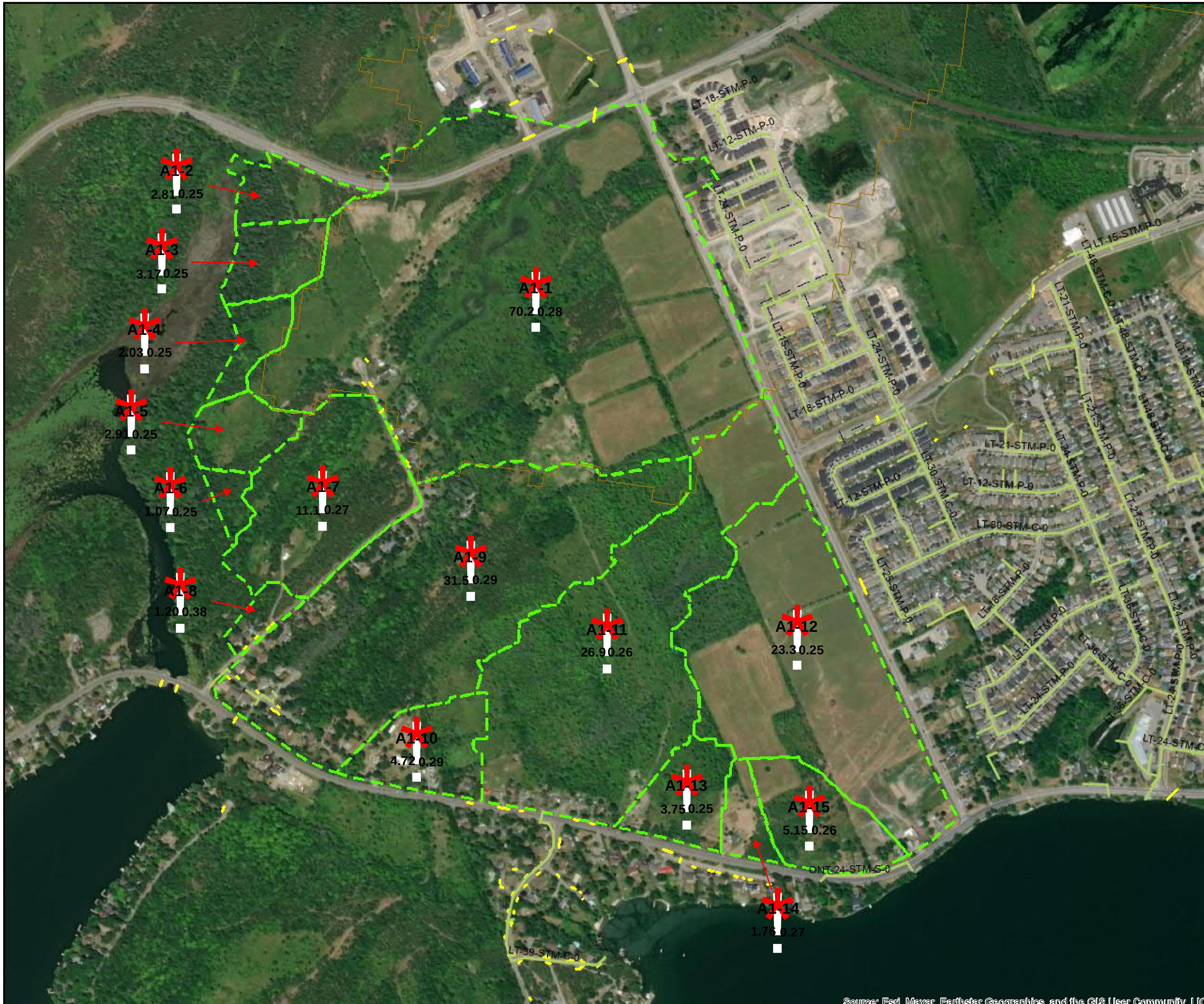
Rainfall Depth:

Rainfall depth (mm)

Duration	5-min	10-min	15-min	30-min	1-hr	2-hr	6-hr	12-hr	24-hr
2-yr	9.9	12.2	13.8	17.0	20.9	25.7	35.8	44.2	54.4
5-yr	13.1	16.2	18.2	22.5	27.7	34.1	47.5	58.5	72.1
10-yr	15.2	18.8	21.2	26.1	32.2	39.7	55.2	68.0	83.8
25-yr	17.9	22.0	24.9	30.7	37.8	46.6	64.8	79.9	98.4
50-yr	19.9	24.5	27.7	34.1	42.0	51.7	72.0	88.7	109.3
100-yr	21.8	26.9	30.4	37.4	46.1	56.8	79.1	97.4	120.0

Appendix

C MODEL RESULTS



1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

LOYALIST TOWNSHIP

Legend

- * Catchment Name, Catchment Area (HA) and C-Factor
- Active Storm Sewer
- Proposed Storm Sewer
- Disposed Storm Sewer
- Cross Culverts
- Catchment Areas

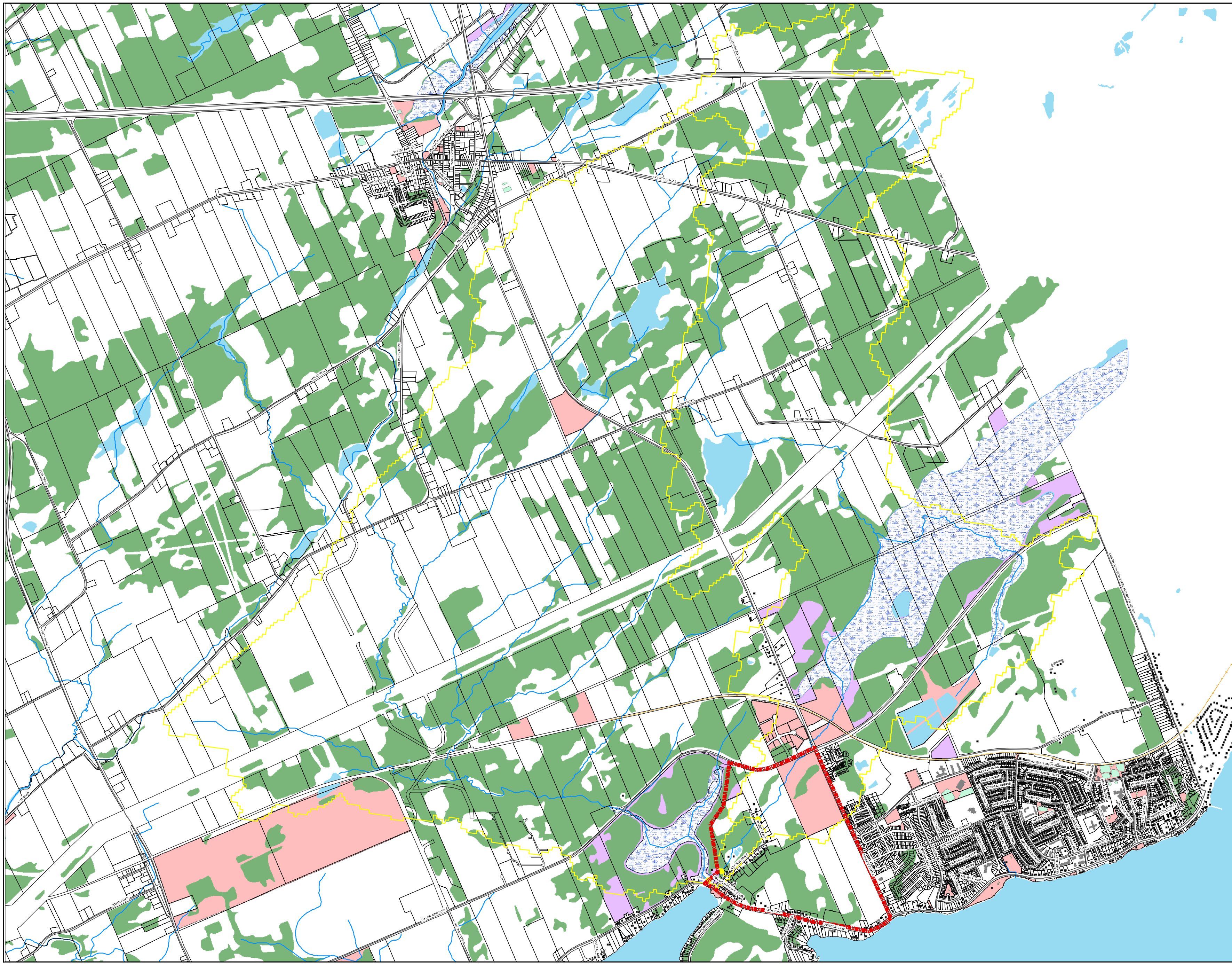
0 95 190 380 Meters

LOYALIST AMHERSTVIEW
WEST SECONDARY PLAN

AMHERSTVIEW WEST
CATCHMENT MAP

Project No.: 211-01353-00		Date: MARCh, 2023
Drawn By: J.D	Checked By: MF	Figure No.: C-1

File Location:C:\Pro\Amherstview\Subcatchment Map Rev 2.mxd



1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

Loyalist Township

BOX 70, 263 MAIN STREET
ODESSA, ONTARIO,
CANADA K0H 2H0
WWW.LOYALIST.CA

Legend

- Study Area
- Pour Point
- Watershed
- Parcel
- Township Roads
- Watercourses
- Railroad
- Building
- Wetlands
- Wetlands
- Waterbody
- Waterbody
- Playgrounds
- Sports Fields
- Wooded Area
- CRCA Lands
- Loyalist Township Land

Scale: 0 220 440 880 Meters

1:15,000

Project:

LOYALIST-AMHERSTVIEW WEST SECONDARY PLAN

Title:

LOST CREEK WATERSHED

Project No.:		Date:
211-01353-00		MARCH, 2021
Drawn By:	Checked By:	Figure No.:
CZ	MF	C-2

WSP

1224 GARDINERS RD, SUITE 201
KINGSTON, ONTARIO,
CANADA, K7P 0G2
WWW.WSPGROUP.COM

LOYALIST TOWNSHIP

Legend

	Study Area		Ditch Inlet CB
	Parcel		Twin Inlet CB
	Storm Laterals		Manhole
	Active Storm Sewer		Ditch Inlet MH
	Proposed Storm Sewer		Culvert
	Disposed Storm Sewer		Sewer Inlet
	Stormwater Treatment Unit		Sewer Outlet
	Catchbasin		Cleanout
	Catchbasin MH		Yard Basin

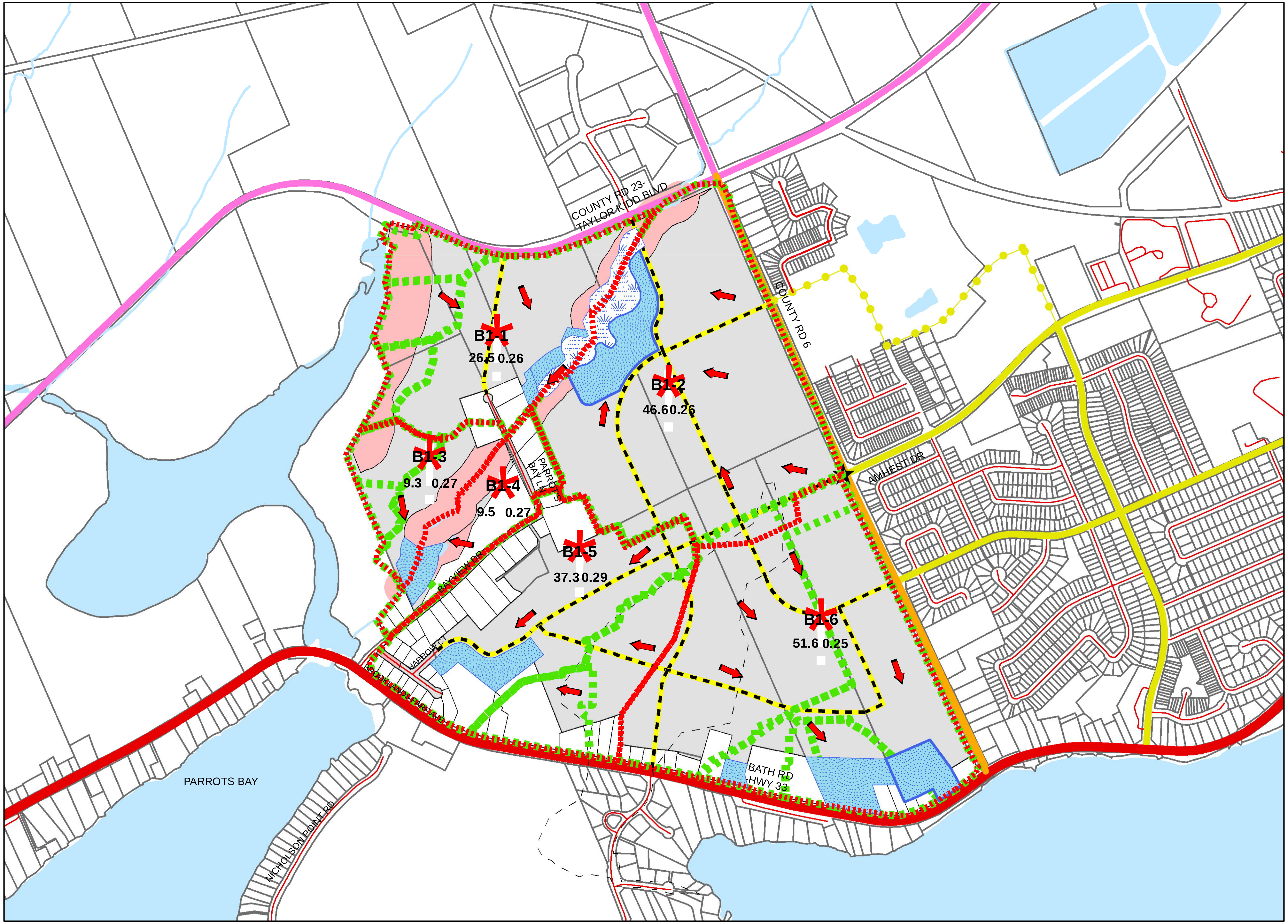
Scale:
0 50 100 200 Meters
1:10,000

N
W E
S

Project:
LOYALIST AMHERSTVIEW
WEST SECONDARY PLAN

Title:
AMHERSTVIEW WEST
STORM SERVICES

Project No.:		Date:
211-01353-00		JULY, 2021
Drawn By: J.D	Checked By: MF	Figure No.: C-3



LEGEND

Secondary Plan Study Area

Conceptual Land Use
- Low Density Residential
- Medium Density Residential
- High Density Residential
- Commercial - Highway
- Commercial - Mixed Use
- Institutional
- Parks and Open Space
- Potential Future Development

Existing Road Network
- Provincial Highway
- Major Arterial
- Urban Arterial
- Urban Collector
- Local

Future Roads
- Collector Residential
- Collector Residential

Development Constraint
- High Constraint - Natural Environment Area

Servicing
- Edgewood Municipal Drain
- Municipal Stormwater Management

Stormwater Management
- Flow Arrow - (Post-Development)
- Pre-Development Catchment Area
- Post-Development Catchment Area - Existing Condtions

Catchment Name, Catchment Area (HA) and C-Factor

Scale:
0 45 90 180 Meters
1:10,000

Project:

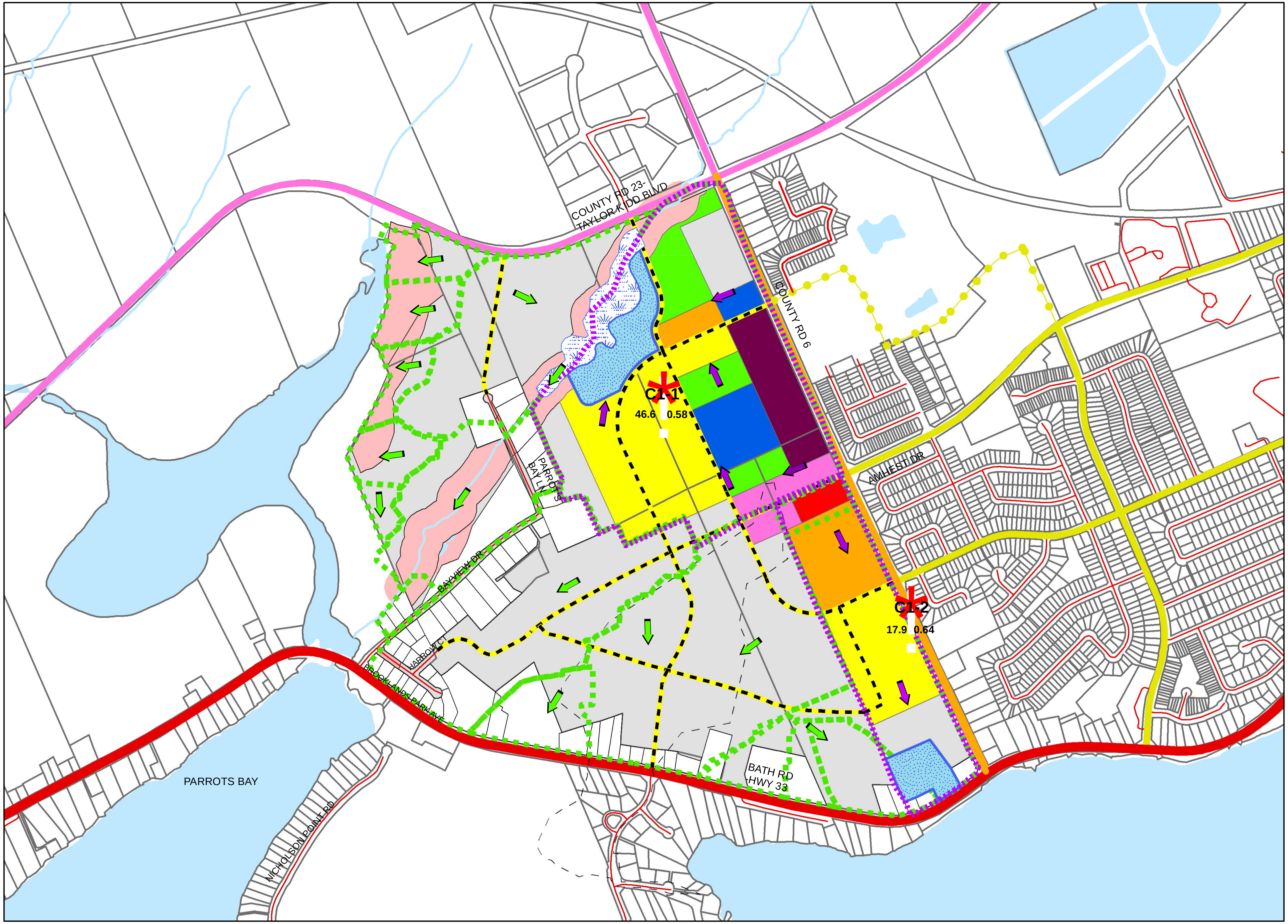
LOYALIST-AMHERSTVIEW WEST SECONDARY PLAN

Title:

POST-DEVELOPMENT CATCHMENT AREAS - EXISTING CONDTIONS STORMWATER MANAGEMENT

Project No.:	Date:	
211-01353-00	OCTOBER, 2024	
Drawn By: DM	Checked By: MF	Figure No.: C-4

File Location:C:\Pro\Amherstview\Servicing Map\C-4-Post-CatchmentAreas-221-01353-00-REV7.mxd



LEGEND

Secondary Plan Study Area

Conceptual Land Use
- Low Density Residential
- Medium Density Residential
- High Density Residential
- Commercial - Highway
- Commercial - Mixed Use
- Institutional
- Parks and Open Space
- Potential Future Development

Existing Road Network
- Provincial Highway
- Major Arterial
- Urban Arterial
- Urban Collector
- Local

Future Roads
- Collector Residential
- Collector Residential

Development Constraint
- High Constraint - Natural Environment Area

Servicing
- Edgewood Municipal Drain
- Municipal Stormwater Management

Stormwater Management
- Flow Arrow - (Pre-Development)
- Flow Arrow - (Post-Development)
- Pre-Development Catchment Area
- 25-Year: Post-Development Catchment Area
- Catchment Name, Catchment Area (HA) and C-Factor

Scale:
0 45 90 180 Meters
1:10,000

Project:

LOYALIST-AMHERSTVIEW WEST SECONDARY PLAN

Title:

POST-DEVELOPMENT CATCHMENT AREAS - 25 YEAR DEVELOPMENT STORMWATER MANAGEMENT

Project No.:		Date:
211-01353-00		OCTOBER, 2024
Drawn By: DM	Checked By: MF	Figure No.: C-5

File Location:C:\Pro\Amherstview\Servicing Map\C-5-Post-CatchmentAreas-221-01353-00-REV7_FIG5.mxd

Model Results Summary

Hydraulic Model : Bentley SewerGEMS Version 8

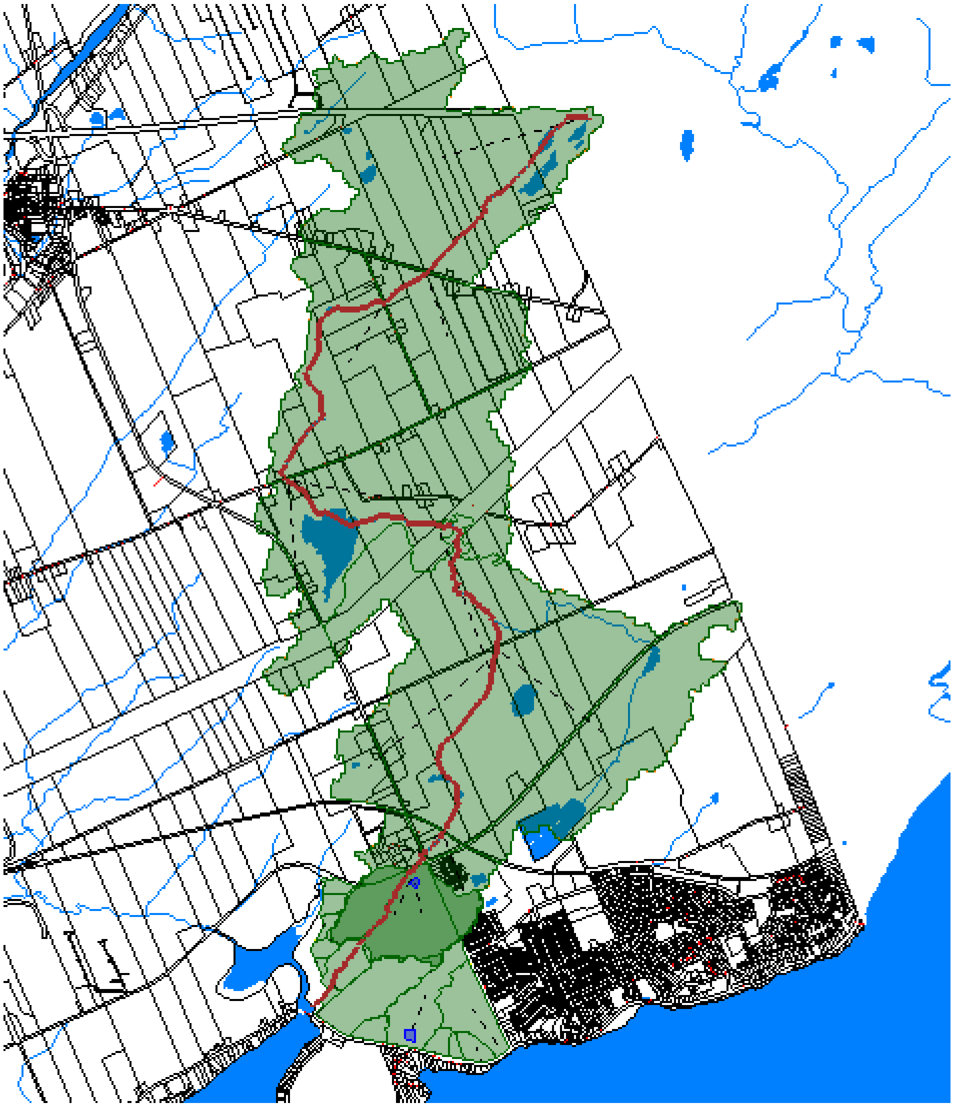


Figure 1 – Overview of SewerGEMS Hydraulic Model

Set-up Details:

Duel-Watershed and local sub catchment model for pre-post condition simulation.

Rainfall Runoff generated using MTO IDF Curves (Refer to Appendix B for details)

Sub catchments within Secondary Plan Area – Refer to Drawing C-1
Contours and Water Shed Map – Refer to Drawing C-2
Existing Storm Sewer & Culvert Locations– Refer to Drawing C-3
Post-Catchment Areas – 25 Year Development – Refer to Drawing C-4
Post-Catchment Areas – Full Build-Out – Refere to Drawing C-5

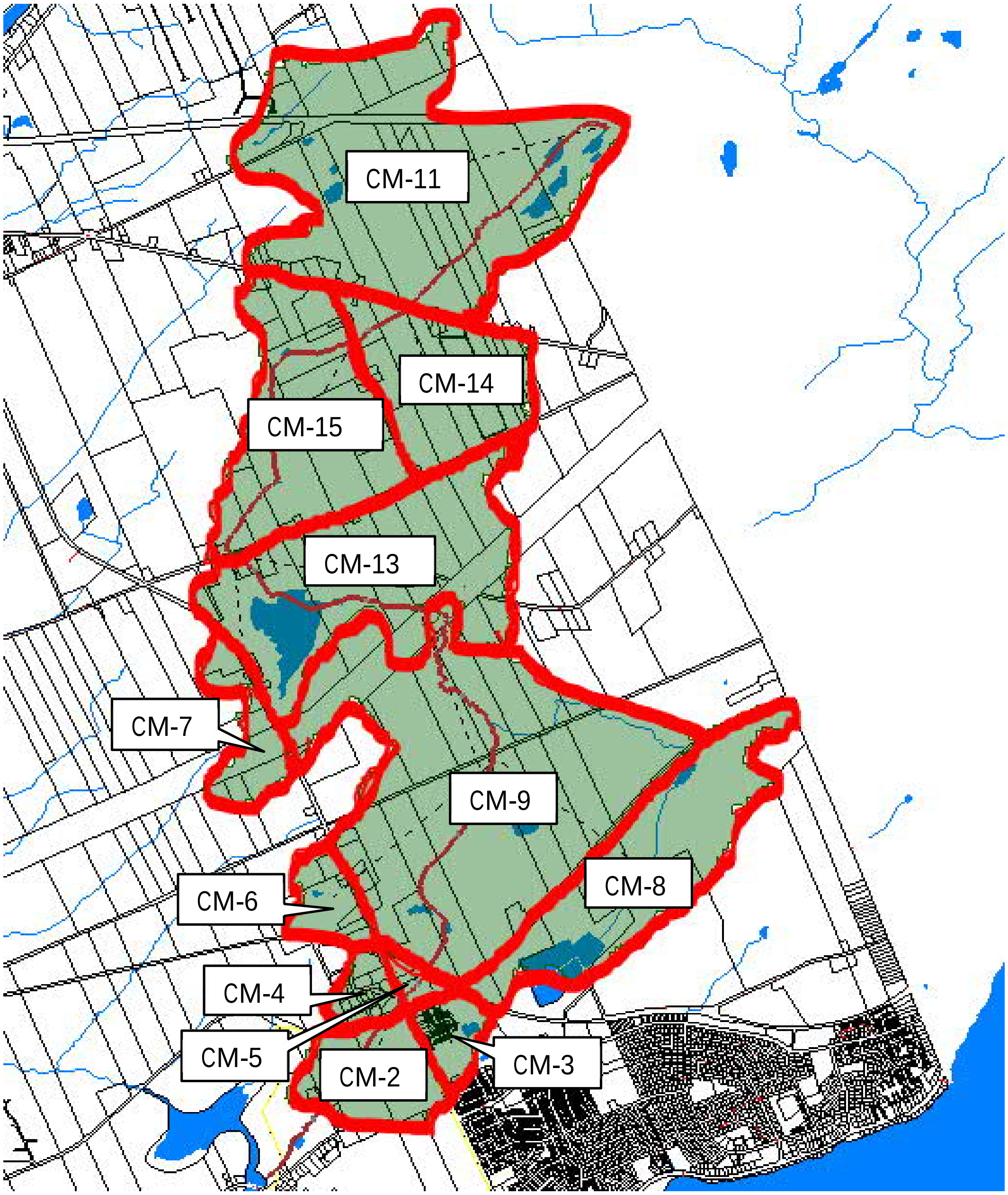


Figure 2 – Lost Creek Watershed Sub-Catchments

	Pre-Development							
	Drainage Areas	Area (Ha)	Mean Slope (m/m)	Existing Building (Ha)	Total Existing Impervious Area (Ha)	Existing % Impervious	Total Existing Pervious Area (Ha)	Existing % Pervious
Area A	CM-2	58.039	0.0396	3.313	3.313	5.71%	54.726	94.29%
Area B	CM-3	24.867	0.044	5.293	5.293	21.29%	19.573	78.71%
Area C	CM-4	20.034	0.05	5.115	5.115	25.53%	14.919	74.47%
Area D	CM-5	8.090	0.065	3.088	3.088	38.18%	5.001	61.82%
Area E	CM-6	26.078	0.066	5.357	5.357	20.54%	20.721	79.46%
Area F	CM-7	33.399	0.029	4.333	4.333	12.97%	29.066	87.03%
Area G	CM-8	145.731	0.026	11.175	11.175	7.67%	134.555	92.33%
Area H	CM-9	385.154	0.085	11.921	11.921	3.10%	373.233	96.90%
Area I	CM-11	311.235	0.029	28.040	28.040	9.01%	283.196	90.99%
Area J	CM-13	210.482	0.037	9.351	9.351	4.44%	201.131	95.56%
Area K	CM-14	104.178	0.031	33.797	33.797	32.44%	70.381	67.56%
Area L	CM-15	155.488	0.03	8.618	8.618	5.54%	146.870	94.46%

Table 1 – Pre-Development Statistics and Inputs – Lost Creek Watershed Sub-Catchments

Table 2 – Pre-Development – Lost Creek Watershed Flow Results (1:2 – 1:100 year)

Runoff Coefficients		
Asphalt, Concrete & roofs	C=	0.90
Granular	C=	0.90
Grassed areas	C=	0.25

Pre-Development – Lost Creek Watershed

AREA 'A'

1:2 Year Storm

Tc= 15 min

Type	Percent	Area (ha)	C	I	Q_2 (L/s)
Pervious	94.3%	54.726	0.25	54.8	2084.87
Asphalt & Concrete	5.7%	3.313	0.90	54.8	454.44
Granular	0.0%	0.000	0.90	54.8	0.00
Building Roof	0.0%	0.000	0.90	54.8	0.00
Total		58.039	0.29 Cw		2539.31

1:5 Year Storm

Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_5 (L/s)
Pervious	94.3%	54.726	0.25	73.0	2776.49
Asphalt & Concrete	5.7%	3.313	0.90	73.0	605.19
Granular	0.0%	0.000	0.90	73.0	0.00
Building Roof	0.0%	0.000	0.90	73.0	0.00
Total		58.039	0.29		3381.68
			Cw		

1:100 Year Storm					
Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_{100} (L/s)
Pervious	94.3%	54.726	0.25	121.5	4620.80
Asphalt & Concrete	5.7%	3.313	0.90	121.5	1007.19
Granular	0.0%	0.000	0.90	121.5	0.00
Building Roof	0.0%	0.000	0.90	121.5	0.00
Total		58.039	0.29		5627.99
			Cw		

AREA 'B'

