City of Guelph

Water and Wastewater Servicing Master Plan

Volume II – Technical Memorandum 5: Design Criterial, Level of Service (LOS) and Sensitivity Analysis

February 2023

TECHNICAL MEMORANDUM

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Subject:	**TM# 5 Design Criteria, LOS and Sensitivity Analysis**		

City of Guelph
Water and Wastewater Servicing Master Plan

TM# 5 Design Criteria, LOS and Sensitivity Analysis

C3 WATER INC.

STANTEC CONSULTING LTD.

February 8, 2023

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1	December 3, 2020	First Draft	Michelle Scott, Marc Telmosse	Sam Ziemann, Dave Eadie, Arun Hindupur, Reg Russwurm, Mary Angelo, Adam Geldart, Tara Roumeliotis
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SIGN OFF

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DATE: February 8, 2023

SEAL

Prepared by: **Sam Ziemann, P.Eng, President**

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Tables

1.0 INTRODUCTION

Establishing appropriate design criteria and levels of service (LOS) is a crucial step in the development of solutions and establishing cost-effective infrastructure investment. The purpose of this technical memo is to summarize relevant water and wastewater servicing design criteria and LOS from Regional Guidelines, City of Guelph (City) guidelines and previous studies completed for the City and neighboring municipalities and to provide recommendations for the Water and Wastewater Servicing Master Plan (WWSMP).

The following existing City Guidelines are referenced in this TM:

- City of Guelph 2009 Water and Wastewater Servicing Master Plan (2009 WWSMP)
- City of Guelph Engineering and Transportation Services 2019 Development Engineering Manual (2019 Engineering Manual)

The following Regional Guidelines are referenced:

- Region of Waterloo and Area Municipalities 2020 Design Guidelines and Supplemental Specifications for Municipal Services (2020 DGSSMS)
- Ontario Ministry of the Environment, Conservation and Parks 2019 Design Guidelines for Sewage Works (2019 MECP Sewage Guidelines)
- Ontario Ministry of the Environment, Conservation and Parks 2019 Design Guidelines for Drinking Water Systems (2019 MECP Water Guidelines)
- 2012 Ontario Building Code (2012 OBC)

The following documentation from neighboring municipalities are referenced:

- Region of Peel 2017 Public Works Design, Specifications & Procedures Manual – Linear Infrastructure – Sanitary Sewer Design Criteria (2017 Region of Peel Design Manual)
- City of Brantford 2021 Water Master Plan (2021 Brantford WMP)
- City of Stratford 2018 Water Infrastructure Evaluation and Needs Assessment (2018 Stratford WIENA)
- City of London 2019 Design Specifications and Requirements Manual (2019 London Design Manual)

Additionally, the following recent studies completed for the City are referenced:

- City of Guelph 2012 York Trunk Sewer and Paisley-Clythe Feedermain Schedule B EA Study (2012 York EA)
- City of Guelph 2013 Clair-Gordon Sanitary Sewer Capacity Analysis (2013 Clair Gordon Analysis) City of Guelph 2013 Update of the 2008 Development Charges Study (2013 DC Study)
- City of Guelph 2015 Guelph Innovation District Water and Wastewater Study (2015 GID Study)
- City of Guelph 2017 Clair-Gordon Sanitary Sewer Capacity Analysis (2017 Clair Gordon Analysis)
- City of Guelph 2019 Clair-Gordon Sanitary Sewer Capacity Analysis (2019 Clair Gordon Analysis)
- 2017 NiMa Trails Sewage Pumping Station – Downstream Capacity Analysis (2017 NiMa Trails)
- City of Guelph 2020 Review of Fire Flow Calculation Practices (2020 Fire Flow Review)
- City of Guelph 2021 Water Supply Master Plan Update (2021 WSMP)
- City of Guelph 2021 Downtown Servicing Study (2021 Downtown Servicing Study)
- City of Guelph 2022 Clair-Maltby Master Environmental Servicing Plan (2022 Clair-Maltby MESP)

2.0 WATER CRITERIA

Water servicing criteria have been reviewed under a number of different sources and are summarized in the following sections. Recommendations have been made for the criteria to be used within the WWSMP.

The purpose of this section is to summarize criteria for neighbouring municipalities, Provincial guidance as well as industry best practices for water systems, to better inform recommended criteria for the City. The criteria used in recent studies for the City were also taken into consideration when developing the recommendations.

2.1 System Pressure

Pressure is an important parameter to consider when assessing water distribution systems. Low pressure can lead to inadequate service to customers or even intrusion of contaminants while high pressure can cause damage to household plumbing and watermain breaks. Table 2-1 below summarizes the water servicing pressure criteria used in the reference documents.

