Prepared for:
The City of Guelph

Stormwater Management Master Plan

Appendix R: Annual Stormwater Monitoring Plan

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Reference #: 66636
March 2023
Final Report

To: **Colleen Gammie, PMP, P.Eng.**
City of Guelph

From: **Alison Gingrich Regehr, EIT, MASc**
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Project: **Guelph Stormwater Management Master Plan**

Subject: **Annual Stormwater Monitoring Plan**

In order to ensure the goals and objectives of the SWM-MP are accomplished over time, a refocused stormwater monitoring program is recommended. Stormwater monitoring helps to identify any existing or emerging water quality and quantity issues, allowing the City to identify when maintenance and/or infrastructure upgrades are required. The City of Guelph has an existing Stormwater Monitoring Program, however it is recommended that this program be revised, as described in the subsequent sections.

1 Background

1.1 Existing Stormwater Monitoring Program

The City's current Stormwater Monitoring Program is associated with the City's SWM facilities, and was developed by AECOM in 2019 in response to the recommendations arising from the City's Natural Heritage Action Plan (NHAP) in 2018. NHAP Action #5 recommended that the City "Enhance and expand the stormwater management monitoring program to assist in improving the hydraulic performance of stormwater management facilities and downstream health of receiving watercourses."

Seven (7) SWMF were monitored in the first year. In 2019 (the most recent monitoring report available to Aquafor Beech), monitoring occurred at SWMF 53, 55, 82, 86, 93, 97, and 102. Most of these facilities are considered to be in poor condition and/or are causing impacts to their receivers. Other facilities that have been considered for monitoring include SWMF 3, 7, 25, 29, 36, 89, 90, 91, and 92.

The three ponds and their receivers in the Hanlon Creek Business Park are also being monitored as part of a time-limited, development-specific monitoring program. SWMF 114 (also known as HCBP Pond 4) is causing thermal impacts to Tributary A of Hanlon Creek and has also been identified as contributing increased nutrient levels as well.

In addition, the NHAP indicated that "expanding the stormwater management system monitoring program to include data collection on receiving water bodies will help us evaluate ecosystem responses to various stormwater techniques and understand green infrastructure performance and maintenance needs. It will also provide feedback into the design of development and capital projects as knowledge is improved."

The City's current surface water monitoring program includes:

- Continuous data collection using water level, temperature, and turbidity sensors at the pond inlet(s) and outlet;
- Dry, baseflow and high flow measurements;
- Dry weather grab sampling which consists of 4 dry events after 72 hours without rain;

- Wet weather grab sampling within an hour of initial rainfall. This consists of 3 wet events greater than 10mm depth of rainfall; and
- Benthic invertebrate monitoring.

1.2 Consolidated Linear Infrastructure Environmental Compliance Approval

The Ministry of Environment, Conservation and Parks (MECP) recently implemented the Consolidated Linear Infrastructure Environmental Compliance Approval (CLI ECA). The CLI ECA consolidates each municipality's SWM infrastructure into one ECA, and grants approval authority for new SWM infrastructure to the municipality provided specific conditions are achieved. In October 2022, the MECP released draft Stormwater Monitoring Guidance for the CLI ECA, which "provides technical and procedural guidance for design considerations and implementation of stormwater monitoring plans."

The draft Stormwater Monitoring Guidance outlines the development and implementation of a monitoring program which focuses on representative monitoring stations to monitor changes to the overall health of a receiver over time. Monitoring the outlets of stormwater management facilities or infrastructure would only occur if the receiver shows water quality issues, and these outlets need to be monitored to determine the source of the issue.

The City of Guelph will need to prepare a Monitoring Plan in compliance with the Stormwater Monitoring Guidance. This monitoring plan must be developed and implemented either by the date of ECA approval or within twenty-four (24) months of the date of the publication of the Monitoring Guidance, whichever is later.

2 Proposed Monitoring Plan Overview

The proposed monitoring plan includes a transition away from monitoring SWMF to monitoring larger outfalls throughout the city. Monitoring individual SWMF is very resource-intensive; full implementation to more than 120 facilities across the City will be cost-prohibitive. In addition, by only monitoring SWMF, the City does not obtain water quality information from the 59 per cent of the urban area that is not controlled through SWMF.

This proposed plan will still align with the NHAP objectives, focusing more on the receiving water bodies and their response to upstream SWM techniques, instead of on individual ponds. By monitoring outfalls, the baseline water quality can be identified, and changes in water quality can indicate issues in the upstream catchment that may warrant additional detailed investigations and remedial work. The proposed monitoring plan also considers the forthcoming MECP monitoring requirements as part of the CLI ECA. Background details relevant to the proposed monitoring plan are included in **Section 2.1.**

2.1 Flow Proportionate Sampling

The use of flow proportionate samples taken for at least one benchmark site is typically required in order to thoroughly assess the variability of water quality through the course of the runoff events and over the course of several seasons and/or years. In this regard it is recommended that the City consider the need to install automated flow and water quality sampling equipment.

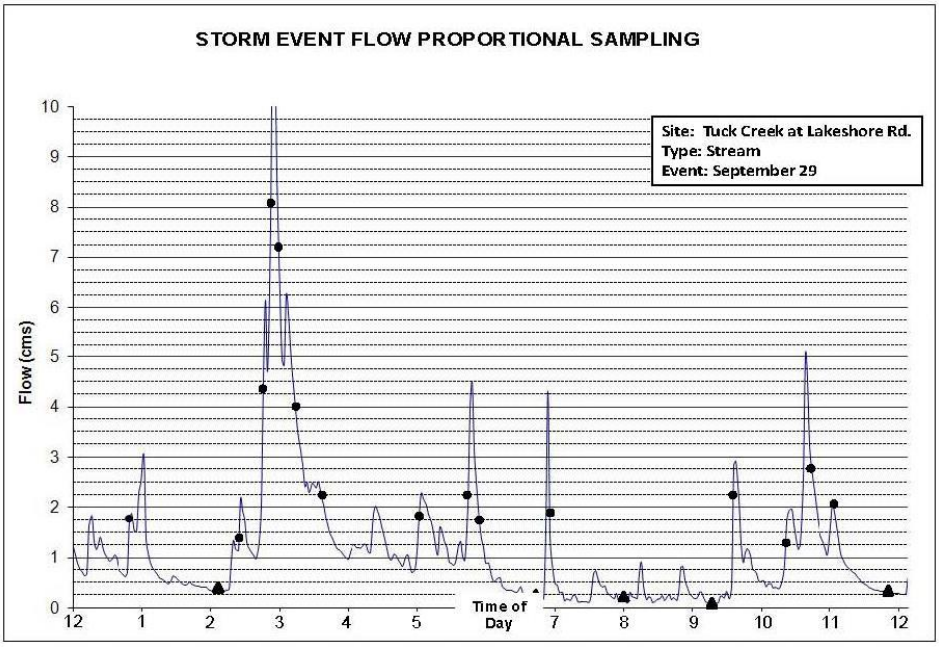
The objective, as explained below, would be to collect 'flow proportionate samples' for at least eight events in order to more rigorously characterize the variability of water quality over the period of sampling.

Event Mean Concentration (EMC) is the primary output of flow proportionate sampling. An EMC is the average concentration of a selected constituent over a unit time of flow, generally a wet-weather

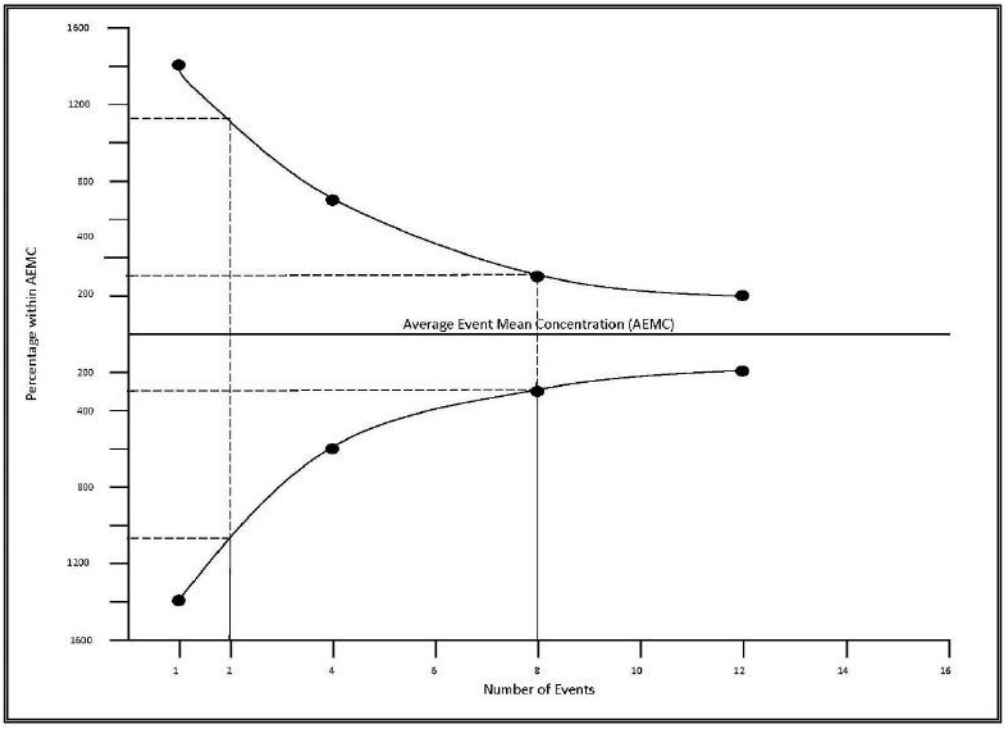
(storm) event. The EMC for a given event (or series of events) can be compared to a regulatory value (e.g., Provincial Water Quality Objective) and be used to calculate pollutant mass loadings into receiving waters and to judge the effectiveness of stormwater management measures.

There are a number of fundamentals for undertaking flow and water quality monitoring which are outlined below.

- **Variability of Pollutant Concentration during an Event:** Pollutant concentrations (see accompanying graph) vary considerably during an event. It is therefore important to gather flow proportionate samples in order to obtain an accurate representative of the average concentration during the event (Event Mean Concentration) as well as the pollutant loading.