1:2 Year Storm					
Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_2 (L/s)
Pervious	78.7%	19.573	0.25	54.8	745.68
Asphalt & Concrete	21.3%	5.293	0.90	54.8	725.99
Granular	0.0%	0.000	0.90	54.8	0.00
Building Roof	0.0%	0.000	0.90	54.8	0.00
Total		24.867	0.39		1471.68
			Cw		

1:5 Year Storm					
Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_5 (L/s)
Pervious	78.7%	19.573	0.25	73.0	993.05
Asphalt & Concrete	21.3%	5.293	0.90	73.0	966.83
Granular	0.0%	0.000	0.90	73.0	0.00
Building Roof	0.0%	0.000	0.90	73.0	0.00
Total		24.867	0.39		1959.88
			Cw		

1:100 Year Storm

Tc=	15	min			
Type	Percent	Area (ha)	C	I	Q_{100} (L/s)
Pervious	78.7%	19.573	0.25	121.5	1652.69
Asphalt & Concrete	21.3%	5.293	0.90	121.5	1609.05
Granular	0.0%	0.000	0.90	121.5	0.00
Building Roof	0.0%	0.000	0.90	121.5	0.00
Total		24.867	0.39		3261.75
			Cw		

AREA 'C'

1:2 Year Storm					
Tc=	15	min			
Type	Percent	Area (ha)	C	I	Q_2 (L/s)
Pervious	74.5%	14.919	0.25	54.8	568.38
Asphalt & Concrete	25.5%	5.115	0.90	54.8	701.46
Granular	0.0%	0.000	0.90	54.8	0.00
Building Roof	0.0%	0.000	0.90	54.8	0.00
Total		20.034	0.42		1269.84
			Cw		

1:5 Year Storm					
Tc=	15	min			
Type	Percent	Area (ha)	C	I	Q_5 (L/s)
Pervious	74.5%	14.919	0.25	73.0	756.93
Asphalt & Concrete	25.5%	5.115	0.90	73.0	934.15
Granular	0.0%	0.000	0.90	73.0	0.00
Building Roof	0.0%	0.000	0.90	73.0	0.00
Total		20.034	0.42		1691.09
			Cw		

1:100 Year Storm					
Tc=	15	min			
Type	Percent	Area (ha)	C	I	Q_{100} (L/s)
Pervious	74.5%	14.919	0.25	121.5	1259.73
Asphalt & Concrete	25.5%	5.115	0.90	121.5	1554.67
Granular	0.0%	0.000	0.90	121.5	0.00
Building Roof	0.0%	0.000	0.90	121.5	0.00
Total		20.034	0.42		2814.41
			Cw		

AREA 'D'

1:2 Year Storm					
Tc=	15	min			
Type	Percent	Area (ha)	C	I	Q_2 (L/s)
Pervious	61.8%	5.001	0.25	54.8	190.54
Asphalt & Concrete	38.2%	3.088	0.90	54.8	423.57
Granular	0.0%	0.000	0.90	54.8	0.00
Building Roof	0.0%	0.000	0.90	54.8	0.00
Total		8.090	0.50		614.11
			Cw		

1:5 Year Storm					
Tc=	15	min			
Type	Percent	Area (ha)	C	I	Q_5 (L/s)
Pervious	61.8%	5.001	0.25	73.0	253.74
Asphalt & Concrete	38.2%	3.088	0.90	73.0	564.08
Granular	0.0%	0.000	0.90	73.0	0.00
Building Roof	0.0%	0.000	0.90	73.0	0.00
Total		8.090	0.50		817.82
			Cw		

1:100 Year Storm					
Tc=	15	min			
Type	Percent	Area (ha)	C	I	Q_{100} (L/s)
Pervious	61.8%	5.001	0.25	121.5	422.29
Asphalt & Concrete	38.2%	3.088	0.90	121.5	938.78
Granular	0.0%	0.000	0.90	121.5	0.00
Building Roof	0.0%	0.000	0.90	121.5	0.00
Total		8.090	0.50		1361.07
			Cw		

AREA 'E'

1:2 Year Storm					
Tc=	15	min			
Type	Percent	Area (ha)	C	I	Q_2 (L/s)
Pervious	79.5%	20.721	0.25	54.8	789.40
Asphalt & Concrete	20.5%	5.357	0.90	54.8	734.70
Granular	0.0%	0.000	0.90	54.8	0.00
Building Roof	0.0%	0.000	0.90	54.8	0.00
Total		26.078	0.38		1524.10
			Cw		

1:5 Year Storm					
Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_5 (L/s)
Pervious	79.5%	20.721	0.25	73.0	1051.26
Asphalt & Concrete	20.5%	5.357	0.90	73.0	978.43
Granular	0.0%	0.000	0.90	73.0	0.00
Building Roof	0.0%	0.000	0.90	73.0	0.00
Total		26.078	0.38		2029.69
			Cw		

1:100 Year Storm					
Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_{100} (L/s)
Pervious	79.5%	20.721	0.25	121.5	1749.58
Asphalt & Concrete	20.5%	5.357	0.90	121.5	1628.36
Granular	0.0%	0.000	0.90	121.5	0.00
Building Roof	0.0%	0.000	0.90	121.5	0.00
Total		26.078	0.38		3377.93
			Cw		

AREA 'F'

1:2 Year Storm					
Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_2 (L/s)
Pervious	87.0%	29.066	0.25	54.8	1107.31
Asphalt & Concrete	13.0%	4.333	0.90	54.8	594.28
Granular	0.0%	0.000	0.90	54.8	0.00
Building Roof	0.0%	0.000	0.90	54.8	0.00
Total		33.399	0.33		1701.59
			Cw		

1:5 Year Storm					
Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_5 (L/s)
Pervious	87.0%	29.066	0.25	73.0	1474.64
Asphalt & Concrete	13.0%	4.333	0.90	73.0	791.42
Granular	0.0%	0.000	0.90	73.0	0.00
Building Roof	0.0%	0.000	0.90	73.0	0.00
Total		33.399	0.33		2266.06
			Cw		

1:100 Year Storm					
Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_{100} (L/s)
Pervious	87.0%	29.066	0.25	121.5	2454.18
Asphalt & Concrete	13.0%	4.333	0.90	121.5	1317.13
Granular	0.0%	0.000	0.90	121.5	0.00
Building Roof	0.0%	0.000	0.90	121.5	0.00
Total		33.399	0.33		3771.31
			Cw		

AREA 'G'

1:2 Year Storm					
Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_2 (L/s)
Pervious	92.3%	134.555	0.25	54.8	5126.12
Asphalt & Concrete	7.7%	11.175	0.90	54.8	1532.66
Granular	0.0%	0.000	0.90	54.8	0.00
Building Roof	0.0%	0.000	0.90	54.8	0.00
Total		145.731	0.30		6658.79
			Cw		

1:5 Year Storm					
Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_5 (L/s)
Pervious	92.3%	134.555	0.25	73.0	6826.62
Asphalt & Concrete	7.7%	11.175	0.90	73.0	2041.09
Granular	0.0%	0.000	0.90	73.0	0.00
Building Roof	0.0%	0.000	0.90	73.0	0.00
Total		145.731	0.30		8867.71
			Cw		

1:100 Year Storm					
Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_{100} (L/s)
Pervious	92.3%	134.555	0.25	121.5	11361.27
Asphalt & Concrete	7.7%	11.175	0.90	121.5	3396.91
Granular	0.0%	0.000	0.90	121.5	0.00
Building Roof	0.0%	0.000	0.90	121.5	0.00
Total		145.731	0.30		14758.17
			Cw		

AREA 'H'

1:2 Year Storm					
Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_2 (L/s)
Pervious	96.9%	373.233	0.25	54.8	14218.97
Asphalt & Concrete	3.1%	11.921	0.90	54.8	1635.00
Granular	0.0%	0.000	0.90	54.8	0.00
Building Roof	0.0%	0.000	0.90	54.8	0.00
Total		385.154	0.27		15853.97
			Cw		

1:5 Year Storm					
Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_5 (L/s)
Pervious	96.9%	373.233	0.25	73.0	18935.84
Asphalt & Concrete	3.1%	11.921	0.90	73.0	2177.38
Granular	0.0%	0.000	0.90	73.0	0.00
Building Roof	0.0%	0.000	0.90	73.0	0.00
Total		385.154	0.27		21113.22
			Cw		

1:100 Year Storm					
Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_{100} (L/s)
Pervious	96.9%	373.233	0.25	121.5	31514.16
Asphalt & Concrete	3.1%	11.921	0.90	121.5	3623.73
Granular	0.0%	0.000	0.90	121.5	0.00
Building Roof	0.0%	0.000	0.90	121.5	0.00
Total		385.154	0.27		35137.89
			Cw		

AREA 'I'

1:2 Year Storm					
Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_2 (L/s)
Pervious	91.0%	283.196	0.25	54.8	10788.84
Asphalt & Concrete	9.0%	28.040	0.90	54.8	3845.57
Granular	0.0%	0.000	0.90	54.8	0.00
Building Roof	0.0%	0.000	0.90	54.8	0.00

Total		311.235	0.31		14634.41
			Cw		

1:5 Year Storm					
Tc=	15	min			
Type	Percent	Area (ha)	C	I	Q_5 (L/s)
Pervious	91.0%	283.196	0.25	73.0	14367.83
Asphalt & Concrete	9.0%	28.040	0.90	73.0	5121.27
Granular	0.0%	0.000	0.90	73.0	0.00
Building Roof	0.0%	0.000	0.90	73.0	0.00
Total		311.235	0.31		19489.09
			Cw		

1:100 Year Storm					
Tc=	15	min			
Type	Percent	Area (ha)	C	I	Q_{100} (L/s)
Pervious	91.0%	283.196	0.25	121.5	23911.80
Asphalt & Concrete	9.0%	28.040	0.90	121.5	8523.12
Granular	0.0%	0.000	0.90	121.5	0.00
Building Roof	0.0%	0.000	0.90	121.5	0.00
Total		311.235	0.31		32434.91
			Cw		

AREA 'J'

1:2 Year Storm					
Tc=	15	min			
Type	Percent	Area (ha)	C	I	Q_2 (L/s)
Pervious	95.6%	201.131	0.25	54.8	7662.43
Asphalt & Concrete	4.4%	9.351	0.90	54.8	1282.51
Granular	0.0%	0.000	0.90	54.8	0.00
Building Roof	0.0%	0.000	0.90	54.8	0.00
Total		210.482	0.28		8944.95
			Cw		

1:5 Year Storm					
Tc=	15	min			
Type	Percent	Area (ha)	C	I	Q_5 (L/s)
Pervious	95.6%	201.131	0.25	73.0	10204.30
Asphalt & Concrete	4.4%	9.351	0.90	73.0	1707.96
Granular	0.0%	0.000	0.90	73.0	0.00
Building Roof	0.0%	0.000	0.90	73.0	0.00

Total		210.482	0.28		11912.26
			Cw		

1:100 Year Storm					
Tc=	15	min			
Type	Percent	Area (ha)	C	I	Q_{100} (L/s)
Pervious	95.6%	201.131	0.25	121.5	16982.61
Asphalt & Concrete	4.4%	9.351	0.90	121.5	2842.49
Granular	0.0%	0.000	0.90	121.5	0.00
Building Roof	0.0%	0.000	0.90	121.5	0.00
Total		210.482	0.28		19825.10
			Cw		

AREA 'K'

1:2 Year Storm					
Tc=	15	min			
Type	Percent	Area (ha)	C	I	Q_2 (L/s)
Pervious	67.6%	70.381	0.25	54.8	2681.27
Asphalt & Concrete	32.4%	33.797	0.90	54.8	4635.21
Granular	0.0%	0.000	0.90	54.8	0.00
Building Roof	0.0%	0.000	0.90	54.8	0.00
Total		104.178	0.46		7316.49
			Cw		

1:5 Year Storm					
Tc=	15	min			
Type	Percent	Area (ha)	C	I	Q_5 (L/s)
Pervious	67.6%	70.381	0.25	73.0	3570.73
Asphalt & Concrete	32.4%	33.797	0.90	73.0	6172.86
Granular	0.0%	0.000	0.90	73.0	0.00
Building Roof	0.0%	0.000	0.90	73.0	0.00
Total		104.178	0.46		9743.59
			Cw		

1:100 Year Storm					
Tc=	15	min			
Type	Percent	Area (ha)	C	I	Q_{100} (L/s)
Pervious	67.6%	70.381	0.25	121.5	5942.63
Asphalt & Concrete	32.4%	33.797	0.90	121.5	10273.24
Granular	0.0%	0.000	0.90	121.5	0.00
Building Roof	0.0%	0.000	0.90	121.5	0.00

Total		104.178	0.46		16215.87
			Cw		

AREA 'L'

1:2 Year Storm Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_2 (L/s)
Pervious	94.5%	146.870	0.25	54.8	5595.29
Asphalt & Concrete	5.5%	8.618	0.90	54.8	1181.88
Granular	0.0%	0.000	0.90	54.8	0.00
Building Roof	0.0%	0.000	0.90	54.8	0.00
Total		155.488	0.29		6777.17
			Cw		

1:5 Year Storm Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_5 (L/s)
Pervious	94.5%	146.870	0.25	73.0	7451.42
Asphalt & Concrete	5.5%	8.618	0.90	73.0	1573.95
Granular	0.0%	0.000	0.90	73.0	0.00
Building Roof	0.0%	0.000	0.90	73.0	0.00
Total		155.488	0.29		9025.36
			Cw		

1:100 Year Storm Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_{100} (L/s)
Pervious	94.5%	146.870	0.25	121.5	12401.09
Asphalt & Concrete	5.5%	8.618	0.90	121.5	2619.46
Granular	0.0%	0.000	0.90	121.5	0.00
Building Roof	0.0%	0.000	0.90	121.5	0.00
Total		155.488	0.29		15020.55
			Cw		

Table 3 – Lost Creek Transect Model Data – Part 1

Transect #	Transect Location	Station 1	Elev #1 (m)	Station 2	Elev #2 (m)	Station 3	Elev #3 (m)	Station 4	Elev #4 (m)
1	MH-514 to MH-517 (CO-529)	0	87.61	4.7	87.43	9.3	87.17	14.4	86.9
2	MH-498 to MH-497 (CO-510)	0	88.75	4.9	88.76	9.6	88.69	13	88.73
3	MH-454 to MH 457 (CO-465)	0	93.04	5.8	92.61	10.9	92.19	15.4	91.78
4	MH-419 to MH-422 (CO-429)	0	95.83	4	95.22	8.9	94.9	13.6	94.65
5	MH-385-MH-386 (CO-389)	0	99.54	6.4	99.46	12.7	99.34	17.6	99.15
6	MH-265 to MH-268 (CO-272)	0	107	4.1	106.84	8.2	106.72	11.8	106.44
7	MH-249 to MH-252 (CO-151)	0	109.26	3.6	109.32	7.7	109.26	11.5	108.88
8	MH-201 to MH-200	0	116.22	2.7	116.24	5.3	116.23	7.4	115.93

	(CO-202)								
9	MH-174 to MH-175 (CO-171)	0	124.69	2.7	124.45	6.4	124.54	9.2	124.53
10	MH-157 to MH-160 (CO-154)	0	126.82	4.2	126.67	8.5	126.61	12.6	126.58
11	MH-111 to MH-112 (CO-106)	0	130.74	4.7	130.6	9	130.4	12.8	130.32
12	MH-508 to MH-581 (CO-37)	0	132.57	2.7	131.86	5.4	130.72	8.1	130.68

Table 4 – Lost Creek Transect Model Data – Part 2

Transect #	Transect Location	Station 5	Elev #5 (m)	Station 6	Elev #6 (m)	Station 7	Elev #7 (m)	Range of Conduit Given Same Characteristics:
1	MH-514 to MH-517 (CO-529)	20.9	87.09	27.2	87.6	34.5	87.75	CO-522 to CO-561
2	MH-498 to MH-497 (CO-510)	16.9	88.78	21	88.85	24.2	88.95	CO-491 to CO-521
3	MH-454 to MH 457 (CO-465)	20.8	92.4	26.3	92.81	33	93.19	CO-461 to CO-490
4	MH-419 to MH-422	18.6	94.67	23.4	94.82	28.2	94.88	CO-418 to CO-460