Table 2-1 Pressure Criteria

Criteria	Source
• Average day demand (ADD) and maximum day demand (MDD): 50psi – 80 psi • Min Hour (MHD): 100 psi • Peak hour (PHD): 40 psi • Minimum under emergency conditions: 20 psi • Maximum pressure: 100 psi	2020 DGSSMS
• Minimum peak hour: 40 psi • Maximum: 100 psi	2009 WWSMP
• 40 – 100 psi	2021 Brantford WMP
• Existing System: 40 – 100 psi • Future Development: 50 – 90 psi	2018 Stratford WIENA
• 40 – 80 psi	2019 London Design Manual
• Normal operating 50 – 70 psi and not less than 40 psi • Pressure outside normal range may be dictated by system side and topography. • Maximum pressure: 100 psi	2019 MECP Water Guidelines

Comparing recent studies completed for the City, the 2021 Downtown Servicing Study pressure criteria was consistent with the 2020 DGSSMS while the 2022 Clair-Maltby MESP and the 2015 GID Study referenced the MECP guidelines.

Of the sources summarized above, in general, the allowable pressure range is 40-100 psi with a preferred range of 50 – 80 psi, where applicable. It is recommended that these criteria are used for the WWSMP. Circumstances where it may be acceptable for the servicing pressure to be outside of the preferred range include areas with aging watermains where increasing operating pressure may lead to increased breakage or areas which cannot reasonably achieve the preferred operating range due to their topography and location within the City's distribution system.

2.2 Fire Flow

Table 2-2 outlines the fire flow criteria for specific buildings or developments that were available from the reference documents. The definition for available fire flow is the flow that can be achieved at a point in the distribution system while maintaining a residual pressure of 20 psi under MDD conditions. This typically does not account for losses through hydrants and several hydrants may be required to achieve the available flow.

Table 2-2 Building Specific Fire Flow Criteria

Criteria	Source
• One-story not exceeding 600m^2 : 30 L/s • Building specific requirement based on construction type, building volume and distance to adjacent buildings: 45 – 150 L/s	2012 OBC
• Determined in accordance with "Water Supply for Public Fire Protection", Fire Underwriters Survey (FUS)	2020 DGSSMS, 2019 MECP Water Guidelines
• Residential Dead-end: 50 L/s • Single/Semi Family: 75 L/s • Townhome: 125 L/s • Multi-Family: 150 L/s • Commercial: 175 L/s • Institutional: 175 L/s • Industrial: 250 L/s • City Centre: 225 L/s	2021 Brantford WMP
• Single Family Dead-end: 50 L/s • Single Family: 75 L/s • Townhome: 90 L/s • Multi-Family: 100 L/s • Commercial: 125 L/s • Institutional: 125 L/s • Industrial: 150 L/s	2018 Stratford WIENA
• Low Density Residential: 76 L/s • Medium Density Residential: 90 L/s • High Density Residential: 151 L/s • ICI: 151 L/s	2019 London Design Manual

• Determined in accordance with the FUS or the MECP Guidelines.
• 2008 MECP Guidelines:
  ○ Residential: 30 L/s
  ○ ICI: 64/200 L/s
• Typical site-specific requirements:
  ○ Large shopping centre: 367 L/s for 5 hours
  ○ Commercial building: 267 L/s for 3.5 hours
  ○ Small shopping centre: 200 for 2.5 hours
	2009 WWSMP

• Residential – low density: 80 L/s for 2 hours • Residential – medium density: 150 L/s for 2 hours	2020 Fire Flow Review

Criteria	Source
• Residential – high density: 200 L/s for 2.5 hours • Commercial – small: 200 L/s for 2.5 hours • Commercial – medium: 267 L/s for 3.5 hours • Commercial – large: 367 L/s for 5 hours • Institutional – small: 150 L/s for 2 hours • Institutional – large: 250 L/s for 3.5 hours • Industrial – 250 L/s for 3.5 hours	

The development specific requirements of the neighboring municipality sources above range from 75 – 150 L/s for residential areas, with the exception of dead-ends. The ICI requirements range from 125 – 225 L/s.

The 2020 DGSSMS and 2019 MECP Water Guidelines do not state development specific fire flow guidelines but reference the FUS which is a standard document for calculating the fire flow requirement of a specific building. While the FUS is a useful document for establishing fire flow requirements, it requires detailed information on the building. The challenge with using the FUS method is that often not all required information is available and conservative assumptions lead to unachievable fire flow requirements.

The Downtown Servicing study referenced the 2009 WWSMP fire flow of 367 L/s for the Quebec Street Mall as the maximum requirement. The Clair-Maltby MESP also referenced the 2009 WWSMP, using the 267 L/s commercial building guideline as the maximum fire flow requirement. The GID Study used a fire flow demand of 250 L/s.

The 2020 Fire Flow Review was a study completed for the City and involved a survey of fire flow requirements for neighbouring municipalities as well as input from the City's fire department, operations and Building Official and industry professionals such as FUS staff, insurance providers and fire flow consultants. It is recommended that the fire flow guidelines established through this study are utilized for the WWSMP and for assessing future developments. The fire flow guidelines established through this study were developed specifically for the City and were consistent with or greater than the neighboring municipality sources listed above. It is recommended that the OBC guideline of 30 L/s is used as a minimum fire flow requirement throughout the existing system.