- **Variability of Event Mean Concentration (EMC) from Event to Event:** The EMC will vary significantly from event to event. This is a result of a number of factors including rainfall patterns, inter event period and time of year. Therefore, as is shown on the accompanying graph, it is necessary to collect flow and water quality information from at least 8 events from storm sewer outfalls if mass loadings are to be reasonably defined.



- **Relationship between Nutrients and Total Suspended Solids:** Previous studies show a strong relationship between nutrient concentrations and Total Suspended Solids. Collection of nutrient data and TSS data is therefore valuable.
- **Influence of Land Uses:** Previous studies have shown that the concentrations from different land uses (i.e. industrial, commercial and residential) do not vary as much as is generally thought. Typically, EMC's from different land uses are within 10-20 percent.

2.2 Adaptive Environmental Management

The revised monitoring plan has been developed in keeping with the Adaptive Environmental Management (AEM) process which is "A systematic process for continually improving management policies and practices by learning from the outcomes of operational programs. Its most effective form - "active" environmental management - employs management programs that are designed to experimentally compare selected policies or practices, by evaluating alternative hypotheses about the system being managed."

Numerous definitions of the AEM exist in the literature, but the process can be described as a risk management strategy utilizing a "learning-by-doing" and "revising-as-appropriate" approach. The primary benefit of an AEM compared to the standard approach is the opportunity to modify the approach by introducing an adjustment step where monitoring program can be adjusted to better meet the needs of the subwatershed.

The primary benefit of an AEM compared to the standard approach is the opportunity to modify the approach by introducing an adjustment step where development and or its system (i.e. stormwater management) designs can be adjusted to better meet the needs of the subwatershed. Adjustments to monitoring sites, parameters and protocols can be made over time, as gaps are identified, to optimize the program.

3 Recommended Program

The stormwater monitoring program has two (2) distinct phases. Monitoring has been phased to permit City staff to build capacity with the municipality, vet the proposed monitoring program with partner agencies (e.g., the GRCA) and permit the alignment of future budgets with the revised program needs. The two (2) distinct phases include:

Phase 1 - Refined Water Resources Monitoring Program (2024-2025) – to establish baseline monitoring results (existing conditions) for new monitoring locations in high priority subwatersheds using three (3) autosamplers. Two additional high priority subwatersheds will be monitored using grab samples, as there are too many outfalls to establish an EMC location.

Phase 2 - Updated Water Quality and Flow Monitoring (2026 - ongoing) – refined monitoring locations and protocols to align with the implementation approach of prioritizing works based on the watersheds in the most need and where there are opportunities to improve conditions but also recognizes the need to protect existing watershed health. Phase 2 monitoring also focuses on the collection of data within subwatersheds that were determined to have insufficient data during the subwatershed prioritization analysis.

Other Monitoring Obligations

In addition, the stormwater monitoring program is recommended to include previous monitoring obligations including but not limited to:

- ECA compliance monitoring. Once the CLI ECA Monitoring Program is implemented, the current ECA compliance monitoring is expected to shift to the CLI ECA monitoring program.
- Other permit compliance monitoring as directed by the GRCA, MNRF, DFO or MECP. To be identified on a case-by- case basis.
    - This includes the Hanlon Creek Business Park monitoring program.

Error! Reference source not found. summarizes the proposed monitoring schedule for Phases 1 and 2 from 2024 to 2032.

Figure 3.1 illustrates the recommended monitoring locations.

Table 3.1: Recommended Monitoring Program Schedule and Priorities

Subwatershed	Monitoring Site ID	Existing Conditions Priority Rating	Phase 1		Phase 2						
			2024 (3)	2025 (4)	2026 (5)	2027 (6)	2028 (7)	2029 (8)	2030 (8)	2031 (8)	2032[1] (8)
Arboretum Tributary	AT	Priority 3									
Bailey Drain[2,3]	BD	Priority 1									
Clythe Creek[4]	CC	Priority 4									
Cutten Tributary[3]	CT	Priority 2									
Eramosa Urban Catchment 1	EUC1	Priority 3									
Hadati Creek	HadC	Priority 3									
Hanlon Creek	HC-A	Priority 4									
	HC-B	Priority 4									
	HC-C	Priority 4									
	HC-G	Priority 4									
	HC-Main	Priority 4									
Imperial Drain[3]	ID	Priority 3									
Kortright Hills Tributary	-	Priority 2	Monitoring not recommended (small catchment)								
Northern Tributary	NT	Priority 4									
Northwest Drain	NWD	Priority 3	Monitoring not recommended (small catchment)								
Riverside Drain[3]	RD	Priority 4									
Silver Creek[3]	SC	Priority 2									
Speed Urban Catchment 1[2,3]	-	Priority 1									
Speed Urban Catchment 2[2,3]	-	Priority 1									
Speed Urban Catchment 3[2,3]	SUC3	Priority 2									
Speed Urban Catchment 4[2,3]	SUC4	Priority 2									
Speed Urban Catchment 5[2,3]	SUC5	Priority 1									
Speed Urban Catchment 6[2]	SUC6	Priority 1									

[1] Subwatershed Health Analysis to be updated in 2032; monitoring locations may also be updated at this time.
[2] Subwatershed Health Analysis had insufficient data to assess Erosion Condition
[3] Subwatershed Health Analysis had insufficient data to assess Aquatic Ecology
[4] Clythe Creek Subwatershed Study (under way) is collecting water quality data from 2023-2025, which may be used to supplement Phase 2.

Subwatershed	Monitoring Site ID	Existing Conditions Priority Rating	Phase 1		Phase 2						
			2024 (3)	2025 (4)	2026 (5)	2027 (6)	2028 (7)	2029 (8)	2030 (8)	2031 (8)	2032[1] (8)
Speed Urban Catchment 7	SUC7	Priority 2									
Torrance Creek	TC	Priority 3									
Willow West Drain	WWD	Priority 1									
Woodland Glen Tributary	WGT	Priority 2									

	EMC - Flow Proportionate WQ Sampling, Dry Weather Sampling, Flow & Temperature Monitoring, Biological and Fisheries Sampling
	Grab samples recommended, as too many outfalls for EMC monitoring

TOWNSHIP OF GUELPH/ERAMOSA

TOWNSHIP OF PUSLINCH

TOWN OF MILTON

Marden Creek
Ellis Creek
Hadati Creek
Clythe Creek
Irish Creek
Hanlon's Creek
Blue Springs Creek

NT
RD
BD
SUC4
SUC3
SUC7
SUC6
SUC5
SC
ID
NWD
WWD
CT
AT
EUC1
HadC
CC
TC
WGT
HC-MAIN
HC-A
HC-G
HC-B
HC-D

Woodlawn Road West
Woodlawn Road East
Speedvale Avenue West
Speedvale Avenue East
Willow Road
Paisley Road
Wellington Street West
York Road
Stone Road West
Stone Road East
Clair Road West
Clair Road East
Victoria Road North
Victoria Road South
Woolwich Street
Edinburgh Road North
Edinburgh Road South
Eramosa Road
Metcalfe Street
Stevenson Street North
Elmira Road North
Imperial Road North
Silvercreek Parkway North
Hanlon Expressway
Gordon Street
Southgate Drive

Legend

- Municipal Boundary
- Rivers
- Watercourse
- Road Centreline
- SWM Facility
- Subwatershed
- Storm Sewer Outfalls
- Recommended Monitoring Locations

LOCATOR MAP

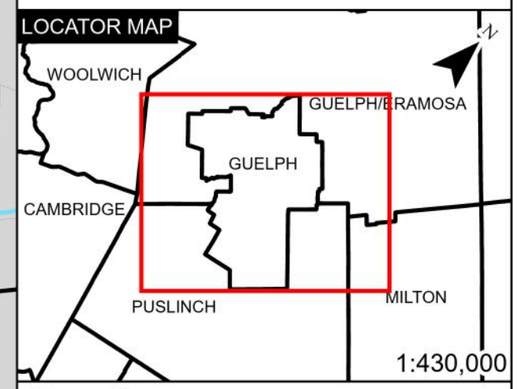


Figure 3.1

Recommended Monitoring Locations

Date: 2023-02-24
Projection: NAD83_UTM_Zone_17N
Data Source: City of Guelph, GRCA
Created by: A.V.

0 0.5 1 2
Kilometres

Aquafor Beech Limited

3.1 Phase 1 - Establishment of a Refined Water Resources Monitoring Program (2024-2025)

As part of Phase 1, the City will transition away from pond-specific monitoring to subwatershed-based monitoring. Priority 1 subwatershed have been included in Phase 1 monitoring efforts as these areas have been prioritized for immediate implementation of the SWM-MP recommended approaches. Baseline data for each Priority 1 subwatershed will provide a benchmark against which future stormwater management efforts can be compared.

The Phase 1 program is recommended to include the following. Monitoring program procedures and protocols are detailed in **Appendix A**.

- **Water Quality** - flow proportionate water quality sampling using automated water quality sampling procedures and equipment to develop Event Mean Concentrations (EMCs) using three (3) automated water quality sampling units to be purchased by the City. In the second year of the Phase 1 program, it is recommended that the City purchase a fourth sampling unit. It is recommended that Phase 1 water quality sampling include:
    - Flow proportionate water quality sampling for three (3) stations annually using automated water quality sampling procedures and equipment to develop EMCs. EMCs will provide the City with the ability to better quantify in-stream water quality in regards to Provincial Water Quality Objectives (PWQO) for various representative pollutants. Station locations are recommended to rotate annually to ensure all Priority 1 subwatersheds are monitored during Phase 1. This recommendation would reduce the overall sampling effort (reduced number of analyzed samples) while providing improved data resolution and comparative analysis.
    - While grab sampling is generally not recommended as part of a long-term monitoring program, there are too many outfalls in Speed Urban Catchments 1 and 2 to enable representative sampling using an automated water quality sampler. Eramosa Urban Catchment 1 and Speed Urban Catchment 5 each have numerous outfalls, but have one outfall that drains a large proportion of the catchment.
        - Ongoing grab sampling is therefore recommended in SUC1 and SUC2 subwatersheds as part of the multi-year sampling rotation schedule (Error! Reference source not found.). With 19 outfalls in SUC1 and 20 in SUC2, it is recommended that 5 outfalls are sampled during each grab sampling event.
        - A combination of EMC monitoring and grab samples is recommended for EUC1 and SUC5. There are 10 outfalls in EUC1 and 15 in SUC5. One EMC monitoring station is recommended at the primary outfall in each of these subwatersheds, with 3 outfalls sampled during each grab sampling event.
        - It is recommended that grab samples are collected during two wet weather events and two dry weather events each year that grab samples are collected. As per standard sampling protocols, wet samples are to be collected within 1 hour following the commencement of a significant storm event (typically greater than 15mm in the previous 24 hours). A dry event occurs after 72 hours without rain. Dry events are sampled to understand

potential spills or infrastructure failure associated with the upstream SWM ponds and/or associated infrastructure.