	(CO-429)							
5	MH-385-MH-386 (CO-389)	23.5	99.61	29.1	100.01	35.4	100.45	CO-324 to CO-417
6	MH-265 to MH-268 (CO-272)	15.6	106.99	19.6	107	23.7	107	CO-266 to CO-323
7	MH-249 to MH-252 (CO-151)	15.7	108.47	20	108.75	24.2	109.04	CO-238 to CO-265
8	MH-201 to MH-200 (CO-202)	10.2	115.78	13.1	116.37	15.7	116.29	CO-183 to CO-237
9	MH-174 to MH-175 (CO-171)	12.4	124.62	15.8	124.64	19	124.66	CO-157 to CO-182
10	MH-157 to MH-160 (CO-154)	17.8	126.59	23.3	126.6	28	126.64	CO-149 to CO-156
11	MH-111 to MH-112 (CO-106)	17.4	130.62	21.7	130.54	25.7	130.59	CO-59 to CO-148
12	MH-508 to MH-581 (CO-37)	11	131.54	14.8	131.48	18.2	131.61	CO-32 to CO-58

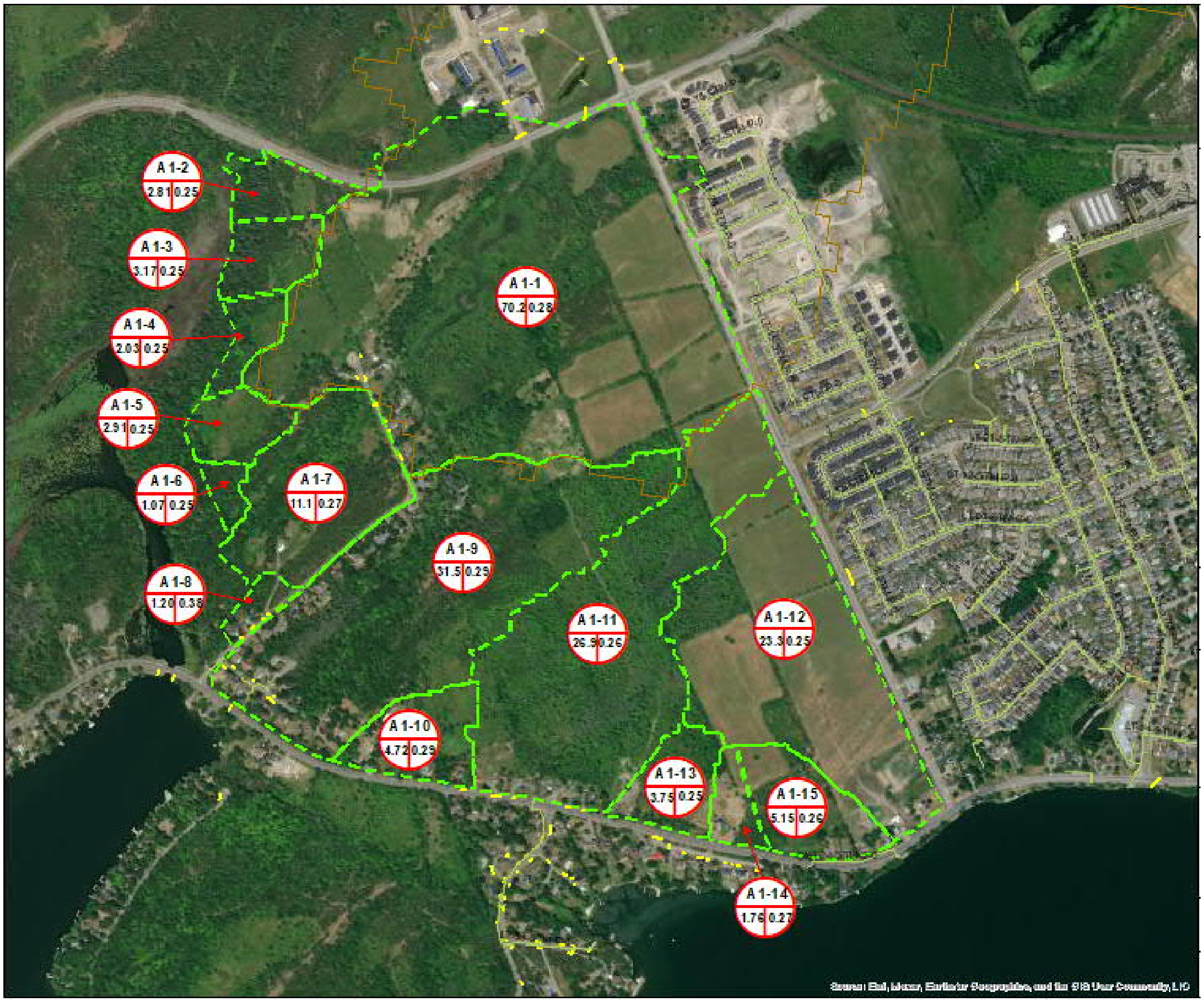


Figure 3 – Amherstview West Secondary Plan Pre-Development Sub-Catchments

Table 5 – Pre-Development Statistics and Inputs – Amherstview West Secondary Plan Sub-Catchments – Existing Conditions

Pre-Development								
Drainage Areas	Area (Ha)	Existing Asphalt & Concrete Area (Ha)	Existing Granular Area (Ha)	Existing Building (Ha)	Total Existing Impervious Area (Ha)	Existing % Impervious	Total Existing Pervious Area (Ha)	Existing % Pervious
A1-1	70.158	2.272	0.388	0.155	2.815	4%	67.343	96%
A1-2	2.813	0.000	0.000	0.000	0.000	0%	2.813	100%
A1-3	3.171	0.000	0.000	0.000	0.000	0%	3.171	100%
A1-4	2.027	0.000	0.000	0.000	0.000	0%	2.027	100%
A1-5	2.911	0.000	0.000	0.000	0.000	0%	2.911	100%
A1-6	1.068	0.000	0.000	0.000	0.000	0%	1.068	100%
A1-7	11.129	0.266	0.000	0.025	0.291	3%	10.838	97%
A1-8	1.201	0.171	0.000	0.076	0.246	21%	0.955	79%
A1-9	31.533	1.076	0.022	0.910	2.007	6%	29.525	94%
A1-10	4.723	0.138	0.000	0.170	0.308	7%	4.415	93%
A1-11	26.891	0.163	0.000	0.195	0.358	1%	26.533	99%
A1-12	23.303	0.060	0.000	0.101	0.161	1%	23.143	99%
A1-13	3.747	0.000	0.000	0.000	0.000	0%	3.747	100%
A1-14	1.765	0.019	0.000	0.024	0.043	2%	1.723	98%
A1-15	5.149	0.043	0.000	0.071	0.114	2%	5.035	98%

Table 6 – Pre-Development – Amherstview West Secondary Plan Sub-Catchments (1:2 – 1:100 year) – Existing Conditions

Pre-Development – Existing Conditions

AREA 'A1-1'

1:2 Year Storm

Tc= 15 min

Type	Percent	Area (ha)	C	I	Q_2 (L/s)
Pervious	96.0%	67.343	0.25	54.8	2565.54
Asphalt & Concrete	3.2%	2.272	0.90	54.8	311.63
Granular	0.6%	0.388	0.90	54.8	53.23
Building Roof	0.2%	0.155	0.90	54.8	21.24
Total		70.158	0.28		2951.64
			Cw		

1:5 Year Storm

Tc= 15 min

Type	Percent	Area (ha)	C	I	Q_5 (L/s)
Pervious	96.0%	67.343	0.25	73.0	3416.61
Asphalt & Concrete	3.2%	2.272	0.90	73.0	415.01
Granular	0.6%	0.388	0.90	73.0	70.88
Building Roof	0.2%	0.155	0.90	73.0	28.29
Total		70.158	0.28 Cw		3930.79

1:100 Year Storm

Tc= 15 min

Type	Percent	Area (ha)	C	I	Q_{100} (L/s)
Pervious	96.0%	67.343	0.25	121.5	5686.12
Asphalt & Concrete	3.2%	2.272	0.90	121.5	690.69
Granular	0.6%	0.388	0.90	121.5	117.97
Building Roof	0.2%	0.155	0.90	121.5	47.08
Total		70.158	0.28 Cw		6541.86

AREA 'A1-2'

1:2 Year Storm

Tc= 15 min

Type	Percent	Area (ha)	C	I	Q_2 (L/s)
Pervious	100.0%	2.813	0.25	54.8	107.17
Asphalt & Concrete	0.0%	0.000	0.90	54.8	0.00
Granular	0.0%	0.000	0.90	54.8	0.00
Building Roof	0.0%	0.000	0.90	54.8	0.00
Total		2.813	0.25 Cw		107.17

1:5 Year Storm

Tc= 15 min

Type	Percent	Area (ha)	C	I	Q_5 (L/s)
Pervious	100.0%	2.813	0.25	73.0	142.73
Asphalt & Concrete	0.0%	0.000	0.90	73.0	0.00
Granular	0.0%	0.000	0.90	73.0	0.00
Building Roof	0.0%	0.000	0.90	73.0	0.00
Total		2.813	0.25 Cw		142.73

1:100 Year Storm

Type	Percent	Area (ha)	C	I	Q_{100} (L/s)
	Tc=	15 min			
Pervious	100.0%	2.813	0.25	121.5	237.53
Asphalt & Concrete	0.0%	0.000	0.90	121.5	0.00
Granular	0.0%	0.000	0.90	121.5	0.00
Building Roof	0.0%	0.000	0.90	121.5	0.00
Total		2.813	0.25		237.53
			Cw		

AREA 'A1-3'

1:2 Year Storm					
	Tc=	15 min			
Type	Percent	Area (ha)	C	I	Q_2 (L/s)
Pervious	100.0%	3.171	0.25	54.8	120.79
Asphalt & Concrete	0.0%	0.000	0.90	54.8	0.00
Granular	0.0%	0.000	0.90	54.8	0.00
Building Roof	0.0%	0.000	0.90	54.8	0.00
Total		3.171	0.25		120.79
			Cw		

1:5 Year Storm					
	Tc=	15 min			
Type	Percent	Area (ha)	C	I	Q_5 (L/s)
Pervious	100.0%	3.171	0.25	73.0	160.86
Asphalt & Concrete	0.0%	0.000	0.90	73.0	0.00
Granular	0.0%	0.000	0.90	73.0	0.00
Building Roof	0.0%	0.000	0.90	73.0	0.00
Total		3.171	0.25		160.86
			Cw		

1:100 Year Storm					
	Tc=	15 min			
Type	Percent	Area (ha)	C	I	Q_{100} (L/s)
Pervious	100.0%	3.171	0.25	121.5	267.71
Asphalt & Concrete	0.0%	0.000	0.90	121.5	0.00
Granular	0.0%	0.000	0.90	121.5	0.00
Building Roof	0.0%	0.000	0.90	121.5	0.00
Total		3.171	0.25		267.71
			Cw		

AREA 'A1-4'

1:2 Year Storm Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_2 (L/s)
Pervious	100.0%	2.027	0.25	54.8	77.24
Asphalt & Concrete	0.0%	0.000	0.90	54.8	0.00
Granular	0.0%	0.000	0.90	54.8	0.00
Building Roof	0.0%	0.000	0.90	54.8	0.00
Total		2.027	0.25		77.24
			Cw		

1:5 Year Storm Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_5 (L/s)
Pervious	100.0%	2.027	0.25	73.0	102.86
Asphalt & Concrete	0.0%	0.000	0.90	73.0	0.00
Granular	0.0%	0.000	0.90	73.0	0.00
Building Roof	0.0%	0.000	0.90	73.0	0.00
Total		2.027	0.25		102.86
			Cw		

1:100 Year Storm Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_{100} (L/s)
Pervious	100.0%	2.027	0.25	121.5	171.18
Asphalt & Concrete	0.0%	0.000	0.90	121.5	0.00
Granular	0.0%	0.000	0.90	121.5	0.00
Building Roof	0.0%	0.000	0.90	121.5	0.00
Total		2.027	0.25		171.18
			Cw		

AREA 'A1-5'

1:2 Year Storm Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_2 (L/s)
Pervious	100.0%	2.911	0.25	54.8	110.91
Asphalt & Concrete	0.0%	0.000	0.90	54.8	0.00
Granular	0.0%	0.000	0.90	54.8	0.00
Building Roof	0.0%	0.000	0.90	54.8	0.00
Total		2.911	0.25		110.91
			Cw		

1:5 Year Storm Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_5 (L/s)
Pervious	100.0%	2.911	0.25	73.0	147.70
Asphalt & Concrete	0.0%	0.000	0.90	73.0	0.00
Granular	0.0%	0.000	0.90	73.0	0.00
Building Roof	0.0%	0.000	0.90	73.0	0.00
Total		2.911	0.25 Cw		147.70

1:100 Year Storm Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_{100} (L/s)
Pervious	100.0%	2.911	0.25	121.5	245.82
Asphalt & Concrete	0.0%	0.000	0.90	121.5	0.00
Granular	0.0%	0.000	0.90	121.5	0.00
Building Roof	0.0%	0.000	0.90	121.5	0.00
Total		2.911	0.25 Cw		245.82

AREA 'A1-6'

1:2 Year Storm Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_2 (L/s)
Pervious	100.0%	1.068	0.25	54.8	40.69
Asphalt & Concrete	0.0%	0.000	0.90	54.8	0.00
Granular	0.0%	0.000	0.90	54.8	0.00
Building Roof	0.0%	0.000	0.90	54.8	0.00
Total		1.068	0.25 Cw		40.69

1:5 Year Storm Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_5 (L/s)
Pervious	100.0%	1.068	0.25	73.0	54.19
Asphalt & Concrete	0.0%	0.000	0.90	73.0	0.00
Granular	0.0%	0.000	0.90	73.0	0.00
Building Roof	0.0%	0.000	0.90	73.0	0.00
Total		1.068	0.25 Cw		54.19

1:100 Year Storm					
Tc=	15 min				
Type	Percent	Area (ha)	C	I	Q_{100} (L/s)
Pervious	100.0%	1.068	0.25	121.5	90.19
Asphalt & Concrete	0.0%	0.000	0.90	121.5	0.00
Granular	0.0%	0.000	0.90	121.5	0.00
Building Roof	0.0%	0.000	0.90	121.5	0.00
Total		1.068	0.25		90.19
			Cw		

AREA 'A1-7'

1:2 Year Storm					
Tc=	15 min				
Type	Percent	Area (ha)	C	I	Q_2 (L/s)
Pervious	97.4%	10.838	0.25	54.8	412.91
Asphalt & Concrete	2.4%	0.266	0.90	54.8	36.52
Granular	0.0%	0.000	0.90	54.8	0.00
Building Roof	0.2%	0.025	0.90	54.8	3.38
Total		11.129	0.27		452.81
			Cw		

1:5 Year Storm					
Tc=	15 min				
Type	Percent	Area (ha)	C	I	Q_5 (L/s)
Pervious	97.4%	10.838	0.25	73.0	549.89
Asphalt & Concrete	2.4%	0.266	0.90	73.0	48.64
Granular	0.0%	0.000	0.90	73.0	0.00
Building Roof	0.2%	0.025	0.90	73.0	4.50
Total		11.129	0.27		603.02
			Cw		

1:100 Year Storm					
Tc=	15 min				
Type	Percent	Area (ha)	C	I	Q_{100} (L/s)
Pervious	97.4%	10.838	0.25	121.5	915.15
Asphalt & Concrete	2.4%	0.266	0.90	121.5	80.95
Granular	0.0%	0.000	0.90	121.5	0.00
Building Roof	0.2%	0.025	0.90	121.5	7.49
Total		11.129	0.27		1003.59
			Cw		

AREA 'A1-8'