2.3 Linear Capacity

Typical criteria used to determine the adequacy of linear capacity are headloss and velocity. High headloss can lead to inefficiencies in the distribution system and reduced service pressure. High velocity in the distribution system can lead to damaged pipes, fittings and valves over time. Headloss and velocity criteria from available sources are summarized in Table 2-3 and Table 2-4, respectively.

Table 2-3 Headloss Criteria

Criteria	Source
• Maximum: 2 m/km	2013 DC Study
• Maximum: 2 m/km (ADD to MDD)	2009 WWSMP
• Maximum for watermains greater than 400mm: 2.3 m/km	2019 London Design Manual

The Downtown Servicing Study used a maximum headloss criteria of 3m/km. However, for the system-wide analysis of the WWSMP, it is recommended that a headloss criteria of 2m/km is used. This is consistent with the 2009 WWSMP and the 2013 DC Study.

Table 2-4 Velocity Criteria

Criteria	Source
• Maximum: 5 m/s (Fire flow or emergency) • Regional watermains maximum: 1.5 m/s (ADD to MDD)	2020 DGSSMS
• Watermains greater than 400mm maximum: 3 m/s	2009 WWSMP
• Peak velocity below 1.5 m/s for new watermains • Peak velocities exceeding 2.0 m/s should be flagged for review and mitigation.	2021 Brantford WMP
• Maximum under PHD: 1.5 m/s • Maximum under fire flow conditions: 2.4 m/s	2019 London Design Manual

Under all of the sources summarized above, the maximum velocity criteria for typical operating conditions are 1.5 m/s. It is recommended that this is used for the WWSMP. A maximum velocity of 5 m/s under fire flow and emergency conditions is recommended based on the 2020 DGSSMS.

2.4 Storage Capacity Criteria

The 2019 MECP Water Guidelines provide a method for calculating the required storage volume for drinking water systems and is summarized in Table 2-5 below.

Table 2-5 Storage Criteria

Criteria	Source

• Guidelines for Total Storage, A+B+C
  ○ A = Fire Storage
  ○ B = Equalization Storage (25% of MDD)
  ○ C = Emergency Storage (25% of A+B)
	2019 MECP Water Guidelines

• 2019 MECP Water Guidelines	2009 WWSMP, 2021 Brantford WMP, 2018 Stratford WIENA

The MECP method for treated water storge requirements was used in the 2009 WWSMP and the Clair Maltby MESP. This method is also referenced in neighboring municipalities' documentation for Brantford and Stratford.

It is recommended that the storage requirement for each pressure zone is calculated using the MECP Water Guidelines, with the equalization storage based on MDD values established using historical demand and production data.

It is recommended that the fire storage for each pressure zone be based on the fire flow requirements summarized in Section 2.2. The largest fire flow criteria for each pressure zone are as follows:

- Zone 1/3: Commercial – large: 367 L/s for 5 hours based on Stone Road Mall or the Quebec Street Mall.

- Zone 2: Commercial – medium: 267 L/s for 3.5 hours based on the commercial plazas in the north-west end of the system.

2.5 Pumping Capacity

The 2019 MECP Water Guidelines states that treated water pumping stations should have a minimum firm capacity sufficient to supply the MDD. The pumping firm capacity must meet the MDD plus highest fire flow requirement if the pressure zone does not have sufficient storage to meet the fire flow requirements. Firm capacity is defined as the capacity of the station with the largest pump out of service.

Based on the MECP Guidelines, the recommended pumping capacity criteria for the WWSMP is that the total firm capacity of the pump stations that supply each pressure zone must meet the MDD for that zone.

2.6 Demands

Criteria for estimating domestic demand growth were established through the 2021 WSMP using a population-based approach and are summarized in Table 2-6 below. It is recommended that these criteria are carried forward for the WWSMP for consistency.

Table 2-6 Growth Demand Criteria

Category	ADD Per capita water usage (Lcd)
Residential	167
Employment	191
Non-revenue water (NRW)	61
MDD	
MDD Peaking Factor	1.34 x ADD

2.7 Redundancy

Through discussions with City staff, it was established that future upgrades to the system should be planned such that MDD can be met if the Arkell Aqueduct or Woods PS is unavailable. This was found to be the most critical existing piece of infrastructure for the water distribution system.

Additionally, it is recommended that the ADD must be met for each Zone for 24-hours if the largest pumping supply is offline:

- Zone 2: Paisley pump station
- Zone 3: Clair pump station

It should be noted that these redundancy criteria are for planning purposes only and are not required to be met under existing conditions. The purpose of these criteria is to plan future upgrades such that system resilience is improved.

2.8 Recommendations – Water

The recommended criteria for water servicing are summarized in Table 2-7 below.