  - Collected water quality samples shall be submitted to a private accredited laboratory for analysis.

- **Water Quantity** – continuous flow monitoring at each EMC station annually corresponding to the flow proportionate water quality sampling stations. Station locations are recommended to rotate annually. Monitoring efforts could be combined with the recommended in-sewer flow monitoring for the calibration of the City-wide PCSWMM stormsewer modelling.

- **Temperature Monitoring** - continuous temperature monitoring for three (3) stations annually corresponding to the flow proportionate water quality sampling stations. Station locations are recommended to rotate annually.

- **Invertebrate Community Sampling** – Benthic macroinvertebrate monitoring should be completed on an annual basis for at each continuous flow monitoring station and dry weather sampling station (one location per subwatershed). The benthic community composition can change very quickly if habitat quality changes (benthics have limited mobility and a short life span), therefore monitoring is best conducted frequently. The results would continue to be compared to previous years, to track changes over time. Results provide a measure of how the benthic community has changed over time and are an excellent indication of in-stream conditions.

- **Fish Community Sampling -** For each sampling station, it is recommended that annual data be collected for a minimum of two (2) years to establish baseline conditions at each station. Fish community sampling is not recommended for stations with a significant sampling history from previous years that includes more than 1 year of fisheries data.

- **Compliance Monitoring: Permit, Construction and ECA –** where possible, it is recommended that compliance monitoring be integrated into the annual stormwater monitoring program.

3.2 Phase 2 - Updated Water Quality and Flow Monitoring (2026 - ongoing)

As part of Phase 2, monitoring locations and protocols have been refined to align with the implementation approach of prioritizing works based on the watersheds in the most need and where there are opportunities to improve conditions but also recognizes the need to protect existing watershed health. Phase 2 monitoring also focuses on the collection of data within subwatershed that were determined to have insufficient data during the subwatershed prioritization analysis.

Subwatershed based monitoring will be undertaken at regular intervals to confirm and/or evaluate the effects of the recommended approaches and refine the Implementation Plan to ensure project and programs are delivering the greatest value-for-dollar for the residents of Guelph. In 2032, it is recommended that subwatershed health be reassessed following the protocol outlined within the SWM-MP and that monitoring priorities be re-prioritized for 2033 based on implementation status of the recommended approaches and revised subwatershed health scores.

The Phase 2 program is recommended to include the following. Monitoring program procedures and protocols are detailed in **Appendix A**.

- **Water Quality** - flow proportionate water quality sampling using automated water quality sampling procedures and equipment to develop Event Mean Concentrations (EMCs) using the four (4) automated water quality sampling units acquired during Phase 1, and the purchase of one (1) additional unit per year, with the ultimate goal of acquiring a total of eight (8) automated units by 2029. It is recommended that future water quality sampling be revised to include:
    - Flow proportionate water quality sampling will continue, using automated water quality sampling procedures and equipment to develop EMCs per the locations detailed in **Table 7.1.** This will increase from five (5) stations per year in 2026 to eight (8) stations per year in 2029.
    - As in Phase 1, there are too many outfalls in Speed Urban Catchments 1 and 2 to enable representative sampling using an automated water quality sampler. Eramosa Urban Catchment 1 and Speed Urban Catchment 5 each have numerous outfalls, but have one outfall that drains a large proportion of the catchment.
        - Ongoing grab sampling is therefore recommended in SUC1 and SUC2 subwatersheds as part of the multi-year sampling rotation schedule (Error! Reference source not found.). With 19 outfalls in SUC1 and 20 in SUC2, it is recommended that 5 outfalls are sampled during each grab sampling event.
        - A combination of EMC monitoring and grab samples is recommended for EUC1 and SUC5. There are 10 outfalls in EUC1 and 15 in SUC5. One EMC monitoring station is recommended at the primary outfall in each of these subwatersheds, with 3 outfalls sampled during each grab sampling event.
        - It is recommended that grab samples are collected during two wet weather events and two dry weather events each year that grab samples are collected. As per standard sampling protocols, wet samples are to be collected within 1 hour following the commencement of a significant storm event (typically greater than 15mm in the previous 24 hours). A dry event occurs after 72 hours without rain. Dry events are sampled to understand potential spills or infrastructure failure associated with the upstream SWM ponds and/or associated infrastructure.
    - Collected water quality samples will continue to be submitted to a private accredited laboratory for analysis.
- **Water Quantity** – continuous flow monitoring for four (4) to eight (8) stations annually per the locations detailed in **Table 7.1** and corresponding to the flow proportionate water quality sampling stations.
- **Temperature Monitoring** - continuous temperature monitoring for four (4) to eight (8) stations annually per the locations detailed in **Table 7.1** corresponding to the flow proportionate water quality sampling stations.
- **Invertebrate Community Sampling** – Benthic macroinvertebrate monitoring should be continued on an annual basis for at each continuous flow monitoring station and dry weather sampling station. The benthic community composition can change very quickly if habitat quality

changes (benthics have limited mobility and a short life span), therefore monitoring is best conducted frequently. The results would continue to be compared to previous years, to track changes over time. Results provide a measure of how the benthic community has changed over time and are an excellent indication of in-stream conditions.

- **Fish Community Sampling –** Continuing from Phase 1**,** for each sampling station, it is recommended that annual data be collected for a minimum of two (2) years to establish baseline conditions at each station. Fish community sampling is not recommended for stations with a significant sampling history from previous years that includes more than 1 year of fisheries data. After baseline conditions have been established for all station, monitoring shall be can be conducted per the following:

    - Stations with no identified sensitive species – sampling may be conducted at a reduced frequency (bi-annual or longer). Station locations are recommended to rotate annually.

    - Stations where sensitive species have been identified, monitoring may be conducted at an increased frequency (annual basis). If sensitive species are found at a station where no sensitive species have been previously identified, monitoring should be conducted at an increased frequency for subsequent years.

  This recommendation focuses sampling effort and budget on a priority basis relating to those stations with sensitive species.

- **Compliance Monitoring: Permit, Construction and ECA –** where possible, it is recommended that compliance monitoring be integrated into the annual stormwater monitoring program.

3.3 Phase 1 and 2 Costs

Each EMC monitoring station is estimated to cost approximately $25,000. The first six years of the program will therefore incur the purchase costs for the stations until the City has its full complement of eight monitoring stations by 2029. Annual costs for program implementation will increase as the number of monitoring sites increases, as presented in **Table 3.2**.

Table 3.2: Monitoring Program Cost Estimates

		EMC Station Purchase Cost	Monitoring Program Cost	Total Annual Cost
Phase 1	2024	$75,000	$12,000	$87,000
	2025	$25,000	$16,000	$41,000
Phase 2	2026	$25,000	$20,000	$45,000
	2027	$25,000	$24,000	$49,000
	2028	$25,000	$28,000	$53,000
	2029	$25,000	$32,000	$57,000
	2030	-	$32,000	$32,000
	2031	-	$32,000	$32,000
	2032	-	$32,000	$32,000

3.4 Flow Monitoring for Model Calibration

While the two-phase monitoring program recommended in **Sections 3.1** and **3.2** focuses on water quality, it is also recommended the City implement storm sewer flow monitoring for the purposes of calibrating the PCSWMM model. Storm sewer flow monitoring should happen in 2024-2025 so that the PCSWMM model can be calibrated for future use. **Appendix B** summarizes the recommended flow monitoring program.

Appendix A: Monitoring Program Procedures and Protocols

Monitoring Program Procedures and Protocols

Autosampling Stations

At each autosampler station, it is recommended water quality monitoring be conducted using automated flow proportionate sampling in order to produce Event Mean Concentrations (EMCs) for selected constituents and therefore enable calculation of pollutant mass loadings into receiving waters. Monitoring activities at the flow proportionate sites would include the following:

1) Installation of an automated sampling device at the selected sites. A flow meter compatible with the selected automated sampling device would be utilized to trigger sampling as flow rates change. Flow meters would record continuous flow data in order to develop the EMC. Recording water levels every 15 minutes is suitable for developing EMCs.

    - A minimum of eight (8) EMC sampling events per year should be undertaken, with two (2) events per season (i.e. Spring, Summer, Fall, and Winter) to ensure statistical significance.

    - Undertaking a minimum of five (5) single discrete flow measurements and installation of a staff gauge is recommended in order to develop a rating curve (i.e. depth versus flow relationship). Continuously recorded depth values are translated to flow rates per the relationship developed by the corresponding rating curve.

    - Continuous temperature monitoring is recommended at the automated flow proportionate sampling locations in order to establish baseline thermal regimes at the respective sampling location. Data should be recorded every 15 minutes.

    - A minimum of three (3) dry weather sampling events should be conducted at each sampling location with one event in each of spring, summer and fall season. Dry weather sampling consists of grab samples which are analyzed to provide an indication of failing infrastructure or contamination due to spills upstream. Dry weather sampling shall be limited to days without rain events and is not conducted within 48 hours of a significant storm event.

    - Sampled parameters shall be consistent with **Table 1.** Laboratory sampling methodology and detection limits should be consistent with the previous sampling efforts (beginning with 2015) to ensure consistency amongst past datasets.

Table 1: Water Quality Parameters Sampling & Sampling Procedure

Parameters	Sampling Procedure/ Dry Weather Sites	Sampling Procedure/Type Flow Proportionate Sites
Chloride	Grab	Automated
E.coli	Grab	Automated
Nitrate	Grab	Automated
Copper	Grab	Automated
Lead	Grab	Automated
Zinc	Grab	Automated
Total and Dissolved Phosphorous	Grab	Automated
Total Suspended Solids (TSS)	Grab	Automated
Hardness (as $CaCO_3$)	Grab	Automated
Additional Water Quality Parameters Sampled		
pH	Field Measurement – collected at time of sample retrieval	
Temperature	Field Measurement – collected at time of sample retrieval	
Dissolved Oxygen	Field Measurement – collected at time of sample retrieval	
Conductivity	Field Measurement – collected at time of sample retrieval	

Water Quantity

Continuous measurements should be uniform in terms of frequency and representative of the flow regime. Therefore, it is recommended that a 15-min interval be employed.

