Bayfield Beach Stormwater Monitoring
2016

Prepared for the Bluewater Beach Committee

by
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Photo: Rain garden installed by community to help manage stormwater runoff.

Introduction

Communities along the southeast shore of Lake Huron largely depend on the tourism industry and the abundance of swimming, fishing and boating opportunities that the lake provides. Increased levels of bacteria, nutrients and sediment however, can result in degraded water quality and ultimately limit recreational opportunities. These contaminants are largely associated with both agricultural and urban non-point source pollution that gets washed into rivers, creeks and storm sewers during snow melts and rain events.

Since 2011 residents of the Main Bayfield watershed have been actively involved in a community-based watershed planning process to help improve water quality within the Bayfield River, which flows into Lake Huron at the village of Bayfield. The Bayfield Main Beach has been a recipient of the internationally-recognized Blue Flag program, which among other things, identifies beaches that meet strict criteria for water quality. In order to help maintain this certification and support water quality initiatives in the area, the Bluewater Beach Committee was formed. This partnership involves the Pioneer Park Association, Municipality of Bluewater, Huron County Health Unit, and Ausable Bayfield Conservation Authority (ABCA).

As the village of Bayfield has stormwater outlets along the beach, a stormwater monitoring program was initiated in the summer of 2014. The goal of this program was to gather some initial water quality data from the stormwater outfalls along the beach at the village of Bayfield. This program was continued in 2015 and 2016, and will help in determining whether the stormwater from the village of Bayfield might be impacting the beach and nearshore water quality.

Methods

Site Description

Water quality was monitored at two stormwater outfalls along the beach adjacent to the village of Bayfield, Ontario, and at one culvert along the road (Tuyll Street) adjacent to the shoreline (Figure 1). The Colina outfall (125 mm pipe) outletted at the top of the bank, while the Delevan outfall (750 mm) extended down the bank. Both were designated stormwater outlets for the village of Bayfield (BM Ross 2014). The Tuyll site was a culvert (~610 mm in diameter) running perpendicular to the shoreline at which overland flow had been observed. According to a report on storm drainage for the village of Bayfield (BM Ross 1985), existing tile drainage for the most developed portion of the village is directed towards the Delevan outfall or an open water course that discharges at the top of the bank (*i.e.*, Tuyll).

The village of Bayfield, which is within the Municipality of Bluewater, is mostly residential with businesses along its main street. It is serviced by the Bayfield Sewage Treatment Plant.

Water Sampling

Beginning in June water samples were collected every other week until the end of August. These routine monitoring events took place on predetermined dates. They were not initiated by wet weather, but typically occurred during a dry weather day (dry sampling). Water samples were also collected after rain events (event sampling), which were characterized as greater than 2.6 mm of rain in less than one hour. If a rain event occurred overnight, sampling was done as soon as possible the following morning.

Grab samples were collected by holding the sample bottle within the flowing water from the outfall, and without touching surrounding surfaces. If water was not flowing from the outfalls, no sample was collected, regardless of whether ponded water was observed below the outfall.