Table 2-7 Water Servicing Criteria Summary

Criteria	Level of Service Objective
System Pressure	• 40 – 100 psi allowable • 50 – 80 psi preferred where applicable
Fire Flow	• Minimum allowable for infrastructure: 30 L/s • Residential – low density: 80 L/s for 2 hours • Residential – medium density: 150 L/s for 2 hours • Residential – high density: 200 L/s for 2.5 hours • Commercial – small: 200 L/s for 2.5 hours • Commercial – medium: 267 L/s for 3.5 hours • Commercial – large: 367 L/s for 5 hours • Institutional – small: 150 L/s for 2 hours • Institutional – large: 250 L/s for 3.5 hours • Industrial – 250 L/s for 3.5 hours
Headloss	• Maximum 2 m/km under typical operating conditions
Velocity	• Maximum 1.5 m/s under typical operating conditions • Maximum 5 m/s under fire or emergency conditions

Storage	• Guidelines for Total Storage, A+B+C
	  ○ A = Fire Storage
	  ○ B = Equalization Storage (25% of maximum day demand)
	  ○ C = Emergency Storage (25% of A+B)
	• Fire storage:
	  ○ Zone 1/3: Commercial – large: 367 L/s for 5 hours
	  ○ Zone 2: Commercial – medium: 267 L/s for 3.5 hours

Pump Capacity	• Firm capacity must exceed the MDD for each pressure zone. • If no floating storage is available, firm capacity must exceed MDD plus fire flow.
Demand	• Residential: 167 Lcd • Employment: 191 Lcd • NRW: 61 Lcd • MDD peaking factor: 1.34 x ADD

Criteria	Level of Service Objective
Redundancy*	• MDD must be met with Arkell Aqueduct or Woods PS offline. • ADD for each pressure zone must be met with largest pump supply offline.

*Redundancy criteria for planning purposes only and not required to be met under existing conditions.

3.0 WASTEWATER CRITERIA

A review of recent planning and design-level engineering reports for the City has shown that the application of wastewater design criteria has varied. It is understood that the City wishes to review and reconcile the general design criteria for wastewater systems, to better harmonize with pertinent neighboring municipalities, provincial guidance document updates, as well as industry best practices.

This section presents the documented methodologies per various guidelines applicable to the City's wastewater collection system. Attention is focused on identifying the requirements per the 2019 MECP Sewage Guidelines and the 2020 DGSSMS, and the City's current Engineering and Transportation Services 2019 Development Engineering Manual (2019 Engineering Manual). Recommendations on modifications are provided. A summary of the approaches applied in past wastewater collection studies is provided – see Table 3-1.

Table 3-1 Wastewater Collection System Modelling Methodologies (Previous Studies)

Study	Residential Loading (Rate and Approach)	Residential Peaking Factor	ICI Loading (Rate and Approach)	GWI (Rate and Approach)	RDII (Rate and Approach)	I&I (Rate and Approach)	Existing and Future Conditions Considered?	Design Event / Condition Considered?
2009 WWSMP	300 L/c/d	Harmon Minimum peak flow: 1.7 L/s/ha (City standard)	300 L/c/d (Equivalent pop – 30ppl/ha)	85% of nighttime flow	Existing Development: RTK hydrograph	New development: 0.1 L/s/ha	Yes	25-year design storm (distribution not specified)
2012 York EA	300 L/c/d	Harmon	300 L/c/d (Equivalent pop – 30ppl/ha)	Not considered separately		0.1 L/s/ha	Yes Future: 2021, 2026 and 2031	Not specified, but refers to previous studies of wet weather conditions
2013 DC Study	Historical: 478 L/c/d (historical) 300 L/c/d	Not specified. Possibly included in 478 L/c/d New areas: diurnal pattern (flow monitoring)	Included in historical rate of 478 L/c/d 300 L/c/d (Equivalent pop – 30ppl/ha)	Not considered separately	Existing Development: RTK hydrograph from 2008 WWSMP	New areas: 0.15 L/s/ha	Yes Future: 2032	25-year design storm (no distribution; partially implemented)
2015 GID Study	300 L/c/d	Harmon	300 L/c/d (Equivalent pop – 30ppl/ha) 0.6 L/s/ha, with peak factor of 2.5 for sensitivity analysis and comparison with 300 L/c/d	Not considered separately		0.1 L/s/ha	No	Not specified
2013 Clair Gordon	1 to 7 L/s/ha depending on development type	Included in area-based flow rate	Commercial and industrial: 1.7 L/s/ha Schools: 2.5 L/s/ha	Not considered separately		0.21-0.53 L/s/ha depending on area, based on 2 methods: 1) Statistical analysis relating storm to I&I rate 2) Calibrating a dynamic model to project flows during design storm (25-year design storm)	Yes	25-year design storm (no distribution)
2017 Clair Gordon	1 to 7 L/s/ha depending on development type	Included in area-based flow rate	Commercial and industrial: 1.7 L/s/ha Schools: 2.5 L/s/ha	Not considered separately		Included in area-based flow rate. Peak inflow rate separated using DWF monitoring data.	Yes	25-year design storm (no distribution)
	300 L/c/d	Harmon: PF = 2	300 L/c/d (Equivalent pop – 30ppl/ha)	Not considered separately		0.11 L/s/ha	Future	
2019 Clair Gordon Analysis	Range: 87.4-400.3 L/c/d depending on catchment area (Flow monitoring; no distinction between land uses)	Measured peaking factor (Flow monitoring)	Range: 87.4-400.3 L/c/d depending on catchment area (Flow monitoring; no distinction between land uses)	Not considered separately	RTK hydrograph		Yes	25-year design storm (3.5 hour-storm with peak intensity of 170 mm/hr)
	1 to 7 L/s/ha depending on development type	Harmon	Commercial and industrial: 1.7 L/s/ha Schools: 2.5 L/s/ha	Not considered separately		Included in area-based flow rate. Peak inflow rate obtained from difference between peak flow and peak DWF. Peak DWF is based on population-based rate of 353 L/c/d and 0.6 x calculated Harmon peaking factor.	Future	
2017 Nima Trails	450 L/c/d	Harmon	0.6 L/ha/s	Flow monitoring comparison provided. Rates not established.	RTK hydrograph	0.36 L/ha/s applied	Yes	25-year design storm (No distribution)
2022 Clair-Maltby MESP	300 L/c/d	Diurnal pattern (From InfoSWMM)	300 L/c/d (Equivalent pop – 30ppl/ha)	Not considered separately	Existing inputs from InfoSWMM model	Existing areas: rates from InfoSWMM model New areas: 0.28 L/s/ha	Yes Future: 2031	25-year design storm (No distribution. From InfoSWMM)