Fisheries Monitoring

A Single Pass Backpack Electrofishing Survey should be conducted annually in spring (second week in March), summer (third week in July) and fall (last week of September) at the sampling station using OSAP Section 3: Module 1. This approach is used to produce a comprehensive fish species inventory within a site, characterizing the fish community, spawning activity and providing a qualitative assessment of species abundance. Species identification, number of fish, individual length and weight will be recorded.

Benthic Macroinvertebrate Sampling

Standard sampling protocols should be followed including the Ontario Benthos Biomonitoring Network Protocol (OBBN) (Jones, 2007) and Ontario Stream Assessment Protocol (OSAP). Benthic samples should be analysed using a multimetric approach to summarize the condition. In addition

to richness (e.g. total number of taxa) and composition metrics (e.g. % Diptera), macroinvertebrate can also be classified according to:

- functional feeding groups (e.g., % Collector-Filterers, % Scrapers, % Shredders)
- habit/behavior characteristics (e.g., % Clingers)

Functional feeding groups provide an indication of food web relationships. Habitat and behaviour characteristics indicate the functionality of the organism (e.g., the way it moves or searches for food).

The samples will be analysed using a multi-metric approach to summarize the condition of the watercourse using the following indices:

- Taxa Richness
- % EPT (Ephemeroptera, Plecoptera and Trichoptera)
- # EPT Taxa
- % Oligochaeta
- % Diptera
- % Chironomidae
- % Collector-filterer
- % Collector-gatherer
- % Scraper
- % Shredder
- % Clinger
- Shannon's Diversity Index
- Hilsenhoff's Biotic Index

Water Quality Database Requirements

The following is the minimum data requirements for inputting results into a water quality database. Each water quality sample result should be accompanied with the following information:

Field Name	Description	Type	Size
SOURCE:	Name of the laboratory	Text	32
ID:	Unique sample number	Long	9
STATION ID:	Name of sampling site	Text	11
PARAMETER DESCRIPTION:	Full description of parameter	Text	50
SAMPLE DATE:	Date of sampling event	Text	12
SAMPLE TIME:	Time of sample event	Text	9
SAMPLE MATRIX:	The medium of the sample (water)	Text	20
RESULT:	Result value	Double	8
UNITS:	Abbreviated form of result unit	Text	28
METHOD DETECTION LIMIT:	The detection limit of the associated method	Double	8
METHOD:	Description of test method	Text	50
SAMPLE TYPE:	Grab, spike, duplicate	Text	20
EQUIPMENT:	Used for continuous sampling	Text	20
EASTING:	UTM Coordinate of sampling site	Double	20
NORTHING:	UTM Coordinate of sampling site	Double	20
MONITORING PROGRAM NAME:	Name of monitoring program	Text	16

Other information that must be provided is the full address and contact information of the laboratory. This data must be delivered as a digital file (.xls, .xlsx, .dbf, .csv).

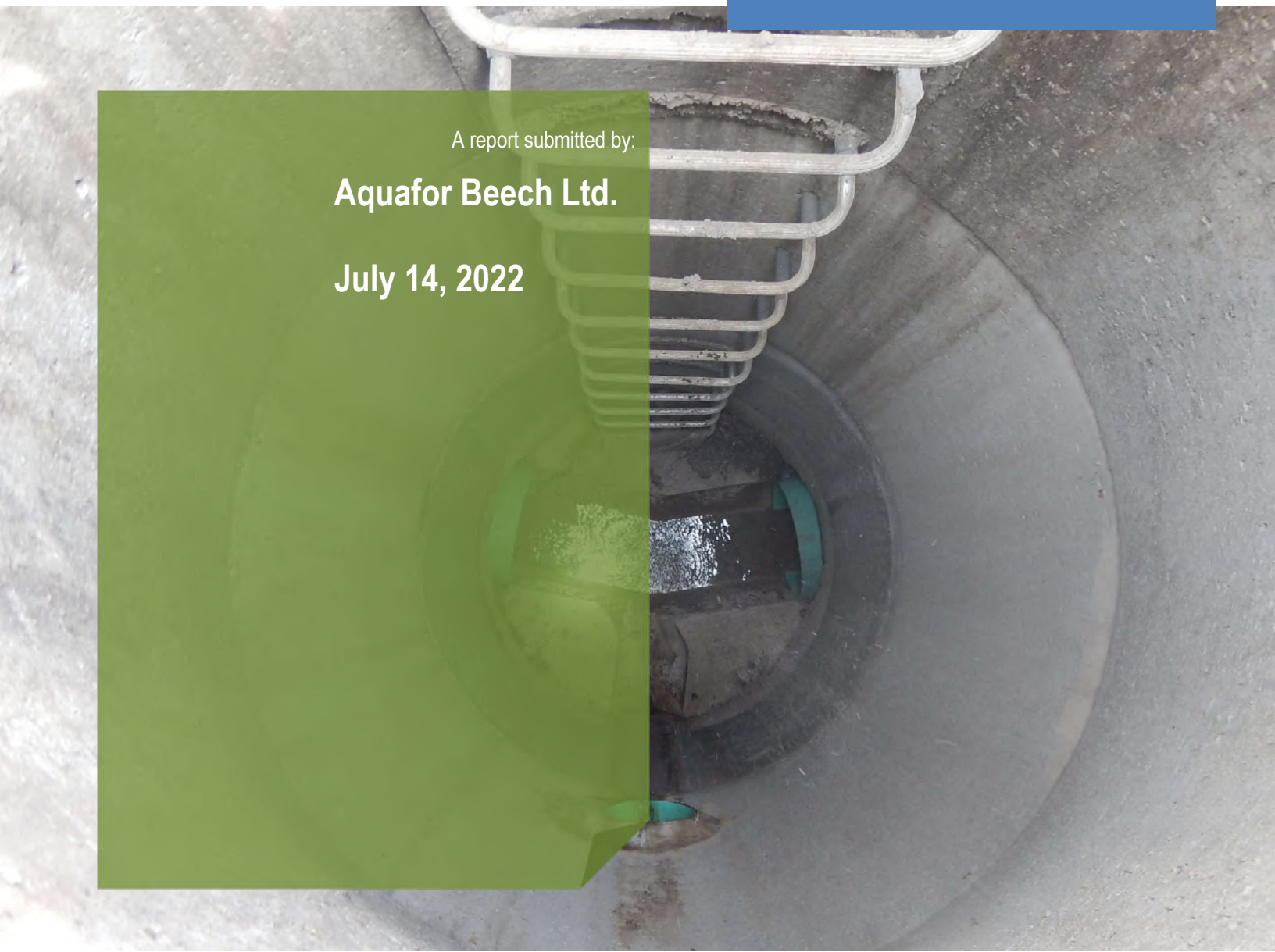
Appendix B: Enhanced Stormwater Runoff Monitoring Program

Submitted to:

The City of Guelph

ENHANCED STORMWATER RUNOFF MONITORING PROGRAM

CITY OF GUELPH SWM MASTER PLAN



A report submitted by:

Aquafor Beech Ltd.

July 14, 2022

1. Introduction

Aquafor Beech Limited has been retained to complete consultant services for the development of a Stormwater Management Master Plan (SWMMP) for the City of Guelph. These services will update the 2012 SWMMP (completed by AMEC) to meet the current needs of the City, following the Municipal Class Environmental Assessment (EA) process, and, in doing so, develop a long-term plan for safe and effective management of stormwater runoff from urban areas while improving the ecosystem health and ecological sustainability of the Eramosa and Speed Rivers and their Tributaries.

A key component of the SWMMP is the development of a comprehensive City-wide integrated hydrologic, hydraulic, and water quality simulation model using PCSWMM for the purpose of study area characterization and impact assessment.

An important element in the development of any comprehensive model is the incorporation of a thorough monitoring plan that details techniques, equipment and industry standards related to real-time, cloud and linked monitoring systems and approaches to obtain representative data of real-life scenarios.

A monitoring program provides important information in regards to key characteristics of the stormwater water system within a study area; and the results obtained from flow monitoring programs are then utilized for the proper calibration of the stormwater network hydrologic and hydraulic computer models. The calibration process results in more accurate model representations of the existing stormwater network, which acknowledges the adaptive environmental management process.

The following sections provide:

- A general overview of stormwater runoff monitoring
- A review of the 2012 SWMMP monitoring program
- Discussion of the measurement of precipitation relating to stormwater monitoring
- Summary of the means and methods for flow monitoring, calibration and validation
- Discussion and comparison of two (2) alternative monitoring approaches for use in this SWMMP
- The financial implications

2. General Stormwater Runoff Monitoring Overview

Stormwater flow monitoring programs provide valuable information to better understand the functionality of existing stormwater infrastructure. They generate information that allows for a better understanding of the existing level of service, definition of problem areas together with direction as to where subsequent efforts should be spent as means of mitigating risks and enabling fast decision making.

The development and implementation of a flow monitoring program involves several activities, including:

1. Supply of flow monitoring devices and rain gauges (if required), and installation at the specified locations;
2. Field verification and calibration of installed equipment;
3. Collection and analysis of data;
4. Completion of monitoring reports;
5. Removal of flow monitoring equipment after completion of monitoring period;

The purpose of the monitoring program is to obtain real-life data in regards to both precipitation and the associated stormwater runoff. In order to obtain representative data that can be used for calibration purposes, it is recommended that the monitoring extend for a period of time sufficient to capture a minimum of six (6) significant storm events, which

are typically defined as storm events with total rainfall depth of 10mm or greater, over a storm duration of three (3) hours or less. Ideally one of either the 2-year or 5-year storm event shall be captured.

In order to obtain representative data, it is recommended that the monitoring period extends from early Spring until late Fall, typically from March to December, for a total of nine (9) months of continuous monitoring for each location selected.

The duration is weather dependent and may require more than nine (9) months to collect the necessary information. A provision of an additional nine (9) months of monitoring is recommended to be included in any program to account for the possibility of dry conditions being predominant during monitoring period, impeding the capture of the required significant storm events.

3. 2012 Monitoring Study

A stormwater flow monitoring program was carried out as part of the City of Guelph Stormwater Management Master Plan, developed by AMEC in 2012. The monitoring program included continuous water level and rainfall monitoring, as well as discrete in-situ stream velocity monitoring for the purpose of calibrating and verifying the hydrologic drainage network modelling. All monitoring points were located in creeks throughout the City.

