Prepared for:
The City of Waterloo

STORMWATER MANAGEMENT MASTER PLAN (SWM-MP)

MUNICIPAL CLASS ENVIRONMENTAL ASSESSMENT

Precipitation Gauge Memo

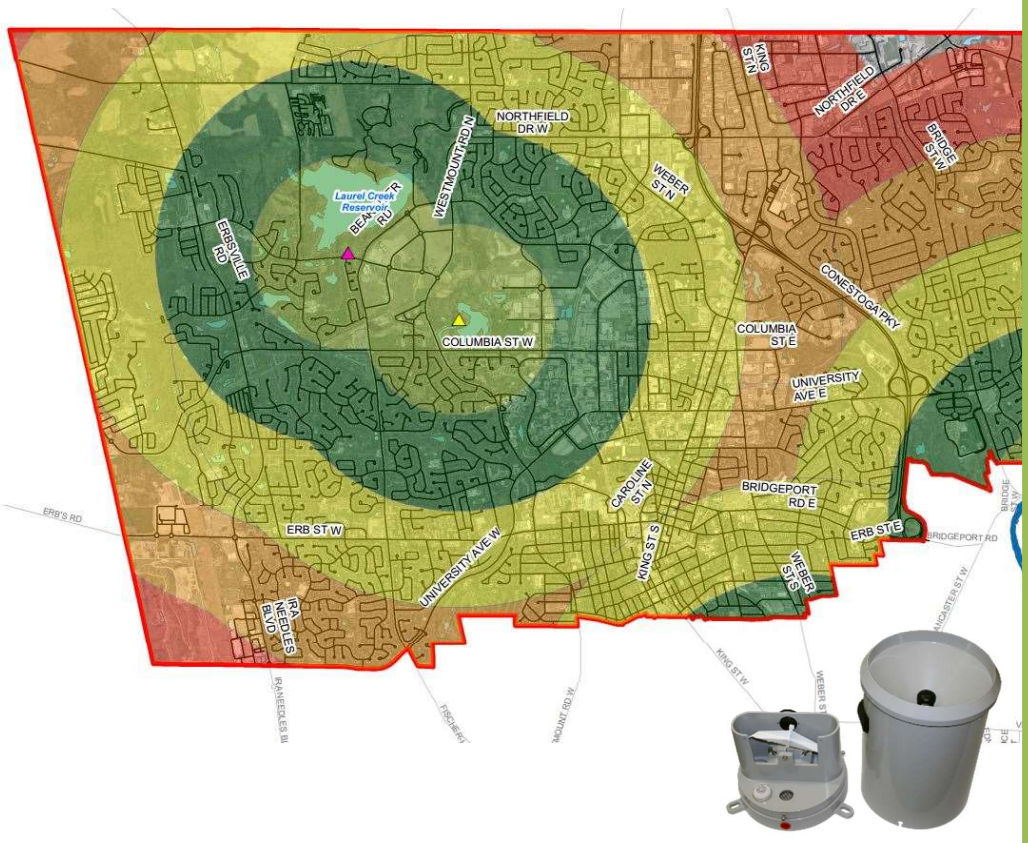

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Table of Contents

1.0 Introduction

It is important for managers of municipal infrastructure to understand the response of stormwater conveyance and treatment networks as well as wastewater conveyance systems to extreme rainfall events. It is also in the best interest of the municipality to quantify the vulnerability of these systems to natural hazards such as riverine flooding and erosion which are directly related to extreme rainfall events and/or long-term hydrologic patterns. A robust and well-designed precipitation monitoring network allows hydrologists and stormwater engineers to establish a level of service associated with normal operating ranges for stormwater systems as well as precipitation thresholds associated with significant impacts such as:

- Sewer surcharging;
- Local urban flooding;
- By-pass of treatment devices;
- Spills from private drainage networks and sub-catchments; and
- Overtopping of roadways, bridges and pathways.

Long-term precipitation monitoring also allows for updates to Intensity-Duration-Frequency (IDF) curves used by stormwater practitioners to consider risk when designing stormwater infrastructure. Even though IDFs are regularly updated, the increased frequency and severity of rainfall events resulting from climate change presents a risk to much of Ontario's stormwater infrastructure. Municipal engineers are typically concerned with short duration events that cause flooding very quickly in urban settings with high impervious cover and short times of concentration. These short-term events (typically 2 hours or less) are often the product of thunderstorms that may be associated with convective heating or fast-moving storm fronts. These storm fronts may be highly localized and can go unrecorded if precipitation monitoring stations are spaced too widely apart. Knowing the magnitude of precipitation events that damage to public infrastructure and/or private property is important for reducing risk and liability associated with the expected level of stormwater service.