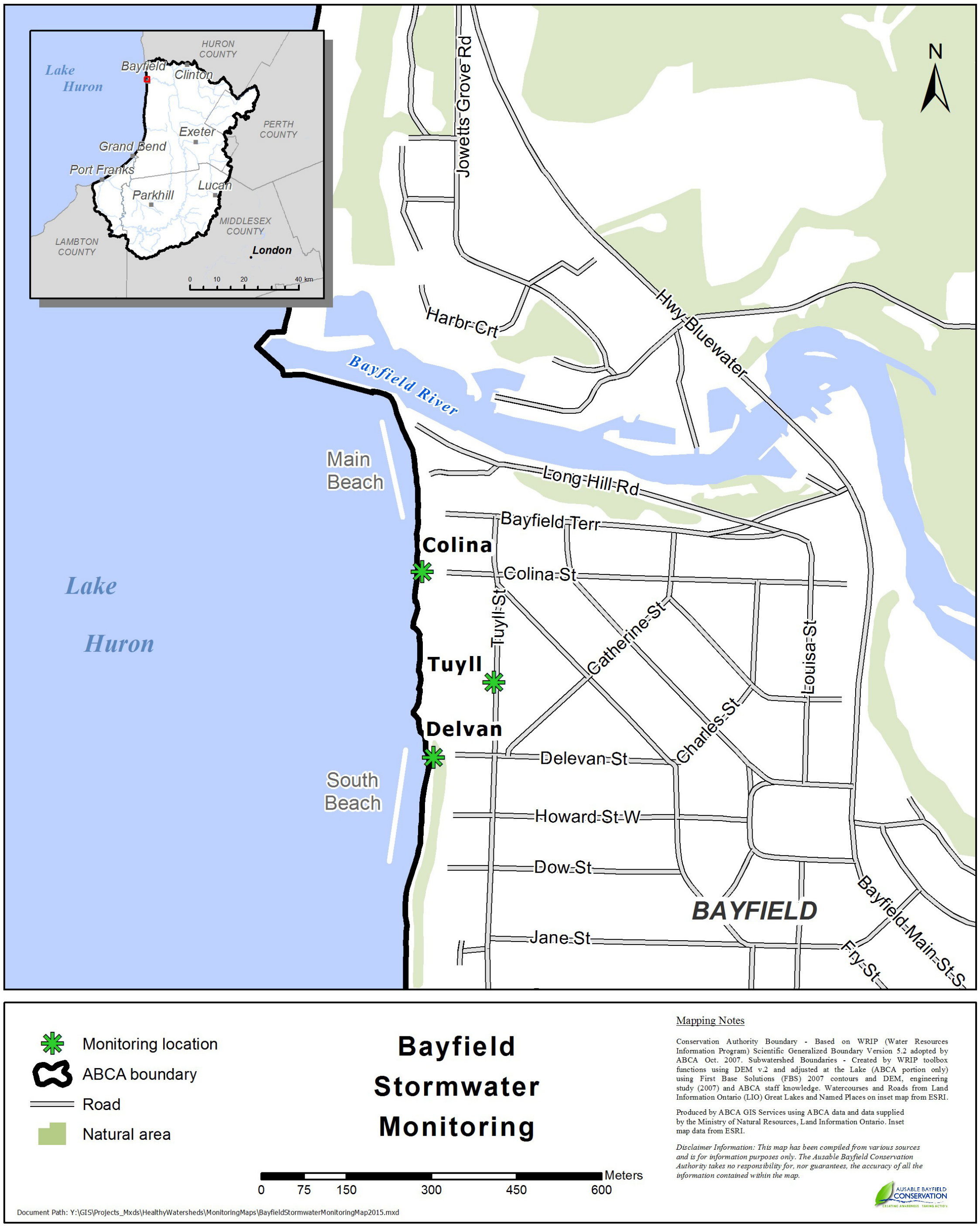

Figure 1. Approximate locations of three stormwater monitoring sites and public beaches along the Lake Huron shoreline in Bayfield, Ontario.

Water samples were analyzed by ALS Environmental in Waterloo, Ontario, to determine the concentrations of *Escherichia coli* (*E. coli*) in colony forming units per 100 millilitres of water (cfu/100 mL), total phosphorus (TP) and soluble reactive phosphorus (SRP) in mg/L.

Data Interpretation

Geometric means were used to summarize *E. coli* and TP concentrations for each monitoring site. A geometric mean is a type of mean or average whereby the effect of uncommonly high or low concentrations on a mean is reduced. Geometric means (dry and event sampling) were calculated for each monitoring site for the months of June through August 2016. These geometric mean concentrations were compared to provincial guidelines for *E. coli* and TP. SRP and TP geometric mean concentrations were used to determine SRP as a percentage of the TP. In some cases SRP concentrations exceeded TP concentrations. These exceedances result from the analysis of separate aliquots of each water sample. Where SRP concentrations were higher than TP concentrations, percentages were determined to be 100 percent. Detection limits were used as actual concentrations for any *E. coli*, TP or SRP concentrations that came back from the lab as less than the detection limit.

Daily precipitation levels were helpful for understanding some of the variability in *E. coli* and phosphorus concentrations. Precipitation data were obtained from the rain gauge maintained by the ABCA in Bayfield, Ontario.