Monitoring activities started on June 25, 2010 and ended on December 3, 2010. The details of the various monitoring locations and dates are summarized below in **Table 3-1**, and shown in **Figure 3.1**. Two rounds of water level/flow monitoring were conducted, with four sites per round.

Table 3-1 - 2012 Monitoring Program Location Details

Round 1 (June 25 – September 1, 2010)		**Round 2 (September 21 – December 3, 2010)**	
Location Name	**UTM (Approximate)**	**Location Name**	**UTM (Approximate)**
Willow West (WW06)	17 T 556509 m E 4820128 m N	NW Channel (NW04)	17 T 557123 m E 4821784 m N
Waverly (US03)	17 T 559610 m E 4824492 m N	Woodlawn (US10)	17 T 558550 m E 4823994 m N
Railway (LS02)	17 T 559208 m E 4820411 m N	Ward 1 (HD02)	17 T 562043 m E 4822544 m N
Stone Road (LS05)	17 T 560727 m E 4817618 m N	Schroder (HD02)	17 T 562572 m E 4823077 m N

Data Loggers at these locations (Solinst Leveloggers) recorded water levels at 5-minute increments, with barometric correction data applied from another of AMEC's monitoring program site. A geodetic survey was conducted to obtain a cross-section and channel profile at all locations. Periodic in-stream velocity measurements were also taken throughout the monitoring program to enable the calculation of observed flow – surface water level elevations. These elevations were then used to fit a rating curve, based on the previously noted surveyed cross-sections and the hydraulic modeling program HEC-RAS v.4.0.

A rainfall gauge was installed on the roof of the new City Hall for the entire duration of the monitoring program. Twelve (12) significant storm events with total rainfall depth ranging from 11.4mm to 38mm were observed between June 25, 2010 and December 3, 2010.

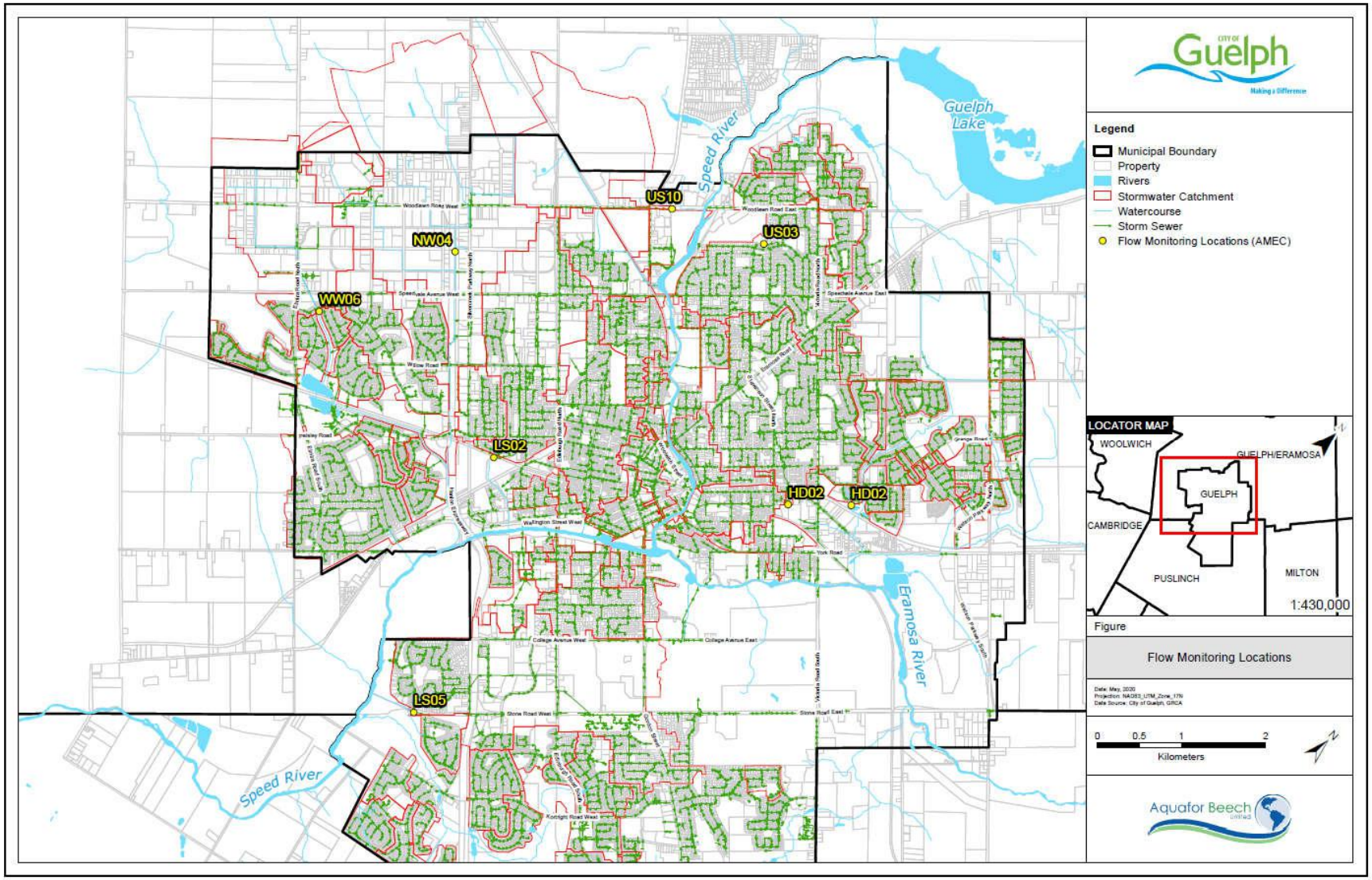


Figure 3.1 - 2012 Flow Monitoring Locations

4. Measurement of Precipitation

Total rainfall can be measured by a network of rain gauges spread throughout the study area to provide a representative coverage of the whole area. Rain gauges are selected based on their proximity to each monitoring station. The City of Guelph currently has two (2) rain gauges reporting to FlowWorks:

1. West End Community Centre, and
2. Helmar Well.

The City operates four (4) additional rain gauges not connected to FlowWorks in other locations, including at:

1. FM Woods,
2. Waste Water Treatment Plant,
3. Arkell 15 Well, and the
4. Emergency Services Building

Additionally, the GRCA operates two (2) rain gauges near Guelph, including one at Guelph Lake and one where Wellington Road 32 crosses the Speed River. These gauges are shown in **Figure 4.1**.

This existing network of rain gauges provides good coverage to the City, with most of the City within a 4 km radius of a rain gauge. To improve the rain gauge coverage, the addition two rain gauges is recommended to increase the existing coverage to a 3 km radius for most of the City, as shown in **Figure 4.2**.