Study	Residential Loading (Rate and Approach)	Residential Peaking Factor	ICI Loading (Rate and Approach)	GWI (Rate and Approach)	RDII (Rate and Approach)	I&I (Rate and Approach)	Existing and Future Conditions Considered?	Design Event / Condition Considered?
2021 Downtown Servicing Study	300 L/c/d	Harmon	300 L/c/d (Equivalent pop – 30ppl/ha)			Retained approach from 2008 WWSMP	Yes Future: 2022, 2027 and 2031	25-year 6-hour Chicago storm

3.1 Design Criteria Guidelines (New Developments)

The following sections provide descriptions of various components of Design Criteria Guidelines that may be considered for the City of Guelph. These guidelines apply primarily to new greenfield developments. They generally are not used to access the performance of an existing wastewater collection system. Rather, these are guidelines to design new infrastructure to accommodate growth. Discussion related to existing system performance and infill development considerations is provided in Section 3.2.

3.1.1 Flow Generation & Sewer Sizing

MECP Sewage Guidelines

The 2019 MECP Guideline recommends the use of population-based rates for residential flow, and area-based rates for institutional and industrial flows; peaking factors are provided or can be calculated based on population. Extraneous flows from wet weather and infiltration should be considered, based on applicable references. Flow rates for present and future conditions should be evaluated.

DGSSMS

Various flow generation rates are provided. Consideration for residential, industrial, commercial, institutional and extraneous flow rates are suggested.

The design sewage flow shall include an allowance for extraneous flows. Allowance shall also be made for future sewage requirements. MOECC (now MECP) Design Guidelines are to be followed.

City of Guelph Engineering Manual

The 2019 Engineering Manual recommends area-based rates for all land-uses. These rates are inclusive of the peaking factor. It is not stated if the peaking factor includes an extraneous flow consideration. Design flow should be restricted to a maximum of 80% of the pipe capacity, and surcharge should be eliminated.

Table 3-2 Flow Generation & Sewer Sizing

Mention / Description	Source

Average flows and peaking factors
• Residential: 275 L/c/d
  ○ Peaking factor: using Harmon Formula
• Industrial: 0.4 L/s/ha
  ○ Peaking factor: as per MECP Guidelines
• Commercial:
  ○ Core: 0.95 L/s/ha; Shopping Mall: 0.3 L/s/ha; General: 0.5 L/s/ha
  ○ Peaking factor: 2.5
• Institutional: 0.25 L/s/ha;
  ○ Hospitals: 0.015 L/s/bed
• Design flow of sewage including extraneous flows
  ○ Extraneous flows: Wet weather inflow & infiltration: 0.25 L/s/ha
Sewer Sizing
• Allowance for future sewage requirements
	2020 DGSSMS

Area-based coefficients, including peaking factor • Residential (singles and semi's): 1 L/s/ha	2019 Engineering Manual

Mention / Description	Source
• Commercial and industrial: 1.7 L/s/ha • Schools and townhomes: 2.5 L/s/ha • Apartments (150 u/ha): 6 L/s/ha • Apartments (295 u/ha): 7 L/s/ha • High-density apartments: 7 L/s/ha No mention of extraneous flows Sewer Sizing • Design flow at maximum of 80% full flow design capacity of pipe size • Eliminate any potential surcharging	
Design flows & Sewer Sizing • Domestic: 302.8 L/c/d (includes Harmon peaking factor) • The Region provides a reference table where a population based design flow rate is provided. This flow rate includes the applicable Harmon peaking factor • Infiltration flow: 0.0002 $m^3/s/ha$ • Maintenance hole inflow: 0.00028 $m^3/s/manhole$ • Allowance for foundation drains (for areas developed more than 25 years ago): 0.00008 $m^3/s/foundation\ drain$	2017 Region of Peel Manual