1:2 Year Storm Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_2 (L/s)
Pervious	79.5%	0.955	0.25	54.8	36.38
Asphalt & Concrete	14.2%	0.171	0.90	54.8	23.39
Granular	0.0%	0.000	0.90	54.8	0.00
Building Roof	6.3%	0.076	0.90	54.8	10.40
Total		1.201	0.38		70.17
			Cw		

1:5 Year Storm Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_5 (L/s)
Pervious	79.5%	0.955	0.25	73.0	48.45
Asphalt & Concrete	14.2%	0.171	0.90	73.0	31.15
Granular	0.0%	0.000	0.90	73.0	0.00
Building Roof	6.3%	0.076	0.90	73.0	13.85
Total		1.201	0.38		93.45
			Cw		

1:100 Year Storm Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_{100} (L/s)
Pervious	79.5%	0.955	0.25	121.5	80.63
Asphalt & Concrete	14.2%	0.171	0.90	121.5	51.84
Granular	0.0%	0.000	0.90	121.5	0.00
Building Roof	6.3%	0.076	0.90	121.5	23.05
Total		1.201	0.38		155.52
			Cw		

AREA 'A1-9'

1:2 Year Storm Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_2 (L/s)
Pervious	93.6%	29.525	0.25	54.8	1124.83
Asphalt & Concrete	3.4%	1.076	0.90	54.8	147.52
Granular	0.1%	0.022	0.90	54.8	2.97
Building Roof	2.9%	0.910	0.90	54.8	124.82

Total		31.533	0.29		1400.14
			Cw		

1:5 Year Storm					
Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_5 (L/s)
Pervious	93.6%	29.525	0.25	73.0	1497.96
Asphalt & Concrete	3.4%	1.076	0.90	73.0	196.46
Granular	0.1%	0.022	0.90	73.0	3.96
Building Roof	2.9%	0.910	0.90	73.0	166.22
Total		31.533	0.29		1864.61
			Cw		

1:100 Year Storm					
Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_{100} (L/s)
Pervious	93.6%	29.525	0.25	121.5	2493.00
Asphalt & Concrete	3.4%	1.076	0.90	121.5	326.97
Granular	0.1%	0.022	0.90	121.5	6.58
Building Roof	2.9%	0.910	0.90	121.5	276.64
Total		31.533	0.29		3103.19
			Cw		

AREA 'A1-10'

1:2 Year Storm					
Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_2 (L/s)
Pervious	93.5%	4.415	0.25	54.8	168.21
Asphalt & Concrete	2.9%	0.138	0.90	54.8	18.98
Granular	0.0%	0.000	0.90	54.8	0.00
Building Roof	3.6%	0.170	0.90	54.8	23.28
Total		4.723	0.29		210.47
			Cw		

1:5 Year Storm					
Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_5 (L/s)
Pervious	93.5%	4.415	0.25	73.0	224.01
Asphalt & Concrete	2.9%	0.138	0.90	73.0	25.28
Granular	0.0%	0.000	0.90	73.0	0.00
Building Roof	3.6%	0.170	0.90	73.0	31.00

Total		4.723	0.29		280.28
			Cw		

1:100 Year Storm Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_{100} (L/s)
Pervious	93.5%	4.415	0.25	121.5	372.81
Asphalt & Concrete	2.9%	0.138	0.90	121.5	42.07
Granular	0.0%	0.000	0.90	121.5	0.00
Building Roof	3.6%	0.170	0.90	121.5	51.59
Total		4.723	0.29		466.47
			Cw		

AREA 'A1-11'

1:2 Year Storm Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_2 (L/s)
Pervious	98.7%	26.533	0.25	54.8	1010.82
Asphalt & Concrete	0.6%	0.163	0.90	54.8	22.37
Granular	0.0%	0.000	0.90	54.8	0.00
Building Roof	0.7%	0.195	0.90	54.8	26.74
Total		26.891	0.26		1059.93
			Cw		

1:5 Year Storm Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_5 (L/s)
Pervious	98.7%	26.533	0.25	73.0	1346.14
Asphalt & Concrete	0.6%	0.163	0.90	73.0	29.79
Granular	0.0%	0.000	0.90	73.0	0.00
Building Roof	0.7%	0.195	0.90	73.0	35.62
Total		26.891	0.26		1411.55
			Cw		

1:100 Year Storm Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_{100} (L/s)
Pervious	98.7%	26.533	0.25	121.5	2240.33
Asphalt & Concrete	0.6%	0.163	0.90	121.5	49.58
Granular	0.0%	0.000	0.90	121.5	0.00
Building Roof	0.7%	0.195	0.90	121.5	59.27

Total		26.891	0.26		2349.18
			Cw		

AREA 'A1-12'

1:2 Year Storm Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_2 (L/s)
Pervious	99.3%	23.143	0.25	54.8	881.66
Asphalt & Concrete	0.3%	0.060	0.90	54.8	8.25
Granular	0.0%	0.000	0.90	54.8	0.00
Building Roof	0.4%	0.101	0.90	54.8	13.79
Total		23.303	0.25		903.70
			Cw		

1:5 Year Storm Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_5 (L/s)
Pervious	99.3%	23.143	0.25	73.0	1174.13
Asphalt & Concrete	0.3%	0.060	0.90	73.0	10.98
Granular	0.0%	0.000	0.90	73.0	0.00
Building Roof	0.4%	0.101	0.90	73.0	18.37
Total		23.303	0.25		1203.48
			Cw		

1:100 Year Storm Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_{100} (L/s)
Pervious	99.3%	23.143	0.25	121.5	1954.06
Asphalt & Concrete	0.3%	0.060	0.90	121.5	18.27
Granular	0.0%	0.000	0.90	121.5	0.00
Building Roof	0.4%	0.101	0.90	121.5	30.57
Total		23.303	0.25		2002.91
			Cw		

AREA 'A1-13'

1:2 Year Storm Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_2 (L/s)
Pervious	100.0%	3.747	0.25	54.8	142.75
Asphalt & Concrete	0.0%	0.000	0.90	54.8	0.00

Granular	0.0%	0.000	0.90	54.8	0.00
Building Roof	0.0%	0.000	0.90	54.8	0.00
Total		3.747	0.25		142.75
			Cw		

1:5 Year Storm Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_5 (L/s)
Pervious	100.0%	3.747	0.25	73.0	190.10
Asphalt & Concrete	0.0%	0.000	0.90	73.0	0.00
Granular	0.0%	0.000	0.90	73.0	0.00
Building Roof	0.0%	0.000	0.90	73.0	0.00
Total		3.747	0.25		190.10
			Cw		

1:100 Year Storm Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_{100} (L/s)
Pervious	100.0%	3.747	0.25	121.5	316.38
Asphalt & Concrete	0.0%	0.000	0.90	121.5	0.00
Granular	0.0%	0.000	0.90	121.5	0.00
Building Roof	0.0%	0.000	0.90	121.5	0.00
Total		3.747	0.25		316.38
			Cw		

AREA 'A1-14'

1:2 Year Storm Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_2 (L/s)
Pervious	97.6%	1.723	0.25	54.8	65.63
Asphalt & Concrete	1.1%	0.019	0.90	54.8	2.55
Granular	0.0%	0.000	0.90	54.8	0.00
Building Roof	1.4%	0.024	0.90	54.8	3.32
Total		1.765	0.27		71.50
			Cw		

1:5 Year Storm Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_5 (L/s)
Pervious	97.6%	1.723	0.25	73.0	87.40
Asphalt & Concrete	1.1%	0.019	0.90	73.0	3.40

Granular	0.0%	0.000	0.90	73.0	0.00
Building Roof	1.4%	0.024	0.90	73.0	4.42
Total		1.765	0.27		95.21
			Cw		

1:100 Year Storm					
Tc=	15 min				
Type	Percent	Area (ha)	C	I	Q_{100} (L/s)
Pervious	97.6%	1.723	0.25	121.5	145.45
Asphalt & Concrete	1.1%	0.019	0.90	121.5	5.65
Granular	0.0%	0.000	0.90	121.5	0.00
Building Roof	1.4%	0.024	0.90	121.5	7.36
Total		1.765	0.27		158.46
			Cw		

AREA 'A1-15'

1:2 Year Storm					
Tc=	15 min				
Type	Percent	Area (ha)	C	I	Q_2 (L/s)
Pervious	97.8%	5.035	0.25	54.8	191.83
Asphalt & Concrete	0.8%	0.043	0.90	54.8	5.87
Granular	0.0%	0.000	0.90	54.8	0.00
Building Roof	1.4%	0.071	0.90	54.8	9.71
Total		5.149	0.26		207.41
			Cw		

1:5 Year Storm					
Tc=	15 min				
Type	Percent	Area (ha)	C	I	Q_5 (L/s)
Pervious	97.8%	5.035	0.25	73.0	255.47
Asphalt & Concrete	0.8%	0.043	0.90	73.0	7.82
Granular	0.0%	0.000	0.90	73.0	0.00
Building Roof	1.4%	0.071	0.90	73.0	12.93
Total		5.149	0.26		276.22
			Cw		

1:100 Year Storm					
Tc=	15 min				
Type	Percent	Area (ha)	C	I	Q_{100} (L/s)
Pervious	97.8%	5.035	0.25	121.5	425.17
Asphalt & Concrete	0.8%	0.043	0.90	121.5	13.01

Granular	0.0%	0.000	0.90	121.5	0.00
Building Roof	1.4%	0.071	0.90	121.5	21.52
Total		5.149	0.26		459.70
			Cw		

Table 7 – Single Event Climate Change Model Output Flows - Amherstview West Secondary Plan Sub-Catchments (1:2 year - 1:100 + 20% year) – Existing Conditions

Drainage Areas	Area (Ha)	1:2 Year (L/s)	1:5 Year (L/s)	1:100 Year (L/s)	1:00 Year + 20% (L/s)
A1-1[1]	70.158	2951.64	3930.79	6541.86	7850.23
A1-2	2.813	107.17	142.73	237.53	285.04
A1-3	3.171	120.79	160.79	267.71	321.25
A1-4	2.027	77.24	102.86	171.18	205.42
A1-5	2.911	110.91	147.70	245.82	294.98
A1-6	1.068	40.69	54.19	90.19	108.23
A1-7	11.129	452.81	603.02	1003.59	1204.31
A1-8	1.201	70.17	93.45	155.52	186.62
A1-9	31.533	1400.14	1864.61	3103.19	3723.83
A1-10	4.723	210.47	280.28	466.47	559.76
A1-11[2]	26.891	1059.93	1411.55	2349.18	2819.02
A1-12	23.303	903.70	1203.48	2002.91	2403.49
A1-13	3.747	142.75	190.10	316.38	379.66
A1-14	1.765	71.50	95.21	158.46	190.15
A1-15	5.149	207.41	276.22	459.70	551.64

1 – Are Contributes to the Lost Creek Watershed

2 – Area Contributes to the Edgewood Municipal Drain

Post-Development Catchments and Analysis

As detailed in figures 4 and 5, the opportunity to regrade post-development area topography for 25-year development projection conditions was further analyzed to determine the number of centralized SWM facilities and relative flow rates for stormwater runoff collection. The analysis consisted of review of the secondary area post-development catchments areas based on a two-part analysis. The first analysis reviewed the revised area of catchment sizing and use of existing conditions for the analysis of impervious area vs. pervious areas (Areas B1-1 to B1-6). This analysis was used to determine the modified pre-development conditions. The final analysis focused on the projected 25-year development based on the preferred land use concept (Areas C1-1 to C1-2).

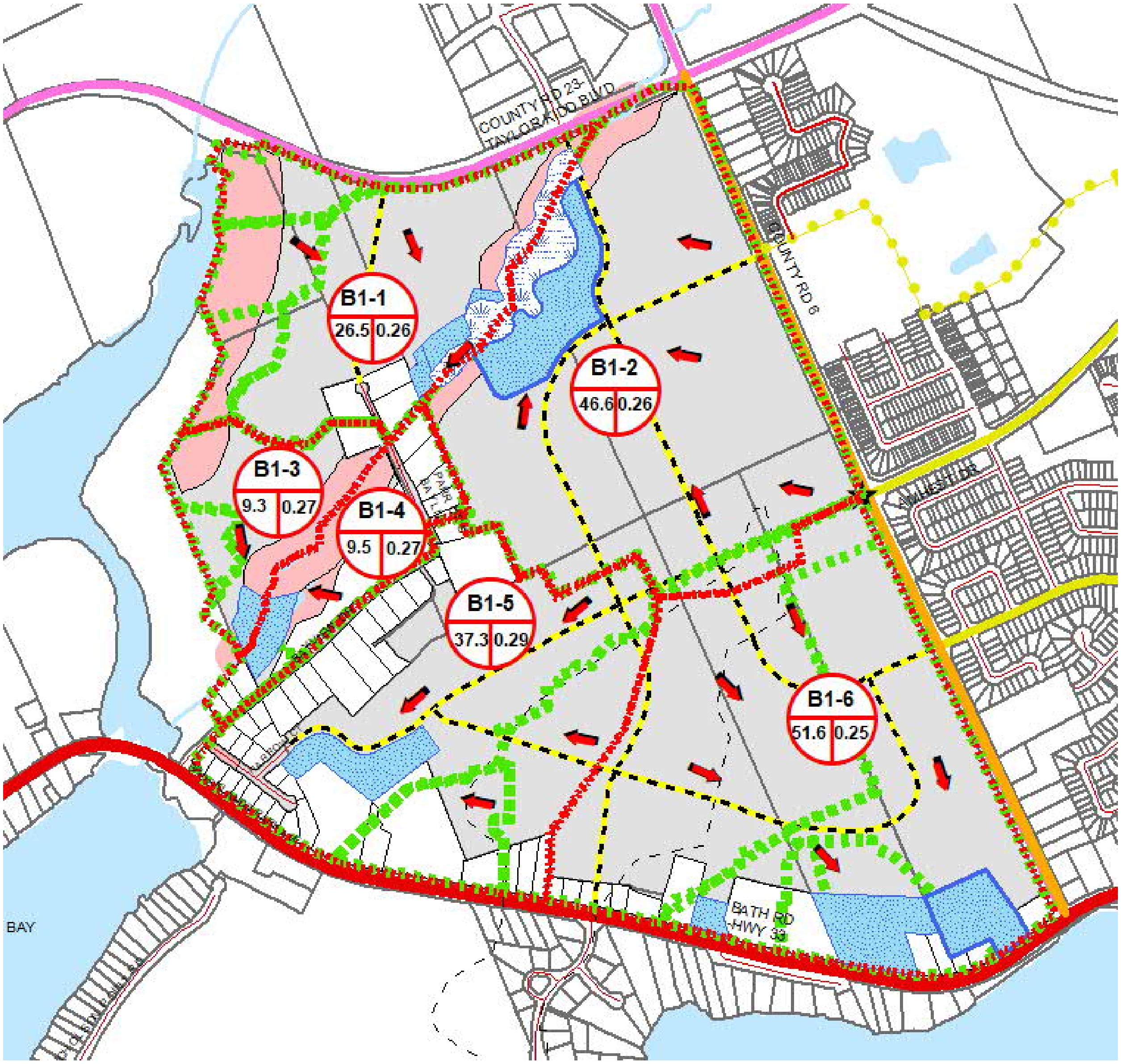


Figure 4 – Amherstview West Secondary Plan Post-Development Sub-Catchments Areas – Existing Conditions