Lastly, precipitation monitoring undertaken concurrently with flow monitoring allows hydrologic and hydraulic models to be calibrated via measured precipitation-runoff events. Calibrated models more accurately allow municipalities to evaluate their stormwater management systems to ensure they are functioning as designed.

2.0 Background

The largest precipitation monitoring network in Canada is run by Environment and Climate Change Canada (ECCC). The closest ECCC precipitation gauge to the City of Waterloo is located at the Region of Waterloo International Airport; however, this is more then 8 km away from the City boundary and should only be used for geographical data interpolation as a last resort.

The Grand River Conservation Authority (GRCA) operates 24 precipitation gauges across their watershed to provide data for; flood forecasting and warning activities, reservoir management, and to establish long-term climate trends. One precipitation gauge is located in the City of Waterloo just north of Laurelwood Drive on the Laurel Creek Park property. Another GRCA

precipitation gauge is located north of Bloomingdale Road in Schaefer Park. This precipitation gauge is outside of the City but is within 1 km of the City boundary and can be used for approximating precipitation in the southeast quadrant of the City.

The University of Waterloo Department of Civil and Environmental Engineering operates a weather station which includes a precipitation gauge for scientific and educational purposes. The gauge is located in the City, just west of Columbia Lake on the North side of Columbia Street West. This gauge is approximately 1.4 km southeast of the Laurel Creek gauge operated by the GRCA.

The City of Kitchener operates a precipitation gauge located on Kitchener City Hall (200 King Street West, Kitchener). This gauge is within 2 km of the City of Waterloo boundary and can be used to approximate precipitation in the south-central area of the City.

All precipitation within the City of Waterloo (GRCA-Laurel Creek and University of Waterloo) and within 2 km of the City boundary (GRCA-Schaefer Park and City of Kitchener) are shown on **Figure 1**. As is demonstrated in the figure, there is good coverage in the central area of the City but there are areas within the northeast, southwest and northwest quadrants of the City that are 4km or more from a precipitation gauge (shaded red in the figure).

3.0 Methodology

In order to provide better coverage of precipitation monitoring within the City of Waterloo, an analysis of publicly owned properties in areas that were greater than 4 km from precipitation gauges was undertaken.

Northeast

Adding a precipitation gauge on the City's RIM Park property would provide valuable coverage in the northeastern portion of the City. Opportunities include incorporating a precipitation gauge on the roof of the Manulife Sportsplex or at the GreenLab complex adjacent to the soccer fields. The impact of a precipitation gauge on this property is shown in **Figure 2**.

Southwest

Adding a precipitation gauge on the Region of Waterloo's Waste Management Centre property would provide valuable coverage in the southwest portion of the City. Alternative properties in the same vicinity are any municipally-owned property in the proposed employment lands to be developed on the former Waterloo Golf Academy Property, or the Region of Waterloo Emergency Services property on Fire Tower Road just outside the City boundary. The impact of a precipitation gauge in the southwest quadrant of the City is shown in **Figure 2**.

4.0 Siting a Precipitation Gauge

ECCC has published siting standards for meteorological observing sites (Environment Canada – Siting Standards for Meteorological Observing Sites, 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 for sites that should be avoided include:

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

Although technical guidance generally suggests that siting precipitation and temperature censors 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.

5.0 Equipment Recommendations

There are several types of precipitation monitors. The two most common types are the tipping buckets and the weighing buckets. A tipping bucket precipitation gauge is the better option due to the low capital cost and minimal maintenance requirements apart from calibration. A tipping bucket precipitation gauge 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. To allow the device to collect a water equivalent of frozen precipitation (sleet, snow, hail, etc.), the device should be equipped with a heating device which melts frozen precipitation on the funnel. These devices should be equipped with telemetry and incorporated into the City's data delivery and data management system.

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FIGURE 1:
RAIN GAUGE PROXIMITY ANALYSIS

- Roads
- Rivers

Rain Gauge Operator

- GRCA
- Kitchener City Hall
- UofW

Rain Gauge Buffer Distance (km)

- 4-5km
- 3-4km
- 2-3km
- 1-2km
- 0 -1km

0 0.5 1 Kilometers

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Base data provided by The City of Waterloo, 2017.

Date: September 2018

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FIGURE 2:
FUTURE RAIN GAUGE PROXIMITY ANALYSIS

- Roads
- Rivers

Rain Gauge Operator

- GRCA
- Kitchener City Hall
- UofW
- Recommended Rain Gauge Locations

Rain Gauge Buffer Distance (km)

- 4-5km
- 3-4km
- 2-3km
- 1-2km
- 0-1km

0 0.5 1 Kilometers

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Base data provided by The City of Waterloo, 2017.

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References

1. Environment Canada, “Siting Standards for Meteorological Observing Sites”- MSC STDS 2 – 2001
2. National Oceanic and Atmospheric Administration’s National Weather Service, “Cooperative Observer Program- Proper Siting”, 2009