Average flows and peaking factors
 	
• Residential:
  ○ Domestic flow: 225 L/c/d to 450 L/c/d
  ▪ Peaking factor: using Harmon or Babbitt formula
  ▪ Peaking factor – minimum: 2.0
  ○ Extraneous flow: peak extraneous flow in L/s/ha from applicable references
• Institutional:
  ○ Based on historical records, if available
  ○ Commercial and tourist areas – minimum: 28 $m^3/ha/d$
  ○ Rates provided in MECP guidelines Table 5-3
  ▪ Peaking factor: similar to relative peak water usage rates
• Industrial:
  ○ Industry/process specific flow predictions
  ▪ Reasonable allowance for peak industrial sewage flows for an area
 	
Sewer Sizing
 	
• Sanitary sewage flows from residential, commercial, institutional and industrial establishments, plus extraneous flow (groundwater, surface runoff)
• Peak sewage flow rates for present and future conditions
	2019 MECP Sewage Guidelines

Mention / Description	Source
• Design for ultimate tributary population, and for maximum anticipated capacity of institutions, industrial parks and other sewage sources	

3.1.2 Other Design Considerations

MECP Guidelines

The 2019 MECP Guidelines outlines criteria for the minimum pipe size, the Manning's "n" roughness coefficient, flow velocities, pipe depth, foundation drains, and roof drainage.

DGSSMS

The direction is to follow the MECP Design Guidelines.

City of Guelph Development Engineering Manual

The sewer design criteria for the minimum pipe size and pipe roughness are similar to the MECP Guidelines. The flow velocities comply with the MECP Guidelines, with additional considerations for subcritical flow. The pipe depth requirements fall within the range of the MECP Guidelines' requirements.

Table 3-3 Minimum sanitary sewer Pipe Size

Mention / Description	Source
• In accordance with MECP Design Guidelines	2020 DGSSMS
• Minimum diameter: 200 mm	2019 Engineering Manual
• Minimum diameter: 250 mm	2017 Region of Peel Manual
• Minimum diameter: 200 mm	2019 MECP Sewage Guidelines

Table 3-4 Manning's Roughness ("n")

Mention / Description	Source
• All pipe materials: 0.013	2020 DGSSMS
• All pipe sizes and types: 0.013	2019 Engineering Manual
• All pipes: 0.013	2017 Region of Peel Manual
• All smooth-walled pipe materials: minimum 0.013	2019 MECP Sewage Guidelines

Table 3-5 Velocity Criteria

Mention / Description	Source
• In accordance with MECP Design Guidelines	2020 DGSSMS
• Wastewater not mentioned	2019 Engineering Manual
• Minimum velocity: 0.75 m/s at actual flow	2017 Region of Peel Manual

Mention / Description	Source
• Maximum velocity: 3.5 m/s • Concrete pipe larger than 450 mm diameter where velocities > 2.0 m/s and drops across maintenance hole > 0.3 m shall be reviewed for protection against sulphuric acid	

• Minimum: 0.6 m/s when flowing full
  ○ For sewers 1200 mm in diameter or larger: 0.9 m/s
• Maximum: 3 m/s
  ○ Especially where high grit loads are expected
• Design with self-cleansing velocities
• To minimize sulphide problems:
  ○ Sewers to flow less than full under peak flow conditions
  ○ Sewers to flow at velocities > 0.6 m/s.
• Sufficient flow velocity to transport sewage solids and avoid deposition
	2019 MECP Sewage Guidelines

Table 3-6 Pipe Depth Criteria

Mention / Description	Source
• Minimum obvert depth: 2.8 m below final road grade. • For depths over 5.0 m: secondary collection system may be required.	2020 DGSSMS
• Top of pipe (obvert) depth: 2.7 m	2019 Engineering Manual

• Minimum obvert depth: 2.5 m below centre line of the road allowance.
  ○ Where this is not possible: minimum basement elevations of 1.0 m above the sanitary pipe obverts
  ○ In commercial areas: Minimum obvert depth: 3.5 m below centre line of the road allowance.
	2017 Region of Peel Manual

• Minimum invert depth: 0.9 m to 1.5 m below basement floor levels.
  ○ Sufficiently deep to receive sewage from basement
  ○ Prevent freezing and damage due to frost.
	2019 MECP Sewage Guidelines

3.1.3 Pumping Stations

Design criteria for sanitary sewer pumping stations are specified in the MECP Guidelines, and were not mentioned in the other manuals and guidelines reviewed.

Table 3-7 Pumping Stations

Mention / Description	Source
• No mention of pumping stations	2020 DGSSMS
	2019 Engineering Manual
	2017 Region of Peel Manual

• Design flow:
  ○ Design peak instantaneous sewage flow
• Number of pumps:
  ○ Multiple pumps
  ○ Where only 2 units: should be of the same size, to provide a firm capacity with one unit out of service and at least capable of handling the 10-year design peak hourly flow
• Pump sizing:
  ○ Minimum diameter: 80 mm
  ○ Minimum diameter – suction and discharge openings: 100 mm
• Hazen-Williams factor "C":
  ○ a. Low sewage level, C = 120
  ○ b. Median sewage level over the normal operating range, C = 130; and
  ○ c. Overflow sewage level in the wet well, C = 140.
• Protection:
  ○ Pumps handling sanitary sewage from ≥ 750 mm diameter sewers should be protected by bar racks.
  ○ Pumps handling sanitary sewage from smaller sanitary sewers should be protected from clogging.
	2019 MECP Sewage Guidelines

3.1.4 Siphons

The 2019 MECP Guidelines state that inverted siphons should be avoided. Design criteria for the minimum number of barrels, the pipe size, and the velocity are provided. Siphon design criteria are not provided in the other manuals considered.