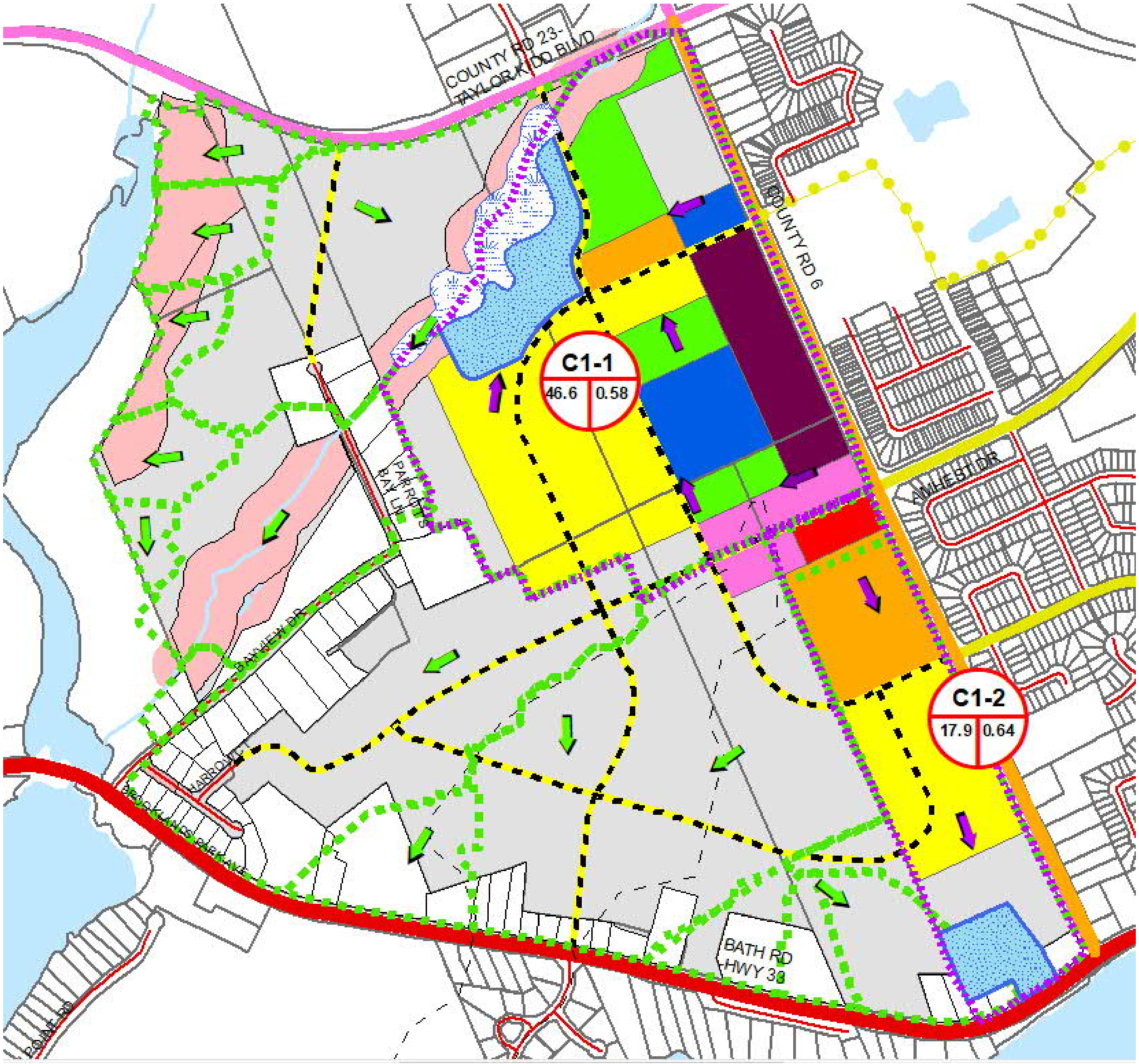


Figure 5 – Amherstview West Secondary Plan Post-Development Sub-Catchments – 25 Year Plan

Table 8 – Pre-Development Statistics and Inputs – Amherstview West Secondary Plan Sub-Catchments – Existing Conditions

Pre-Development Combined Catchments								
Drainage Areas	Area (Ha)	Existing Asphalt & Concrete Area (Ha)	Existing Granular Area (Ha)	Existing Building (Ha)	Total Existing Impervious Area (Ha)	Existing % Impervious	Total Existing Pervious Area (Ha)	Existing % Pervious
B1-1	26.5	0.33	0.25	0.12	0.7	2.6%	25.8	97%
B1-2	46.6	0.00	0.60	0.00	0.6	1.3%	46.0	99%
B1-3	9.3	0.10	0.15	0.05	0.3	3.2%	9.0	97%
B1-4	9.5	0.15	0.11	0.095	0.355	3.8%	9.145	96%
B1-5	37.3	0.95	0.85	0.75	2.55	6.8%	34.75	93%
B1-6	51.6	0.00	0.10	0.20	0.3	0.6%	51.30	99%

Table 9 – Post-Development – Amherstview West Secondary Plan Sub-Catchments (1:2 – 1:100 year) – Existing Conditions

Pre-Development – Combined Catchments – Existing Conditions

AREA 'B1-1'

1:2 Year Storm Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_2 (L/s)
Pervious	97.4%	25.800	0.25	54.8	982.90
Asphalt & Concrete	1.2%	0.330	0.90	54.8	45.26
Granular	0.9%	0.250	0.90	54.8	34.29
Building Roof	0.5%	0.120	0.90	54.8	16.46
Total		26.500	0.27 Cw		1078.90

1:5 Year Storm Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_5 (L/s)
Pervious	97.4%	25.800	0.25	73.0	1308.95
Asphalt & Concrete	1.2%	0.330	0.90	73.0	60.27
Granular	0.9%	0.250	0.90	73.0	45.66
Building Roof	0.5%	0.120	0.90	73.0	21.92
Total		26.500	0.27 Cw		1436.80

1:100 Year Storm Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_{100} (L/s)
Pervious	97.4%	25.800	0.25	121.5	2178.44
Asphalt & Concrete	1.2%	0.330	0.90	121.5	100.31
Granular	0.9%	0.250	0.90	121.5	75.99
Building Roof	0.5%	0.120	0.90	121.5	36.48
Total		26.500	0.27		2391.22
			Cw		

AREA 'B1-2'

1:2 Year Storm Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_2 (L/s)
Pervious	98.7%	46.000	0.25	54.8	1752.45
Asphalt & Concrete	0.0%	0.000	0.90	54.8	0.00
Granular	1.3%	0.600	0.90	54.8	82.29
Building Roof	0.0%	0.000	0.90	54.8	0.00
Total		46.600	0.26		1834.74
			Cw		

1:5 Year Storm Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_5 (L/s)
Pervious	98.7%	46.000	0.25	73.0	2333.79
Asphalt & Concrete	0.0%	0.000	0.90	73.0	0.00
Granular	1.3%	0.600	0.90	73.0	109.59
Building Roof	0.0%	0.000	0.90	73.0	0.00
Total		46.600	0.26		2443.38
			Cw		

1:100 Year Storm Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_{100} (L/s)
Pervious	98.7%	46.000	0.25	121.5	3884.04
Asphalt & Concrete	0.0%	0.000	0.90	121.5	0.00
Granular	1.3%	0.600	0.90	121.5	182.38
Building Roof	0.0%	0.000	0.90	121.5	0.00
Total		46.600	0.26		4066.42
			Cw		

AREA 'B1-3'

1:2 Year Storm					
Tc=	15 min				
Type	Percent	Area (ha)	C	I	Q_2 (L/s)
Pervious	96.8%	9.000	0.25	54.8	342.87
Asphalt & Concrete	1.1%	0.100	0.90	54.8	13.71
Granular	1.6%	0.150	0.90	54.8	20.57
Building Roof	0.5%	0.050	0.90	54.8	6.86
Total		9.300	0.27		384.02
			Cw		

1:5 Year Storm					
Tc=	15 min				
Type	Percent	Area (ha)	C	I	Q_5 (L/s)
Pervious	96.8%	9.000	0.25	73.0	456.61
Asphalt & Concrete	1.1%	0.100	0.90	73.0	18.26
Granular	1.6%	0.150	0.90	73.0	27.40
Building Roof	0.5%	0.050	0.90	73.0	9.13
Total		9.300	0.27		511.41
			Cw		

1:100 Year Storm					
Tc=	15 min				
Type	Percent	Area (ha)	C	I	Q_{100} (L/s)
Pervious	96.8%	9.000	0.25	121.5	759.92
Asphalt & Concrete	1.1%	0.100	0.90	121.5	30.40
Granular	1.6%	0.150	0.90	121.5	45.60
Building Roof	0.5%	0.050	0.90	121.5	15.20
Total		9.300	0.27		851.11
			Cw		

AREA 'B1-4'

1:2 Year Storm					
Tc=	15 min				
Type	Percent	Area (ha)	C	I	Q_2 (L/s)
Pervious	96.3%	9.145	0.25	54.8	348.39
Asphalt & Concrete	1.6%	0.150	0.90	54.8	20.57
Granular	1.2%	0.110	0.90	54.8	15.09
Building Roof	1.0%	0.095	0.90	54.8	13.03

Total		9.500	0.27		397.08
			Cw		

1:5 Year Storm Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_5 (L/s)
Pervious	96.3%	9.145	0.25	73.0	463.97
Asphalt & Concrete	1.6%	0.150	0.90	73.0	27.40
Granular	1.2%	0.110	0.90	73.0	20.09
Building Roof	1.0%	0.095	0.90	73.0	17.35
Total		9.500	0.27		528.81
			Cw		

1:100 Year Storm Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_{100} (L/s)
Pervious	96.3%	9.145	0.25	121.5	772.16
Asphalt & Concrete	1.6%	0.150	0.90	121.5	45.60
Granular	1.2%	0.110	0.90	121.5	33.44
Building Roof	1.0%	0.095	0.90	121.5	28.88
Total		9.500	0.27		880.07
			Cw		

AREA 'B1-5'

1:2 Year Storm Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_2 (L/s)
Pervious	93.2%	34.750	0.25	54.8	1323.86
Asphalt & Concrete	2.5%	0.950	0.90	54.8	130.29
Granular	2.3%	0.850	0.90	54.8	116.58
Building Roof	2.0%	0.750	0.90	54.8	102.86
Total		37.300	0.29		1673.59
			Cw		

1:5 Year Storm Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_5 (L/s)
Pervious	93.2%	34.750	0.25	73.0	1763.03
Asphalt & Concrete	2.5%	0.950	0.90	73.0	173.51
Granular	2.3%	0.850	0.90	73.0	155.25
Building Roof	2.0%	0.750	0.90	73.0	136.98

Total		37.300	0.29		2228.77
			Cw		

1:100 Year Storm
Tc= 15 min

Type	Percent	Area (ha)	C	I	Q_{100} (L/s)
Pervious	93.2%	34.750	0.25	121.5	2934.14
Asphalt & Concrete	2.5%	0.950	0.90	121.5	288.77
Granular	2.3%	0.850	0.90	121.5	258.37
Building Roof	2.0%	0.750	0.90	121.5	227.98
Total		37.300	0.29		3709.26
			Cw		

AREA 'B1-6'

1:2 Year Storm
Tc= 15 min

Type	Percent	Area (ha)	C	I	Q_2 (L/s)
Pervious	99.4%	51.300	0.25	54.8	1954.36
Asphalt & Concrete	0.0%	0.000	0.90	54.8	0.00
Granular	0.2%	0.100	0.90	54.8	13.71
Building Roof	0.4%	0.200	0.90	54.8	27.43
Total		51.600	0.25		1995.51
			Cw		

1:5 Year Storm
Tc= 15 min

Type	Percent	Area (ha)	C	I	Q_5 (L/s)
Pervious	99.4%	51.300	0.25	73.0	2602.69
Asphalt & Concrete	0.0%	0.000	0.90	73.0	0.00
Granular	0.2%	0.100	0.90	73.0	18.26
Building Roof	0.4%	0.200	0.90	73.0	36.53
Total		51.600	0.25		2657.48
			Cw		

1:100 Year Storm
Tc= 15 min

Type	Percent	Area (ha)	C	I	Q_{100} (L/s)
Pervious	99.4%	51.300	0.25	121.5	4331.55
Asphalt & Concrete	0.0%	0.000	0.90	121.5	0.00
Granular	0.2%	0.100	0.90	121.5	30.40
Building Roof	0.4%	0.200	0.90	121.5	60.79

Total	51.600	0.25 Cw		4422.74

Table 10 – Single Event Climate Change Model Output Flows - Amherstview West Secondary Plan Post-Development Sub-Catchments (1:2 year - 1:100 + 20% year)

Drainage Areas	Area (Ha)	1:2 Year (L/s)	1:5 Year (L/s)	1:100 Year (L/s)	1:00 Year + 20% (L/s)
B1-1	26.5	1078.90	1436.80	2391.22	2869.45
B1-2	46.6	1834.74	2443.38	4066.42	4879.70
B1-3	9.3	384.02	511.41	851.11	1021.33
B1-4	9.5	397.08	528.81	880.07	1056.08
B1-5	37.3	1673.59	228.77	3709.26	4451.11
B1-6	51.6	1995.51	2657.48	4422.74	5307.29

As detailed in figures 4 and 5, the opportunity to regrade post-development area topography for 25-year development projection conditions was further analyzed to determine the number of centralized SWM facilities and relative flow rates for stormwater

Table 11 – Post-Development % Pervious vs. Impervious Assumptions per Land Use Designation - Total Area for 25-Year Development Catchments

	Open Space	Low Density - Residential	Medium Density - Residential	High Density - Residential	Institutional	Mixed-Use Commercial	Highway Commercial
Asphalt & Roofs	5%	50%	60%	80%	50%	75%	80%
Granular	10%	20%	20%	15%	25%	15%	15%
Grassed Areas	85%	30%	20%	5%	25%	10%	5%

1- Based on review of existing properties of similar land use designation in village of Amherstview

Post 25-Year Development – Catchments

Table 12 – Post 25-Year Development – Catchments Statistics and Inputs – Amherstview West Secondary Plan Sub-Catchments

Drainage Areas	Area (Ha)	Post Asphalt & Roof Area (Ha)	Post Granular Area (Ha)	Total Post Impervious Area (Ha)	Post % Impervious	Total Post Pervious Area (Ha)	Post % Pervious
C1-1	46.6	16.5	7.2	23.6	51%	23.0	49%
C1-2	17.9	7.7	3.0	10.7	60%	7.2	63%

Table 13 – Post 25-Year Development – Amherstview West Secondary Plan Sub-Catchments (1:2 – 1:100 year)

Post 25-Year Development – Catchments

AREA 'C1-1'

1:2 Year Storm

Tc= 15 min

Type	Percent	Area (ha)	C	I	Q_2 (L/s)
Pervious	49.3%	22.99	0.25	54.82	875.85
Asphalt & Roofs	35.3%	16.46	0.90	54.82	2257.09
Granular	15.4%	7.16	0.90	54.82	981.87
Total		46.61	0.58		4114.81
			Cw		

1:5 Year Storm

Tc= 15 min

Type	Percent	Area (ha)	C	I	Q_5 (L/s)
Pervious	49.3%	22.99	0.25	73.00	1166.40
Asphalt & Roofs	35.3%	16.46	0.90	73.00	3005.84
Granular	15.4%	7.16	0.90	73.00	1307.59
Total		46.61	0.58		5479.83
			Cw		

1:100 Year Storm

Tc= 15 min

Type	Percent	Area (ha)	C	I	Q_{100} (L/s)
Pervious	49.3%	22.99	0.25	121.49	1941.19
Asphalt & Roofs	35.3%	16.46	0.90	121.49	5002.50
Granular	15.4%	7.16	0.90	121.49	2176.17

Total		46.61	0.58		9119.85
			Cw		

AREA 'C1-2'

1:2 Year Storm Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_2 (L/s)
Pervious	40.1%	7.17	0.25	54.82	273.12
Asphalt & Roofs	43.1%	7.70	0.90	54.82	1056.29
Granular	16.8%	3.00	0.90	54.82	411.51
Total		17.87	0.64		1740.92
			Cw		

1:5 Year Storm Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_5 (L/s)
Pervious	40.1%	7.17	0.25	73.00	363.72
Asphalt & Roofs	43.1%	7.70	0.90	73.00	1406.70
Granular	16.8%	3.00	0.90	73.00	548.02
Total		17.87	0.64		2318.44
			Cw		