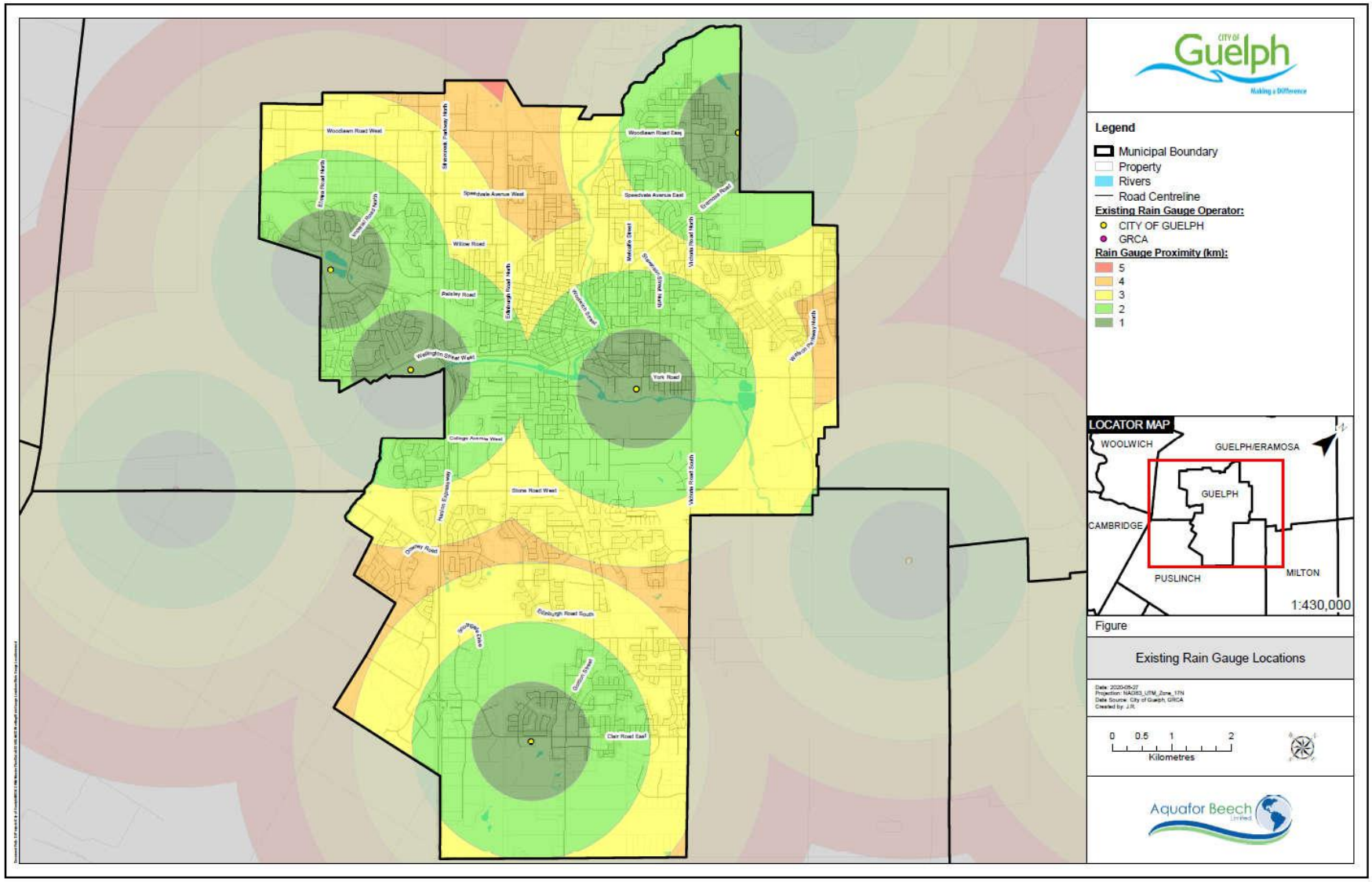


Figure 4.1 - Existing Rain Gauge Network

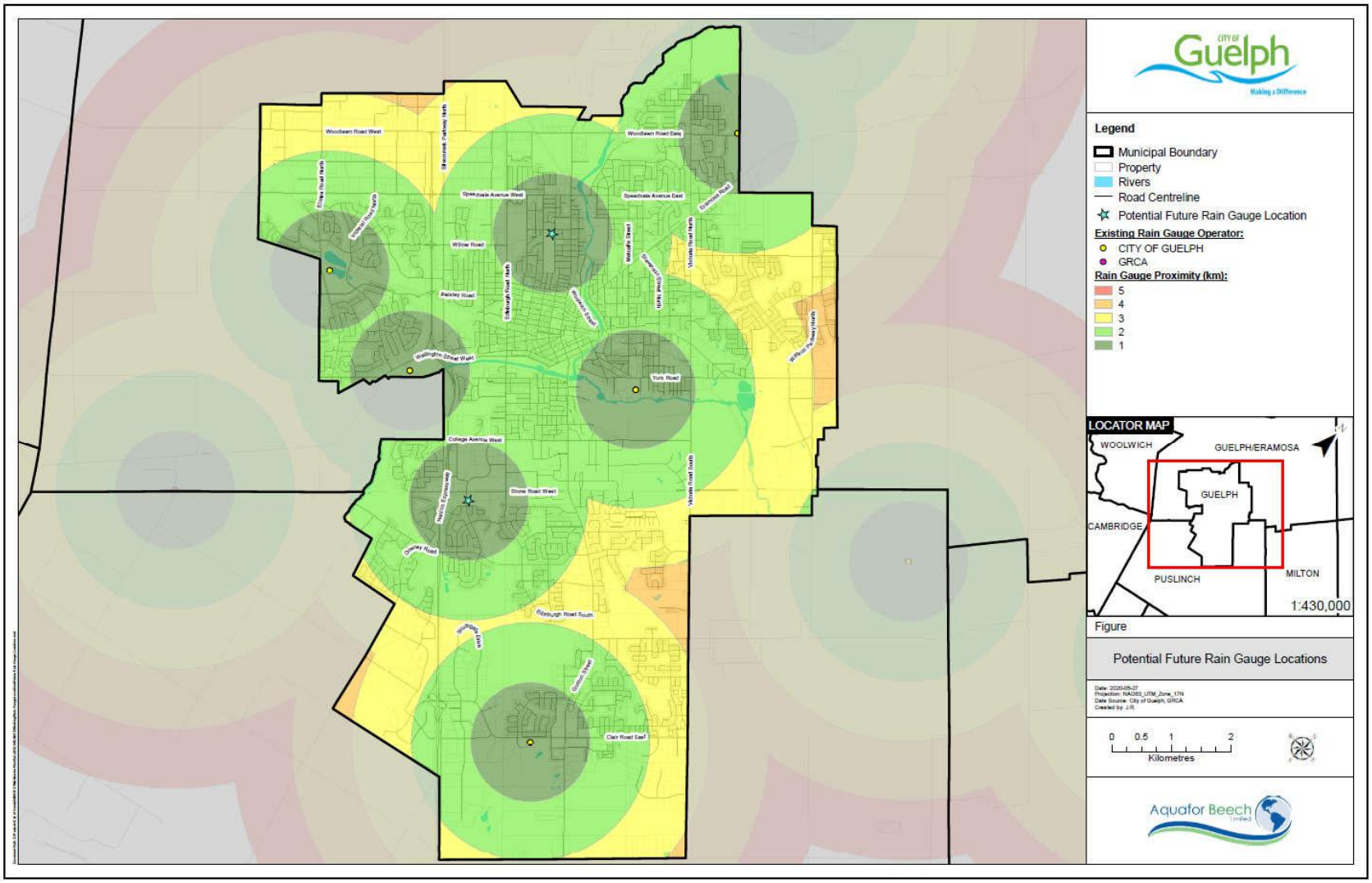


Figure 4.2 – Potential New Rain Gauges Locations

5. Measurement of Flow, Calibration and Validation

The monitoring locations shall be selected based on numerous factors, including:

1. Coverage of full range of land use types in the study area, isolating land use types where practical;
2. Coverage of system portions of various ages, both with and without stormwater management included in their original design;
3. Coverage of areas where the existing modeling predicts surcharging from relatively small storm events storm;
4. Coverage of strategic locations where bottlenecks or flooding events have been previously identified;
5. Coverage of key storm sewer outfalls (within 1 to 2 pipes of them);
6. Incorporation of areas where ground water tables are known to be high since these could have excessive base infiltration which would reduce their effective level of service;
7. Selected locations shall have satisfactory hydraulic sewer conditions in order to allow for the highest accuracy and reliability of measurements;
8. Selected locations are ideally easy to access, preferably away from areas requiring high-traffic control or locations of deep sewers;
9. Coverage of areas with known problems;
10. Selected monitoring points shall be located in representative catchment areas, such that the hydrologic component of the hydraulic model can be calibrated.

The selection of 8 to 10 sites, in accordance with the requirements outlined above, is considered sufficient for a good representation of the study area land use. After selection of the monitoring locations, site visits are typically undertaken to ensure that the hydraulics at the site are suitable for obtaining representative information.

The installation of the monitoring equipment is carried out following the selection and field evaluation of the monitoring locations. The monitoring equipment can vary depending on specific site conditions and the desired information to be collected. In general, the equipment shall be able to capture rainfall records, flow levels and velocity on a continuous basis, and also be able to address backwater issues and surcharging. Monitoring equipment shall be preferable installed within the sewer network itself, rather than of instream.

Model Calibration - The collected flow monitoring information will be used to calibrate and validate the new PCSWMM model developed for the City of Guelph. Calibration involves adjusting key parameters (percent impervious, drainage area, travel length, percent downspout disconnection, catch basin inlet capacity infiltration parameters as well as others) for typically three or more events that were recorded. Calibration should consider peak flow, volume and hydrograph shape. In general, for all studies it was found that the default values used to start the calibration process had to be lowered as the initial modelled flow volumes and peak flows far exceeded the monitored values due to factors such as split drainage from homes, poor road and property drainage and areas adjacent to parks. A similar adjustment may be required with the expanded model and the key parameters will be adjusted on a case by case basis once the runoff surfaces have been recalculated based on land use. For the calibration of the hydrological and hydraulic detailed model, the performance criteria, which is consistent with our approach, will be set at: **+/- 20% on runoff volumes and +/- 20% on peak flows.**

Model Validation - The model is then validated using three different events to confirm suitability of the results.

Once the calibration/validation process is carried out for the sewersheds where flow monitoring was provided then the appropriate key parameters are applied to the remaining sewersheds to provide flows for existing conditions as well as design events.

6. Proposed Monitoring Program

Two (2) alternatives are proposed as part of the stormwater flow monitoring program.

1. **Alternative 1: Consistent with the 2012 SWM-MP** - consists of additional flow monitoring conducted similarly as the 2012 monitoring program, and at the same locations, in order to allow for comparison of current flow levels with the results found as part of the 2012 Study. Minor adjustments are also proposed.

2. **Alternative 2: Enhanced Storm Sewer Monitoring Program** - consists of an enhanced monitoring program implemented following all the standards and considerations described in the previous sections, including site selection, installation of new rain gauges and the adoption of high capability flow monitors. The details of both phases are described in the following sections.

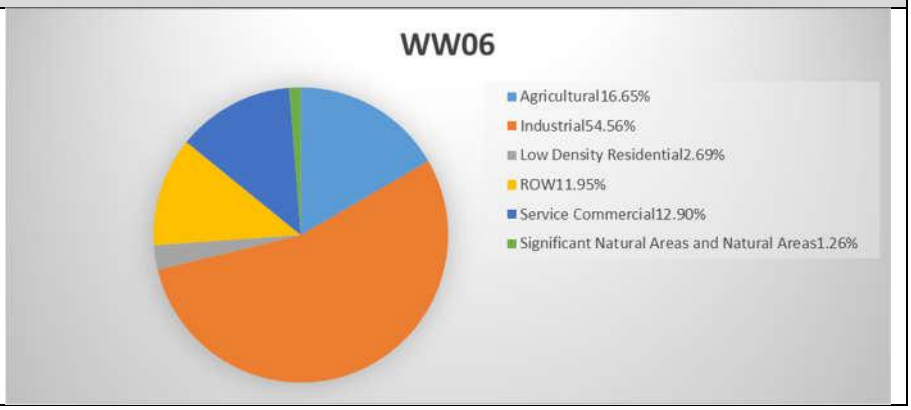
6.1. Alternative 1 – Consistent with the 2012 SWM-MP

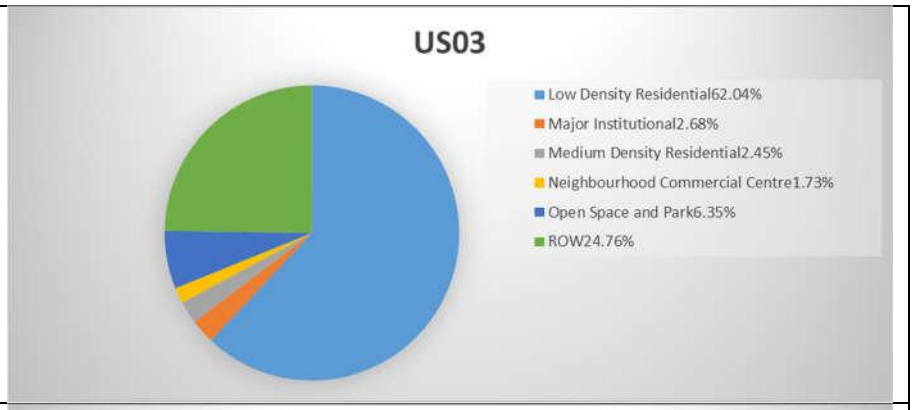
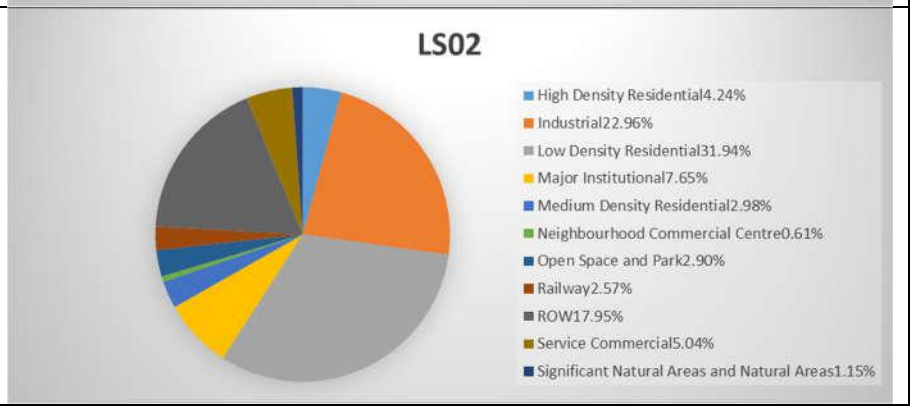
Monitoring alternative 1 is similar to the one developed as part of the 2012 SWMMP, including continuous water level and rainfall monitoring, as well as in-situ stream velocity monitoring in eight (8) different points throughout the City of Guelph. The selected monitoring locations are the same as the 2012 monitoring program, as described in Table 3-1. These locations are distributed among existing creeks within the city.