Table 3-8 Siphons

Mention / Description	Source
• No mention of siphons	2020 DGSSMS
	2019 Engineering Manual
	2017 Region of Peel Manual
• Inverted siphons should be avoided. • Minimum number of barrels: 2 • Minimum pipe size: 150 mm • Minimum velocity – at average daily flows: 0.9 m/s	2019 MECP Sewage Guidelines

3.2 Level of Service Analysis Guidelines (Existing Conditions Assessments & Infill Development)

The design criteria presented in Section 3.1 informs and provides preferred direction for new development related infrastructure. It is also very important however to understand how new or increased flows impact the performance of existing infrastructure. This type of capacity assessment can be referred to as a Level of Service (LOS) analysis. A LOS analysis provides perspective into the resiliency of the collection system and assists in identifying if modifications to the existing infrastructure are required. This LOS analysis can be required to further understand and assess existing operational interests, and is recommended as part of the approval process to understand the impacts and requirements to service infill development, and also part of a downstream assessment of new development.

A LOS analysis begins with understanding the performance of the collection system under dry weather flow conditions. The extent of the existing system's ability to accommodate increasingly rare wet weather flow events is then explored.

3.2.1 Dry Weather Flow Performance

The performance of the collection system under dry weather flow (DWF) condition should consider the range of flows expected throughout an average day. This can be accomplished considering a diurnal pattern which can be based on appropriate sewer flow monitoring data from a dry period.

The hydraulic performance of the collection system can be assessed by analyzing the hydraulic grade line (HGL) throughout under DWF conditions. Under DWF conditions, the HGL should be within the obvert of the gravity sewer.

3.2.2 Wet Weather Flow Performance

The collection systems' performance under wet weather flow (WWF) conditions provides insight into where basement and surface flooding concerns may be present. WWF analysis can be completed using various synthetic design storm distributions; and these for a range of return periods (i.e., frequency of events). Alternatively, the City may also identify an event that has occurred in the past and use this as their design event for WWF LOS analysis.

For the wastewater LOS analysis, it is suggested that both the 3-hour and 24-hour event durations be considered. The 3hr event would be used when the peak WWF is of interest (i.e., when conveyance capacity is the focus). The 24hr event would be used when the total WWF volume is the focus (i.e., when sizing inline/offline storage). This approach is recommended regardless of the LOS target (2yr, 5yr, 10yr, 25yr, etc.) established by the City. The current assessment for the MP update considers the 25yr design event.

The minimum freeboard requirement between the hydraulic grade line (HGL) and basement slab elevation is identified as 0.5m in the City's current stormwater guidelines. This same requirement could be applied for the wastewater analysis. Other municipalities including the City of Toronto have adopted a freeboard of 1.8m (~6ft) from the nearest maintenance hole surface elevation as a reasonable estimate for basement protection. However, it has been confirmed that there are areas in Guelph (specifically in the downtown core) with shallow sewers where a smaller amount of surcharge may result in increased basement flooding risk. For this reason, any surcharge allowance warrants confirmation of basement elevations before consideration. The City's current approach of not allowing surcharging is appropriate without this confirmation.

3.2.3 Other considerations

The LOS analysis also needs to consider the performance of the hydraulic structures throughout the collection system – namely the pumping stations, siphons, and the wastewater treatment plant.

3.2.3.1 Pumping Stations

The peak WWF used in the LOS analysis should be compared to the design capacity of the pumping station. The analysis should consider the upstream HGL with the design operating flow, as well as the downstream HGL if the pumping station were upgraded (if necessary) to accommodate the peak WWF.

For Master Plan level assessments, the downstream HGL consideration may be prioritized to enable identification of overall system upgrade requirements.

3.2.3.2 Siphons

The performance of the existing siphons should be assessed for both the DWF and WWF LOS scenarios. Minimum velocity targets as well as upstream HGLs are of interest.

3.2.3.3 Wastewater Treatment Plant

The instantaneous peak WWF, as well as the range of operating levels at the WWTP are of interest.

3.3 Recommendations

The City's guidelines (2019 Development Engineering Manual) were reviewed and compared to the Regional (Waterloo) and to the Provincial 2019 MECP Guidelines. In general, it is recommended to align with the MECP and then Regional guidelines. This alignment will ensure that expected considerations are included and maintained. The City's guideline can then act to further characterize variances specifically for its own use. This will provide an approach to design and level of service criteria that include the components required at the Provincial and Regional level that are characterized to the City of Guelph's unique needs and priorities.