1:100 Year Storm Tc= 15 min					
Type	Percent	Area (ha)	C	I	Q_{100} (L/s)
Pervious	40.1%	7.17	0.25	121.49	605.33
Asphalt & Roofs	43.1%	7.70	0.90	121.49	2341.11
Granular	16.8%	3.00	0.90	121.49	912.04
Total		17.87	0.64		3858.49
			Cw		

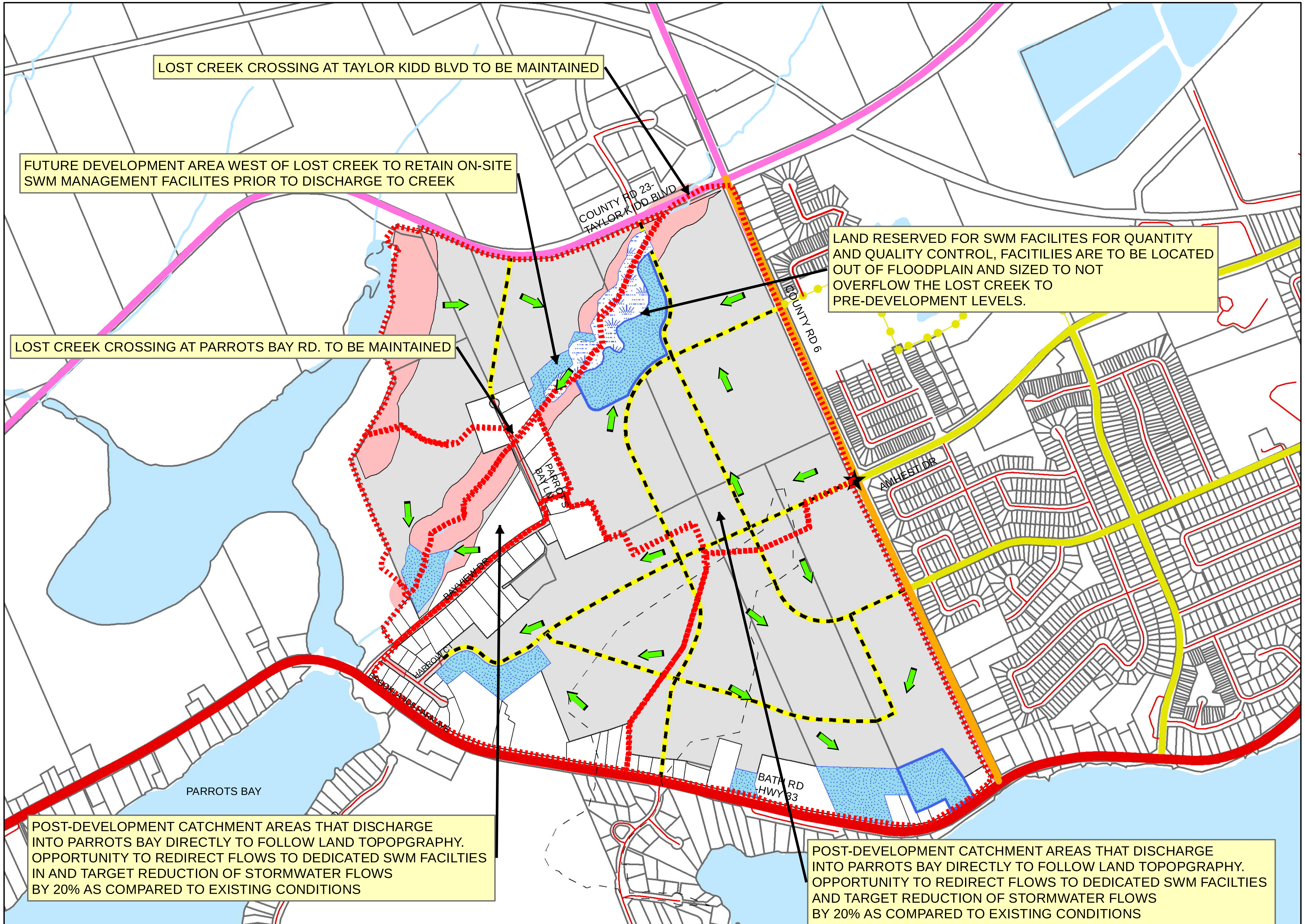
Table 14 – Single Event Climate Change Model Output Flows - Amherstview West Secondary Plan Post-Development Sub-Catchments (1:2 year - 1:100 + 20% year)

Drainage Areas	Area (Ha)	1:2 Year (L/s)	1:5 Year (L/s)	1:100 Year (L/s)	1:00 Year + 20% (L/s)
C1-1	26.5	4114.81	5479.83	9119.85	10943.82
C1-2	17.9	1740.92	2318.44	3858.49	4630.19

Appendix

D

STORM INFRASTRUCTURE IMPROVEMENT AREAS



LEGEND

Secondary Plan Study Area

Potential Future Development

Existing Road Network

Provincial Highway
Major Arterial
Urban Arterial
Urban Collector
Local

Future Roads

Collector Residential
Potential Collector Residential

Development Constraint

High Constraint - Natural Environment Area

Servicing

Edgewood Municipal Drain
Municipal Stormwater Management

Stormwater Management

Flow Arrow - (Post-Development)

Post-Development Catchment Area

Scale:
0 45 90 180 Meters
1:10,000

Project:

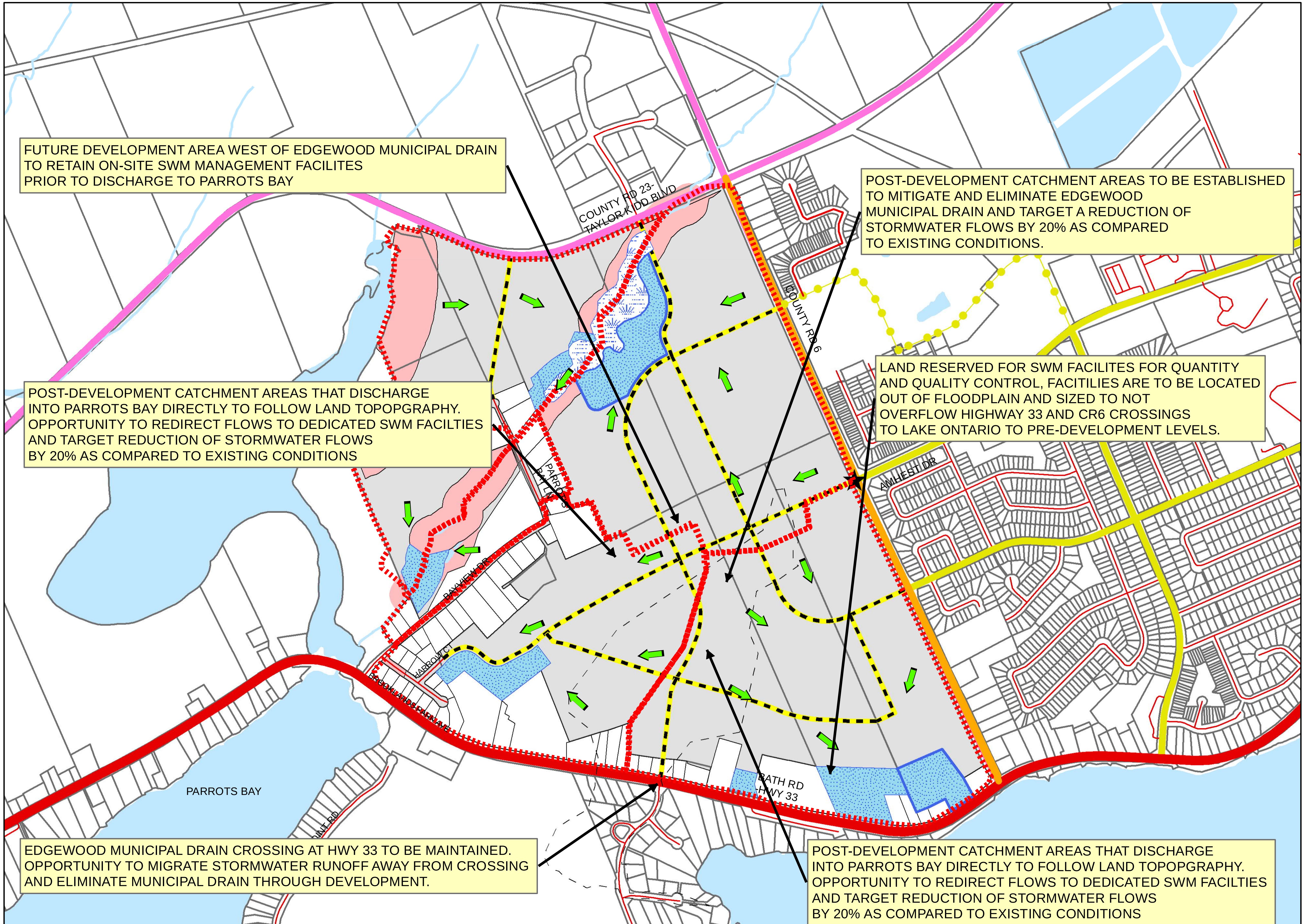
LOYALIST-AMHERSTVIEW WEST SECONDARY PLAN

Title:

LOST CREEK STORMWATER MANAGEMENT

Project No.:		Date:
211-01353-00		OCTOBER, 2024
Drawn By: DM	Checked By: MF	Figure No.: D-1

File Location:C:\Pro\Amherstview\Servicing Map\D-1-LostCreek-221-01353-00-REV6.mxd



LEGEND

- Secondary Plan Study Area
- Potential Future Development

Existing Road Network

- Provincial Highway
- Major Arterial
- Urban Arterial
- Urban Collector
- Local

Future Roads

- Collector Residential
- Potential Collector Residential

Development Constraint

- High Constraint - Natural Environment Area

Servicing

- Edgewood Municipal Drain
- Municipal Stormwater Management

Stormwater Management

- Flow Arrow - (Post-Development)
- Post-Development Catchment Area

Scale:
0 45 90 180 Meters
1:10,000

Project:

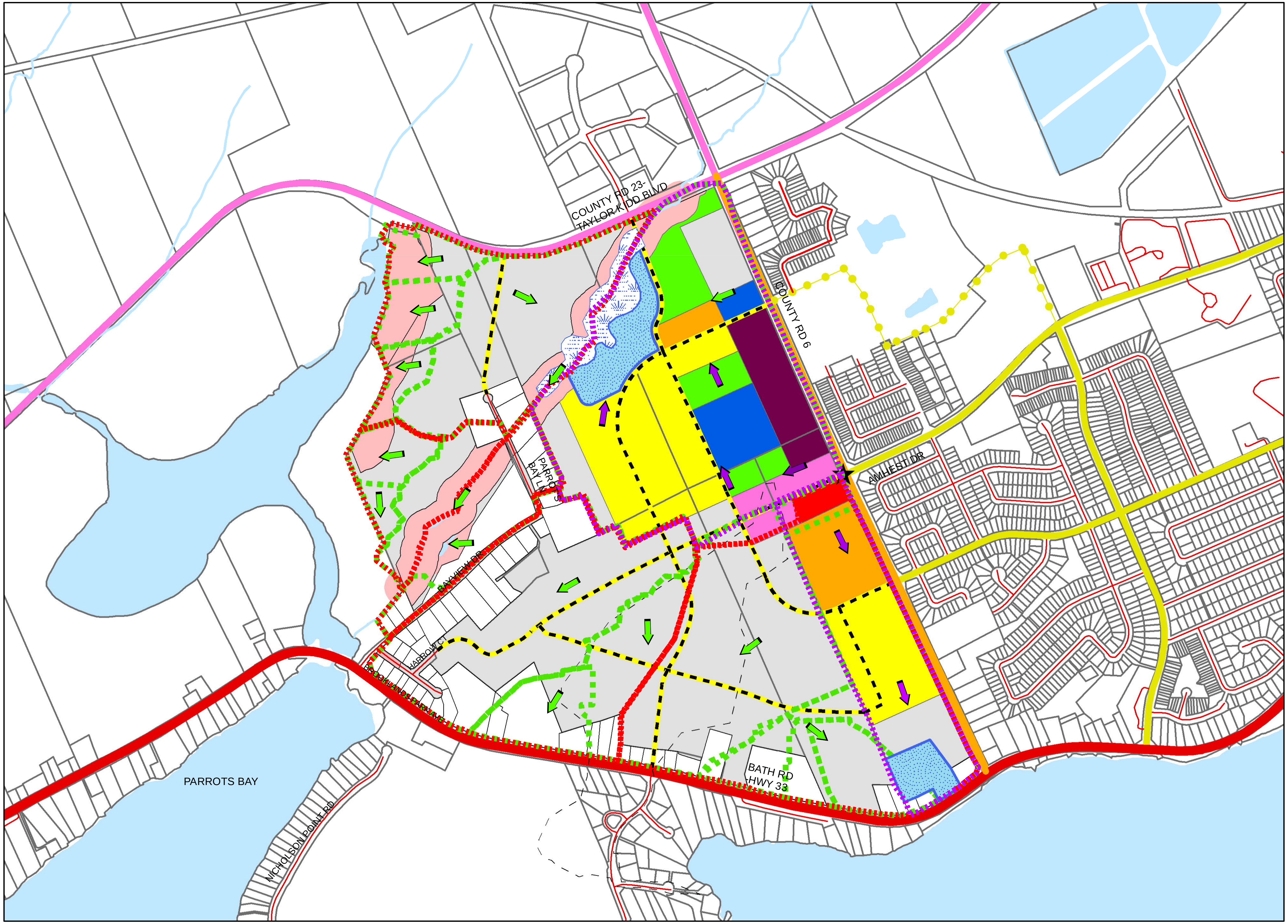
LOYALIST-AMHERSTVIEW
WEST SECONDARY PLAN

Title:

EDGEWOOD MUNICIPAL
DRAIN CATCHMENT
STORMWATER MANAGEMENT

Project No.: 211-01353-00		Date: OCTOBER, 2024
Drawn By: DM	Checked By: MF	Figure No.: D-2

File Location:C:\Pro\Amherstview\Servicing Map\D-2-EdgewoodDrain-221-01353-00-REV7.mxd



LEGEND

Secondary Plan Study Area

Conceptual Land Use
- Low Density Residential
- Medium Density Residential
- High Density Residential
- Commercial - Highway
- Commercial - Mixed Use
- Institutional
- Parks and Open Space
- Potential Future Development

Existing Road Network
- Provincial Highway
- Major Arterial
- Urban Arterial
- Urban Collector
- Local

Future Roads
- Collector Residential
- Collector Residential

Development Constraint
- High Constraint - Natural Environment Area

Servicing
- Edgewood Municipal Drain
- Municipal Stormwater Management

Stormwater Management
- Flow Arrow - (Pre-Development)
- Flow Arrow - (Post-Development)
- Pre-Development Catchment Area
- 25-Year: Post-Development Catchment Area