Results and Discussion

Escherichia coli

Escherichia coli (E. coli) are fecal coliform bacteria commonly found in the intestinal tract of warm-blooded animals. While *E. coli* itself is not a threat to the environment, its presence in water collected from drains may indicate contamination by other harmful bacteria, viruses, or parasites that are associated with animal wastes. Sources may include human, pets, livestock and wild animals. The Ontario Ministry of Health and Long-term Care established a recreational guideline for *E. coli* of 100 colony forming units (cfu) per 100 mL (MOEE 1994).

Concentrations of *E. coli* at the outfalls ranged from 10 cfu/100 mL at Tuyll (July 4 and 18) and Delevan (July 18) to 9500 cfu/100 mL at Tuyll (August 16) (Table 1). Concentrations of *E. coli* at Delevan and Tuyll were higher following rain events than routine (dry) sampling dates (no samples were collected from Colina on routine sampling dates as there was no flow). Elevated concentrations were greater than the provincial guideline, and exceeded it by one order of magnitude after one of the rain events (*i.e*., August 16 at all three sites). Only once did an elevated concentration occur during a period without rainfall (*i.e.*, June 6 at Delevan). (Please refer to the Appendix for precipitation graphs.) This suggests that factors other than rainfall may influence bacteria concentrations at this outfall.

Geometric mean *E. coli* concentrations at the outfalls ranged from 28 cfu/100 mL at Tuyll to 62 cfu/100 mL at Delevan for dry sampling (no samples for Colina during dry sampling), and increased to 396 cfu/100 mL at Tuyll to 562 cfu/100 mL at Delevan following rain events (event sampling) (Figure 2). Geometric mean *E. coli* concentrations at both Delevan and Tuyll exceeded the provincial water quality guideline following rain events. A geometric mean for Colina was not calculated as there were only two samples collected after rain events.

Since 2014, the median *E. coli* concentration for dry sampling at both Tuyll and Delevan has been below the provincial guideline with the exception of Delevan for the 2014 year (Figure 3). Median *E. coli* concentrations for event sampling have exceeded the guideline every year.

Table 1. *Escherichia coli* concentrations, in colony forming units (cfu) per 100 mL on each sampling day in 2016 for three stormwater monitoring sites draining into Lake Huron along the shoreline of Bayfield, Ontario. Highlighted values denote concentrations that exceed the Ontario Ministry of Health and Long-term Care guideline of 100 cfu/100 mL. Shaded columns indicate event sampling dates.

Site	Jun 6[b]	Jun 16	Jun 20	Jul 4	Jul 14	Jul 18	Jul 25	Aug 2	Aug 14[b]	Aug 15[b]	Aug 16[c]	Aug 21[b]	Aug 29
Colina	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	3100	700	ns
Tuyll	40	70	20	10	90	10	200	20	800	130	9500	400	70
Delevan	280	220	30	20	70	10	800	60	1900	240	4500	300	140

[a] More than 10 mm of rainfall in 24 hours prior to sampling.
[b] More than 10 mm of rainfall in 48 hours prior to sampling.
[c] More than 70 mm of rainfall in 3 days prior to sampling.
ns = no sample was collected due to lack of flow.

Table 2. Total phosphorus (TP) and soluble reactive phosphorus (SRP) in mg/L on each sampling day in 2016 for three stormwater monitoring sites draining into Lake Huron along the shoreline of Bayfield, Ontario. Highlighted values denote concentrations that exceed the Provincial Water Quality Objective (PWQO) of 0.030 mg/mL. Shaded columns indicate event sampling dates.