Recommendations as they pertain to the City's current Design Criteria and LOS analysis approach are provided in Table 3-9 and Table 3-10.

3.3.1 Discussion – Area-based and Population-based Flow Generation

The City currently require an area-based approach for generating flows as part of the design criteria (2019 Development Engineering Manual). The recommendation provided in Table 3-9 is to update this to a population-based approach. There are several reasons for this recommendation:

- Both the regional and provincial guidelines recommend a population-based approach. Adopting this would align Guelph with most other municipalities in Ontario while satisfying the local regional and province wide recommendations.
- The population-based approach is more accurate in estimating the flow generation parameters as it considers the actual occupancy type and density considered. With an area-based approach, no matter the number of units and expected dwelling densities, the flow per area rate remains unchanged.
- Differentiating between average and peak DWF and WWF conditions is often of interest. The current area-based approach does not provide instruction on how to calculate these differences. A population-based approach can be used to calculate these flows as the Harmon peak factor equation can be applied. The area-based approach does not differentiate between peak and non-peaked flows. By calculating the DWF and peak DWF, the extraneous flow allowance be used to estimate the WWF condition.

Table 3-9 Recommended Wastewater Design Criteria

Criteria	2019 Engineering Manual	Recommendation
Flow Generation & Sewer Sizing	Design flow at maximum of 80% full flow design capacity of pipe size Eliminate any potential surcharging Sanitary flow calculated using area-based coefficients	<u>Sewer Sizing</u> New Development (greenfield) sewer sizing: For sewers greater than 450mm diameter: To be designed no more than 70% full (design flow/full flow, Q/Qf) and be triggered for upsizing if it reaches 80% full. For sewers equal or less than 450mm diameter: To be designed no more than 60% full and be triggered for upsizing if it reaches 70% full. Infill development or existing infrastructure sewer sizing: To be designed to eliminate full pipe conditions (i.e., no surcharging). Deviations from this approach (less or more surcharging) may be considered but will require consultation with the City for operational considerations. <u>Design Flows</u> Calculate design flows using population and 300L/c/d aligned with the 2020 DGSSMS and 2019 MECP Guideline recommendations. Apply Harmon peaking factor equation. • Minimum PF = 2 • Maximum PF = 4 Add extraneous flows of 0.25 L/s/ha. Extraneous flow to be established on an effective area basis. This effective area should not include areas that do not contribute flows (grassy areas, parks, etc.). The method for estimating this area must be provided.

Criteria	2019 Engineering Manual	Recommendation
		A suggested approach would be to apply a buffer around the sewer or roadway network. Evaluate present and future conditions
Wastewater Sewer Design – Minimum Pipe Size	Minimum diameter: 200 mm	Maintain requirement
Sewer Design - Manning's "n" Roughness Coefficient	All pipe sizes and types: 0.013	Maintain requirement
Wastewater Sewer Design – Flow Velocities	Not mentioned for Wastewater	Minimum velocity: 0.6 m/s Maximum velocity: 3 m/s Actual velocities to be established, not theoretical full pipe conditions. Requirements to help prevent operational problems including solids deposition and H2S generation.
Wastewater Sewer Design – Pipe Depth	A minimum cover of 2.7m (from future road grade) is required to the top outside edge of pipe barrel for the storm and sanitary sewers. Piping must be insulated if minimum burying depth cannot be achieved.	Maintain requirement
Wastewater Maintenance Hole Design - Benching	Plan and Profile drawings must show benching specifications.	Any sewers designed with flows greater than 50% capacity will have their MH benching set to the obvert of the sewer to reduce hydraulic losses.
Pumping Stations	No mention of pumping stations	Min Design according to 2019 MECP Guidelines, see Table 3.11 Recommend the City develop a Water/Wastewater Vertical Design manual, or a Wastewater Pumping Station Design manual.
Siphons	No mention of siphons	Avoid inverted siphons. If required, design according to Follow MECP Guidelines, see Table 3.12

Table 3-10 Recommended Wastewater Level of Service Criteria & Approach (Existing & Infill Development)

Criteria	Recommendation
DWF Performance	HGL should be within sewer obvert. Diurnal pattern considered. This could be based on recent sewer flow monitoring data, or an established City approach considering residential and ICI contributions (if applicable).
WWF Performance	Conveyance & Storage Requirements: 3-hr 25yr Chicago event for peak flow conveyance considerations 24-hr 25yr SCS Type II event for peak volume storage considerations. Other return periods and event distributions can be considered. Consultation with the City required. Surcharge: No surcharge above obvert is permitted without survey verified basement elevation checks. Confirmation with the City and approval of any design allowing surcharge is required.
Pumping Stations	The as-operating condition should be used to establish the resultant upstream HGL. The downstream HGL with the pumping station conveying the peak WWF to be established.
Siphons	Minimum velocity (DWF) and upstream HGLs (WWF) to be considered.
Wastewater Treatment Plant	The range of operating levels at the WWTP is to be considered in the hydraulic modelling of the collection system. Ensure an appropriate boundary condition is considered. The City to be consulted.