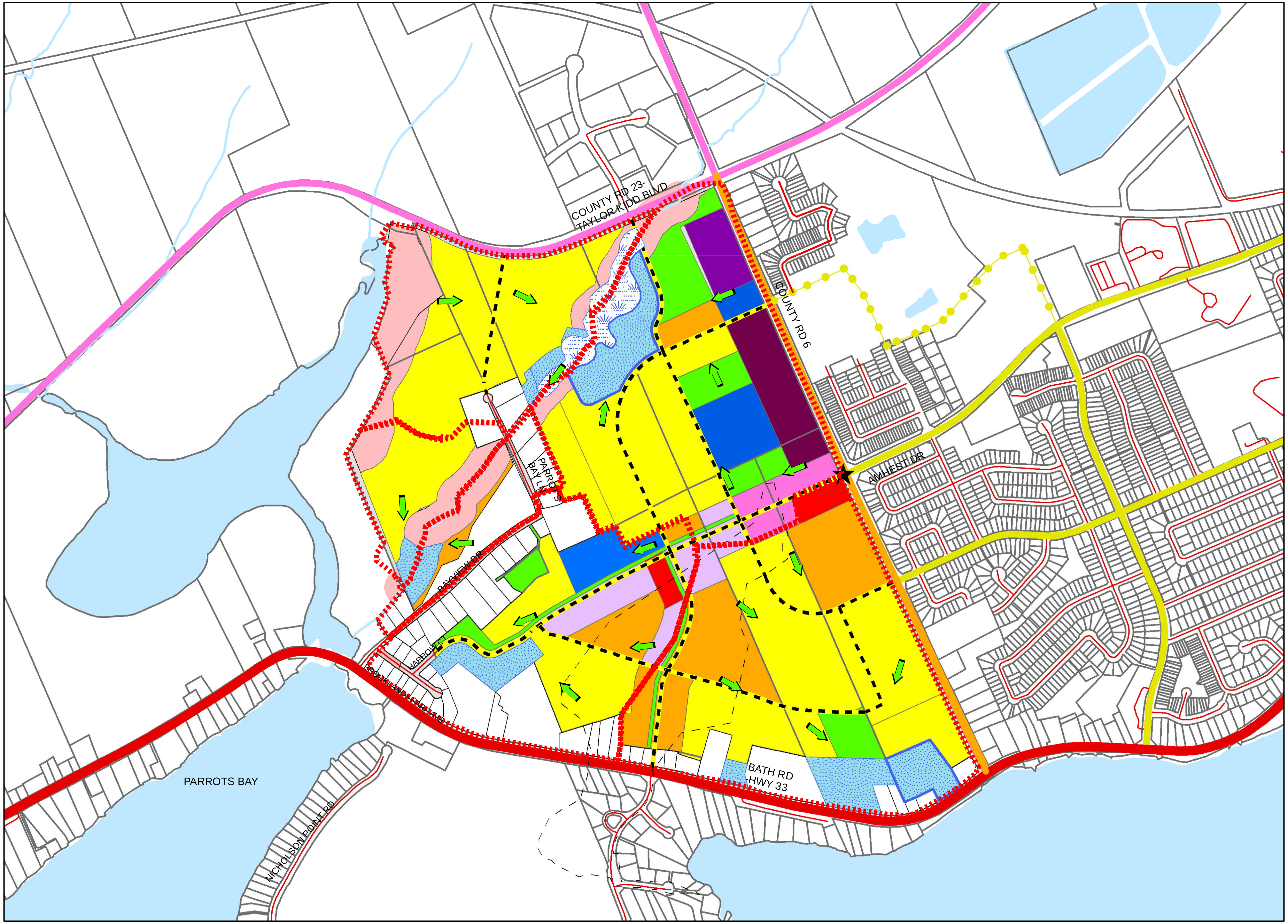
Scale:
0 45 90 180 Meters
1:10,000

Project:
LOYALIST-AMHERSTVIEW WEST SECONDARY PLAN

Title:
CONCEPTUAL LAND USE 25 YEAR DEVELOPMENT STORM FLOW ROUTES

Project No.:	Date:	
211-01353-00	OCTOBER, 2024	
Drawn By: DM	Checked By: MF	Figure No.: D-3

File Location:C:\Pro\Amherstview\Servicing Map\D-3-SWM-25-Year-221-01353-00-REV7.mxd



LEGEND

Secondary Plan Study Area

Conceptual Land Use

- Low Density Residential
- Medium Density Residential
- High Density Residential
- Commercial - Highway
- Commercial - Mixed Use
- Institutional
- Parks and Open Space
- Potential Future Development

Existing Road Network

- Provincial Highway
- Major Arterial
- Urban Arterial
- Urban Collector
- Local

Future Roads

- Collector Residential
- Potential Collector Residential

Development Constraint

- High Constraint - Natural Environment Area

Servicing

- Edgewood Municipal Drain
- Municipal Stormwater Management

Stormwater Management

- Flow Arrow - (Post-Development)

Post-Development Catchment Area

Scale:
0 45 90 180 Meters
1:10,000

Project:

LOYALIST-AMHERSTVIEW WEST SECONDARY PLAN

Title:

CONCEPTUAL LAND USE
FULL BUILD-OUT DEVELOPMENT
STORMWATER FLOW ROUTES

Project No.: 211-01353-00		Date: OCTOBER, 2024
Drawn By: DM	Checked By: MF	Figure No.: D-4

File Location:C:\Pro\Amherstview\Servicing Map\D-4-SWM-Build-Out-Year-221-01353-00-REV7.mxd

E

LOW IMPACT DEVELOPMENT SUMMARY

Low Impact Development Summary

In accordance with the Ministry of Environment, Conservation and Parks (MECP) Low Impact Development (LID) Stormwater Management Guidance Manual there is a growing trend to use LID's as a part of the solution for stormwater Quality and Quantity control. These current proposed guidelines were reviewed and additional research was collected and compiled for best management practices (BMP) from the Sustainable Technologies Evaluation Program are compiled in this summary.

The summary provided additional context towards for suitability of LIDS within the Amherstview West Secondary Plan area for best management practices (BMP) and planning considerations have been included four (4) suitable LID solutions.

- *Chambers*
- *Bioretention*
- *Enhanced Swales*
- *Bioswales (Dry Swales)*

This summary provideds best

Chambers:

<u>Suitability</u>

- *Installing below any type of surface or landscape*
- *Receiving and infiltrating large volumes of water*

<u>Planning Considerations</u>

Geometry and Site Layout

Infiltration chambers and soakaways can be designed in a variety of shapes, although facilities should have level or nearly level bottoms to spread flow evenly throughout. Typically designed with an impervious drainage area to pervious facility footprint area ratio (i.e. I:P ratio) between 5:1 on low permeability soils (HSG C & D) to 20:1 on high permeability soils (HSG A & B). Not typically deeper than 4 m. The Amherstview West Secondary Plan Area has a combination permeable soils.

Native Soil

Infiltration trenches, chambers and soakaways can be constructed over any soil type, but hydrologic soil group (HSG) A or B soils are best for achieving water balance and erosion control objectives. Facilities should be located on portions of the site with the highest infiltration rates. Native soil infiltration rate at the proposed facility location and depth should be confirmed through in-situ measurements of hydraulic conductivity under field saturated conditions.

Available Space

Recommended under parking, walkway or landscape areas and require little surface space, solely for inlets, outlets and access structures. Chambers can be considered within Municipal Drain areas to limit discharge from developments or considered at designated Municipal catchment areas.

Site Topography

Facilities cannot be located on natural slopes greater than 15%.

Water Table

Maintaining a separation of one (1) metre between the elevations of the base of the practice and the seasonally high water table, or top of bedrock is recommended. Lesser or greater values may be considered based on groundwater mounding analysis.

Pollution Hot Spot Runoff

To protect groundwater from possible contamination, runoff from pollution hot spots should not be treated by infiltration trenches, chambers or soakaways.

Proximity to Underground Utilities

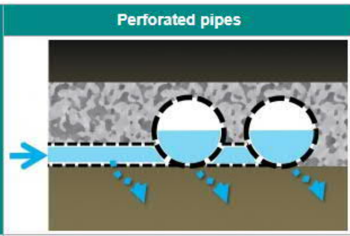
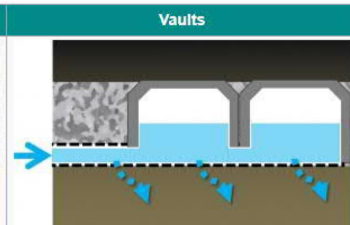
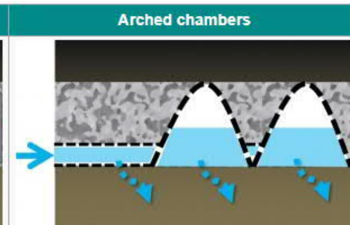
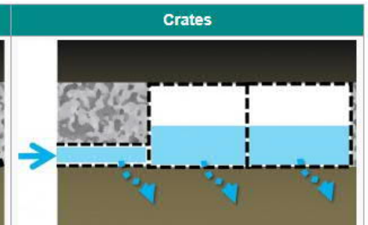
Designers should consult local utility design guidance for the horizontal and vertical clearances required between storm drains and storm sewers.

Karst

Infiltration trenches, chambers and soakaways are <u>not suitable in areas of known or implied karst topography.</u> Its noted that the Secondary Plan area is known for potential Karst topography, however these areas were not directly identified during the borehole investigation as part of the Amherstview West Secondary Plan Geotechnical and Hydrogeological study (Refer to background report for further details.)

Setback from Buildings

Facilities should be setback a minimum of four (4) metres from building foundations.

System type	Perforated pipes	Vaults	Arched chambers	Crates
				
Materials	Plastic or Metal	Concrete	Plastic	Plastic
Footprint	Medium	Small	Medium	Small
Stackable	Yes	No	Yes	Yes
Effective Porosity (n')	0.60 - 0.65	0.75 - 0.85	0.50 - 0.65	0.95
Maintenance Access	Moderate	Excellent	Moderate	Difficult
Standard Strength	H-20	H-25	H-20	H-20 - H-25

Bioretention Area:

Suitability

- *Fitting multi-functional vegetation into urban landscapes*
- *Treating runoff collected from nearby impervious surfaces*

Planning Considerations

Infiltration

Bioretention with an underdrain is a popular choice in areas with 'tighter' soils where infiltration rates are < 15 mm/hr. Including a perforated pipe in the reservoir aggregate layer helps to empty the facility between storm events, which is particularly useful in areas with low permeability soils.

The drain discharges to a downstream point, which could be an underground infiltration trench or chamber facility. Volume reduction is gained through infiltration and evapotranspiration. By raising the outlet of the discharge pipe the bottom portion of the BMP can only drain through infiltration, creating an internal water storage reservoir. This creates a fluctuating anaerobic/aerobic environment which promotes denitrification.

Increasing the period of storage has benefits for promoting infiltration, but also improves water quality for catchments impacted with nitrates. A complimentary technique is to include fresh wood mulch in the storage reservoir aggregate, which fosters denitrifying biological processes.

Bioretention areas can be considered and/or incorporated along with traditional stormwater management ponds within collection areas throughout the Amherstview West Secondary plan development areas to capture runoff and promote infiltration to reduce the overall rate of discharge to Lost creek or Edgewater Municipal Drain.

Space

- For optimal performance bioretention facilities should receive runoff from impervious drainage areas between 5 to 20 times their own permeable footprint surface area.
- In the conceptual design stage it is recommended to set aside approximately 10 - 20% of the contributing drainage area for bioretention facility placement.
- Bioretention cells work best when distributed, so that no one facility receives runoff from more than 0.8 Ha, although there is a trade off to be considered regarding distributed collection and treatment versus ease of maintenance.
- Bioretention can be almost any shape, from having very curvilinear, soft edges with variable depth, to angular, hard-sided and uniform depth.
    - For ease of construction and to ensure that the vegetation has adequate space, cells should be no narrower than 0.6 m at any point.
    - The maximum width of a facility is determined by the reach of the construction machinery, which must not be tracked into the cell.

- Setback from buildings: A typical four (4) metre setback is recommended from building foundations. If an impermeable liner is used, no setback is needed.
- Proximity to underground utilities and overhead wires: Consult with local utility companies regarding horizontal and vertical clearance required between storm drains, ditches, and surface water bodies. Further, check whether the future tree canopy height in the bioretention area will not interfere with existing overhead wires.

The principles of bioretention can be applied in any scenario where planting or vegetation would normally be found.

Streetscape

Bioretention is a popular choice for making urban green space work harder. Design configurations include extending the cells to accommodate shade trees, and using retrofit opportunities to create complete streets with traffic calming and curb extensions or 'bump outs'.

Parkland and natural areas

Naturalized landscaping and soft edges can make a bioretention facility 'disappear' into green space surroundings. In some scenarios, a larger bioretention (50 - 800 m^2) cell may be used as an end-of-pipe facility treating both sheet flow and concentrated flow before it enters an adjacent water course. In these larger installations care must be made in the design to distribute the inflow, preventing erosion and maximizing infiltration.

Enhanced Grass Swales:

Generally have lower stormwater management potential. The enhancement over a basic grass swale is in the addition of check dams to slow surface water flow and create small temporary pools of water which can infiltrate the underlying soil. Withing the context of the Amherstview West Secondary Plan proposed development areas the use of enhances swale may be considered for conveyance as part of the collection systems to designated stormwater management collection and retention areas, while also provided the benefit of enhanced Quality control.

Suitability

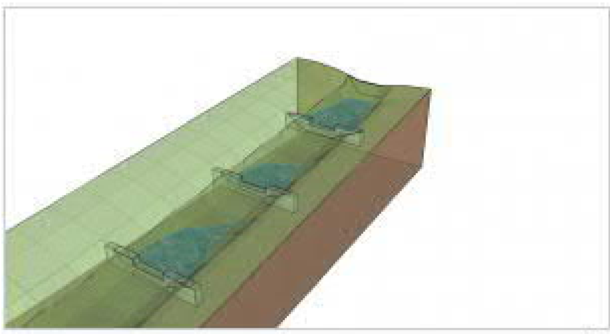
- *Sloped sites,*
- *Cheaply retrofitting and improving the performance of existing grass swales.*

Planning Considerations

Best cross sections
Enhanced swales aim to both reduce the flow rate and retain a portion of the conveyed water. For these purposes the best cross section is one that maximizes the wetted perimeter for a given area. For a given width and depth, the difference between a triangular and trapezoidal section is small.

Safety

As shallow grassed swales are a common roadside construction. Considerations for high-risk environments susceptible to high runoff flows and flooding needs to be accounted for in the design to ensure that the primary conveyance objectives are achieved. In many urban environments the principle of applying check dams to enhance all surface BMPs can be safely used to encourage ponding and subsequent infiltration for a day or two.



The check dams are spaced slightly further apart than would be recommended to maximize infiltration capacity i.e. ponding isn't quite continuous between the dams.

Dry Swales (Bioswales):

Form of bioretention with a long, linear shape (surface area typically >2:1 length:width) and a slope which conveys water. These swales are suitable for urban environments when and have specific advantages as compared to enhanced grass swales when it comes to stormwater management benefits.

Types of Swale

Property	Bioswale	Enhanced grass swale
Surface water	Minimal Any surface flow can be slowed with check dams	Ponding is encouraged with check dams
Soil	Filter media required	Amendment preferable when possible
Underdrain	Common	Uncommon
Maintenance	Medium to high	Low
Stormwater benefit	High	Moderate
Biodiversity benefit	Increased with native planting	Typically lower

Suitability

- *Sites with long, linear landscaped areas, such as parking lots*
- *Connecting with one or more other types of LID*

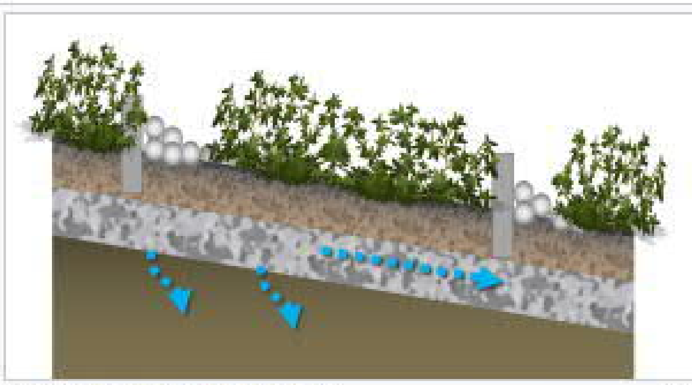
Planning Considerations

A linear design (surface area typically >2:1 length: width) is a common feature of swales:

- An absolute minimum width of 0.6 m is required for bioswales to promote healthy plant growth, and to facilitate construction,
- Grassed swales are usually mown as part of routine maintenance, so the cross section will be triangular or trapezoidal in shape with maximum side slopes of 1:3. The minimum width for this type would be 2 m.

Swales may be graded along longitudinal slopes between 0.5-6 %:

- Between 1 - 6 %, check dams are recommended to bring the compensation gradient <1 %.
- Slopes > 6% can accommodate a series of stepped bioretention cells, each overflowing into the next with a spillway.



Bioswale with check dams