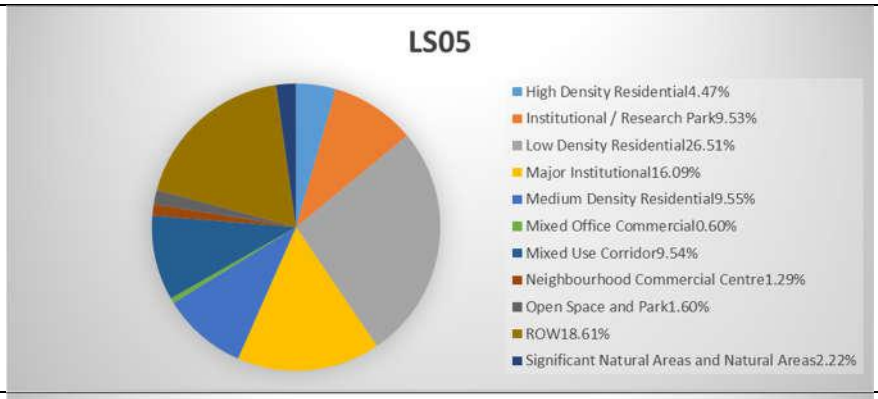
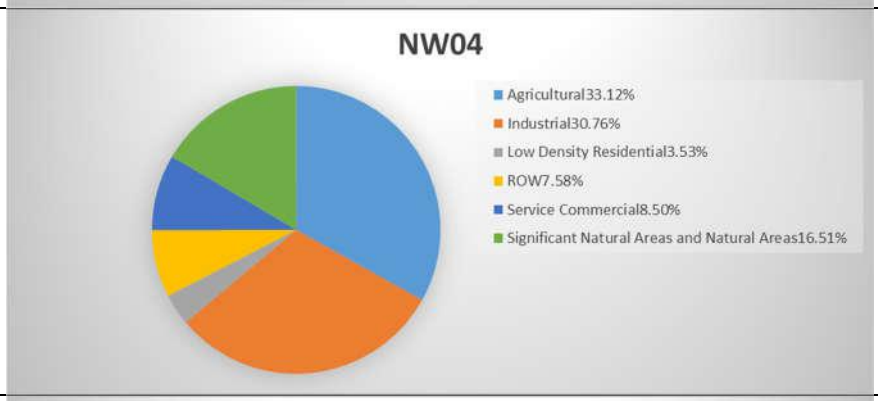
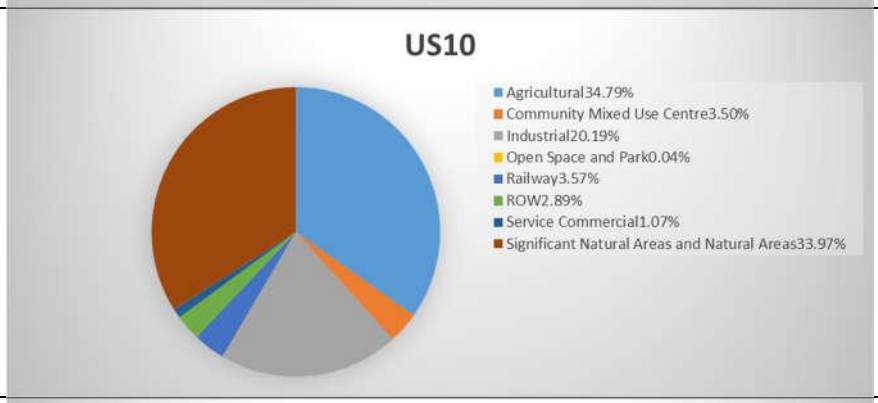
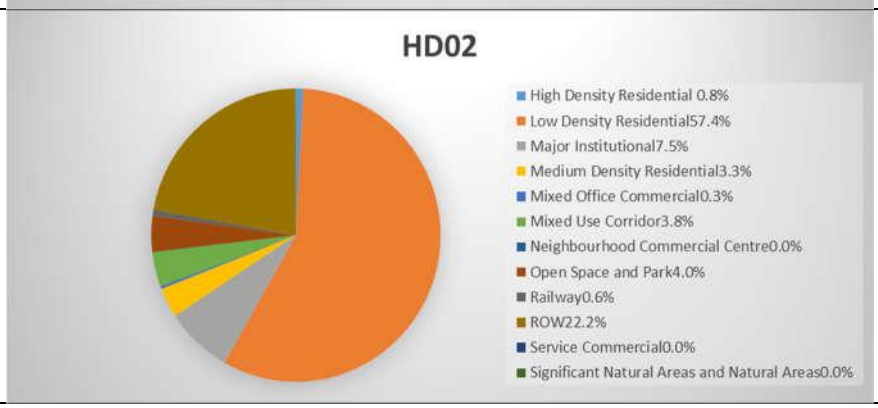
Assessment of Contributing Drainage Areas:

To better understand the characteristics of the contributing drainage area for the various monitoring locations from the 2012 SWMMP, an assessment of the land-uses was completed. Table 6-1 and Figure 6.1 provides a summary of all land-uses as well as the ranking of the top three (3) most prevalent land-uses in each contributing drainage area.

Table 6-1 - Drainage Area Land-uses (2012 SWWMP Monitoring Locations)

Location Name	Major Land uses (top 3)	
Willow West (WW06)	1. Industrial (54.65%) 2. Agricultural (16.65%) 3. ROW (11.95%)	

Waverly (US03)	1. Low Density Residential (62.04%) 2. ROW (24.76%) 3. Parks & Open Space (6.35%)	
Railway (LS02)	1. Low Density Residential (31.94%) 2. Industrial (22.96%) 3. ROW (17.95%)	

Stone Road (LS05)	1. Low Density Residential (26.51%) 2. ROW (18.61%) 3. Mixed Density Residential (9.55%)	
NW Channel (NW04)	1. Agricultural (33.1%) 2. Industrial (30.76%) 3. Natural Areas (16.51%)	
Woodlawn (US10)	1. Agricultural (34.79%) 2. Natural Areas (33.97%) 3. Industrial (20.19%)	
Ward 1 (HD02) & Schroder (HD02)	1. Low Density Residential (57.4%) 2. ROW (22.2%) 3. Major Institutional (7.5%)	

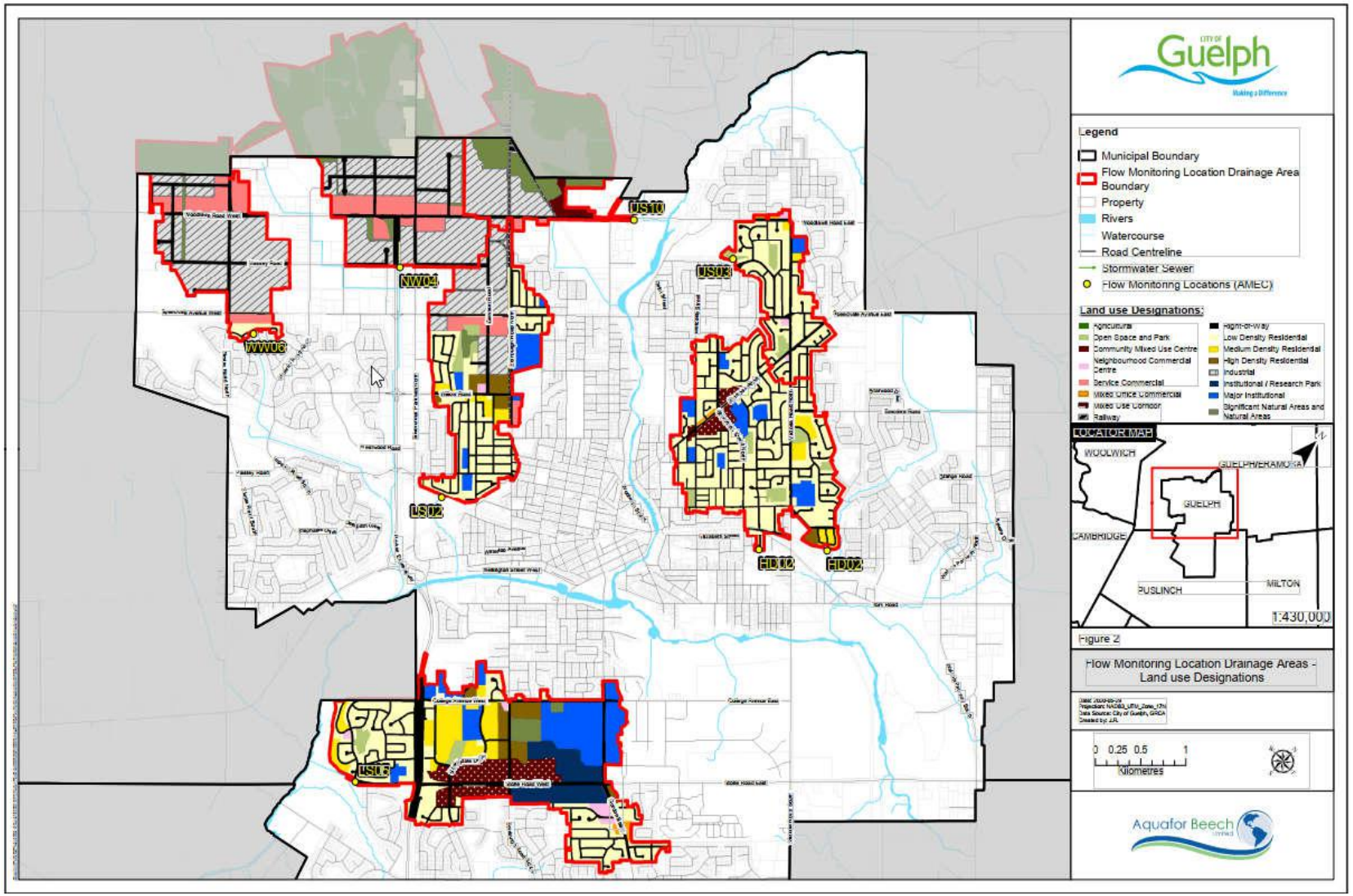


Figure 6.1 - Alternative 1 Contributing Drainage Areas Land Use

Monitoring Parameters and Equipment

The proposed works for Alternative 1 include the supply and installation of eight (8) monitoring stations, each consisting of the following:

- 1 Hobo U-20 Water Level and Temperature (pressure transducer) data logger;
- 1 staff gauge;
- 1 YSI Professional Plus Series multimeter
- 1 SonTek Flow Tracker;
- All associated hardware and housing required for proper functionality of monitoring equipment;

An additional Hobo U-20 logger will be installed at a central location for barometric compensation purposes.

Monitoring will start in July 2020, and is expected to extend during nine (9) months, split into two (2) continuous time periods. The initial monitoring period will undergo from July 2020 until December 2020. Equipment will be removed during the winter and reinstalled in March 2021 for the second monitoring period, which will extend until June 2021, for a total of nine (9) months. Should the City of Guelph decide to implement Alternative 2 prior to the end of the pre-established monitoring period, Alternative 1 will be interrupted and replaced with an enhanced monitoring program, as described in **Section 6.2**.

At a minimum, it is recommended that Alternative 1 be modified to undertake the monitoring of all eight (8) locations simultaneously for a nine-month period, with a provisional period of an additional nine months if required.

It has been observed in past studies of similar nature conducted by Aquafor, that 15-minute logging intervals accurately depict hydrologic responses to rainfall and runoff events. Therefore, Hobo U-20 loggers will be set to record water levels and temperature at 15-minute intervals in order to prolong data storage, battery life and remain consistent with industry standards.

Flow Trackers will be set to collect measurements at appropriate time intervals depending on the size of the watercourse. Water velocity measurements will be collected using the industry standard approach, specifically, for water levels less than 60 cm, velocity measurements will be taken at 60% of the flow depth and for water levels greater than 60 cm, the mean of two (2) water velocity measurements will be taken: one at 20% of the depth and the other at 80% of the depth.

At the time of the flow measurements, field measurements are to be conducted as part of quality control procedures and will include: pH, dissolved oxygen (DO), temperature and conductivity using YSI Professional Plus Series multimeter.

Data Collection and Deliverables

During the first month of the monitoring period, weekly visits will be carried out for inspection of the equipment and QA/QC of the measurements. Data will be collected once a month and will be made available to the City of Guelph in monthly reports.

6.2. Alternative 2 – Enhanced Storm Sewer Flow Monitoring

Monitoring alternative 2 consists of an enhanced monitoring program implemented following all the standards and considerations described in the previous sections, including site selection, installation of new rain gauges and the adoption of high capability flow monitors.

Assessment of Contributing Drainage Areas:

Monitoring alternative 2 consists of an enhanced monitoring program focused in obtaining data from the existing sewer network, rather than from water courses. A secondary assessment of the existing drainage areas will be completed for the selection of eight to ten (10) new monitoring locations within the existing storm sewer network, in accordance with the criteria outlined on Section 5. The layout of the activities conducted as part of alternative 2 are as follows:

- Review of background information in regards to storm sewer network and land use within the City of Guelph for the selection of eight to ten (10) potential monitoring locations;
- The proposed monitoring locations will be submitted to the City of Guelph for review and approval;
- Field inspections will be conducted to assess the suitability for accurate monitoring and proper equipment required for the installation of the monitoring equipment. If necessary, alternative locations can be added to the list of sites to be inspected;
- Following field inspection, eight to ten (10) locations will be selected to be included in the monitoring program;

Monitoring Parameters and Equipment

Monitoring stations will be installed for each location, each consisting of the following:

- Pipeline Model PSA-AV Area Velocity Smart Sensor in combination with a Ru-33 Recording Telemetry Units or equivalent (i.e. Telogs or Tritons). As an option, cellular enable units allowing real-time data can be installed.
- 1 SonTek Flow Tracker (used for discrete flow measurement for logger validation);
- Storm sewer weirs (primary devices) as required;
- All associated hardware and housing required for proper functionality of monitoring equipment;

Data Collection and Deliverables

Monitoring will start upon request of the City of Guelph, and it shall extend during the nine (9) months covering early Spring to late Fall. Depending on the starting date of the enhanced monitoring alternative, it might be necessary to break the monitoring period into two (2) continuous intervals to avoid winter conditions.

A/V smart sensors will be set to record water levels and temperature at 15-minute intervals in order to prolong data storage, battery life and remain consistent with industry standards. It has been observed in past studies of similar nature conducted by Aquafor, that 15-minute logging intervals accurately depict hydrologic responses to rainfall and runoff events. Flows in the sewers will be assessed using discrete measurements via a SonTek Flow Tracker or equivalent. The field program will consist of the following:

- Monthly visits will be conducted at each location for field checks, discrete flow sampling, and sensor cleaning;
- QA/QC will be carried out once a week during the first month of the monitoring program, followed by QA/QC visits monthly during the remainder of the monitoring period;

- Raw field data will be available on a daily basis on the Flow Works data platform. Finalized data will be made available on monthly reports to be submitted to the City;
- After the completion of the monitoring period, all monitoring stations will be removed and final report and documentation provided to the City of Guelph.

Rainfall Monitoring

For alternative 2, rainfall data will be collected from the existing City of Guelph rain gauge network, and correlated with corresponding runoff measurements according to the proximity of the rain gauge and each monitoring station. As discussed on **Section 4** of this report, the addition of two (2) extra rain gauges is recommended to refine the coverage of the City of Guelph rain gauge network.

The Meteorological Service of Canada has published siting standards for meteorological observing sites (MSC, 2001), including precipitation stations. The standards state that the site should be located:

1. On open, level ground with a primary area at least 15m x 15m covered with short grass or at least on natural ground with a secondary turf covered area of at least 30m x 30m, surrounded as by a single rail, cable, or chain link fence, and a protected area of 90m x 90m centered on the primary area.
2. Such that sensors shall be at a distance from vertical obstructions of four times the height of the obstruction for precipitation gauges.
3. In an area which provides ease of access for the observer and for maintenance of instruments and the installation of electrical ducts.

The standards state that locations that should be avoided for the installation of rain gauges include:

- the top of hills.
- in hollows, at the bottom of narrow valleys, and near hills or ridges, or cliffs.
- near isolated ponds or streams.
- near roads where snow from snow clearance operations, or dust, can affect the site.
- where there is excessive human or animal traffic.
- where excessive drifting snow accumulates.
- near vehicle parking areas.
- where heat is exhausted by vehicles or buildings

Although technical guidance generally suggests that siting precipitation and temperature sensors on rooftops should be avoided due to wind turbulence and rooftop temperature bias, rooftop installations are common in urban setting as a result of limited availability of accessible open space. Rooftops also have the advantage of being close to an electrical source to power heaters and telemetry (note: solar is another option), and are generally safe from accidental damage or vandalism by site users including the public.

There are several types of precipitation gauges, with the two most common being tipping bucket gauges and weighing bucket gauges. A tipping bucket precipitation gauge is recommended due to the low capital cost and minimal maintenance requirements apart from calibration. It consists of a funnel that collects and channels the onto a tipping device. After a pre-set amount of precipitation falls, the lever tips, dumping the collected water and sending an electrical signal. These devices should be equipped with telemetry and incorporated into the City's data delivery and data management system.

The two (2) recommended permanent or temporary locations as shown in **Figure 4.2** and include the rooftops of:

1. the Scottsdale Branch of the Guelph Public Library, and
2. the Exhibition Park Arena.

- Permanent Rain Gauges – can be supplied by the City of Guelph and installed by Aquafor Beech Ltd. as part of the monitoring program tasks.
- Temporary Rain Gauges – can be supplied and installed by Aquafor Beech Ltd. as part of the monitoring program tasks. Inspection and data collection of all temporary rain gauges to be part of this monitoring program will follow the same schedule as the inspection and data collection of the flow monitoring devices, including weekly visits during the first month of the monitoring period and subsequent visits monthly for further inspection and data collection. Rainfall data will be available on a monthly basis as part of the monthly monitoring reports.

7. Financial Implications

To accurately assess the financial implications, a full costing must be completed for Alternative 2. However, to provide a relative sense of the monitoring effort the following Class C cost estimate has been provided for Alternative 2 and compared to the costs of Alternative 1 as outline in the current scope of work. Should the City wish to proceed with an enhanced monitoring program, Aquafor will provide a detailed cost estimate for review and approval.

Alternatives	Base Cost	Additional Fees	Notes
Alternative 1 – 2012 SWM-MP	$19,890	$17,000	Additional fees required to undertake continuous monitoring at all 8 sites simultaneously
Rain Gauge (2)	n/a	$6,500	Assumes the Aqufor supplies the equipment as part of a temporary installation
TOTAL	**$19,890**	**$23,500**	
Alternative 2 – Enhanced Sewer Monitoring			
Monitoring Program Development	n/a	$15,000	Reallocation of the base costs can be used to negate this cost
Storm sewer Monitoring	n/a	$60,000	Assumes the City purchases equipment as part of a permanent installation
Storm sewer Monitoring	n/a	$140,000	Assumes the Aqufor supplies the equipment as part of a temporary installation
Rain Gauge (2)	n/a	$6,500	Assumes the Aqufor supplies the equipment as part of a temporary installation
TOTAL	**n/a**	**$81,500 - $161,500**	