Site	Jun 6[b]	Jun 16	Jun 20	Jul 4	Jul 14	Jul 18	Jul 25	Aug 2	Aug 14[b]	Aug 15[b]	Aug 16[c]	Aug 21[b]	Aug 29
Colina – TP	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	0.107	0.031	ns
Colina – SRP	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	0.080	0.025	ns
Tuyll – TP	0.035	0.036	0.040	0.041	0.038	0.044	0.045	0.045	0.038	0.042	0.090	0.042	0.043
Tuyll – SRP	0.038	0.038	0.040	0.042	0.057	0.046	0.046	0.047	0.051	0.051	0.072	0.047	0.047
Delevan – TP	0.052	0.060	0.076	0.052	0.051	0.057	0.075	0.061	0.055	0.050	0.126	0.050	0.049
Delevan - SRP	0.053	0.066	0.073	0.056	0.074	0.061	0.070	0.051	0.062	0.055	0.102	0.053	0.052

[a] More than 10 mm of rainfall in 24 hours prior to sampling.
[b] More than 10 mm of rainfall in 48 hours prior to sampling.
[c] More than 70 mm of rainfall in 3 days prior to sampling.
ns = no sample was collected due to lack of flow.

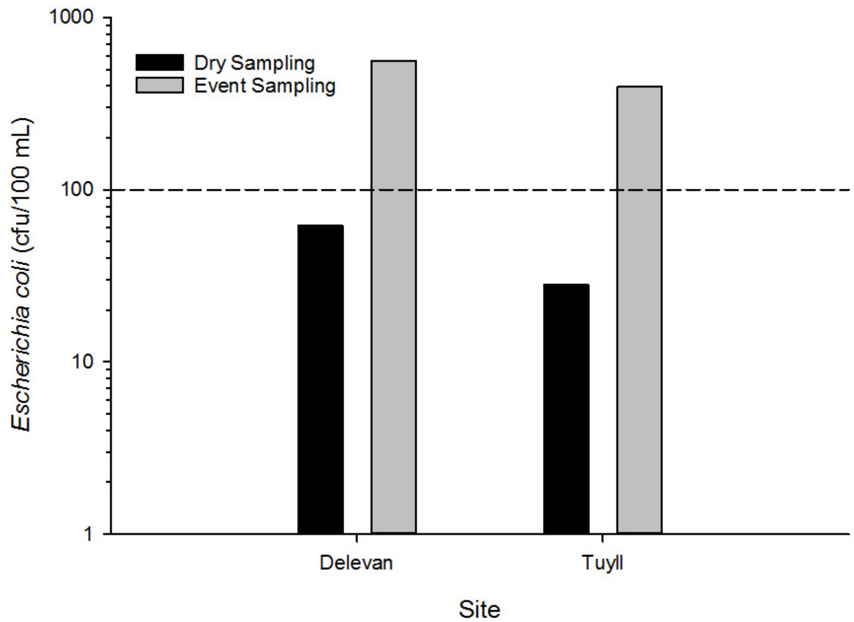

Figure 2. Dry (n=7) and event (n=6) sampling geometric mean *Escherichia coli* concentrations in colony forming units per 100 mL at two stormwater monitoring sites draining into Lake Huron along the shoreline of Bayfield, Ontario in 2016. Dashed line indicates Ontario Ministry of Health and Long-term Care guideline of 100 cfu/100 mL.

Bacterial contaminants in urban stormwater can originate from both human and animal sources. Since the village of Bayfield has a separate system for sanitary sewers, *E. coli* contamination is more likely a result of stormwater runoff that has come into contact with domestic and/or wild animal waste. Pick up and proper disposal of pet waste should be encouraged throughout the village. It is also important the Municipality of Bluewater ensure there are no cross connections or leaks between sanitary sewers or old septic systems and stormwater drainage facilities in the areas drained by the outfalls.

The abundance of fecal bacteria has been strongly linked to the amount of impervious (not allowing water to pass through) surfaces within a watershed (Mallin *et al.* 2000). Protecting and creating green space in existing and new urban development is therefore an essential component of ensuring good water quality at the beach in the village of Bayfield. Low impact development (LID) is an approach to land development that mimics the natural movement of water in order to manage stormwater close to where it falls (CVC 2015). The following LID techniques reduce runoff in urban areas by increasing infiltration (process by which water on the ground surface enters the soil) and slowing water down:

- Naturalized landscapes (trees/shrubs/flowers absorb more rainwater than regular patch of grass)
- Rain barrels
- Rain gardens (shallow depressions that contain soil and plants that promote infiltration and treat pollutants)
- Green roofs (vegetation or roof-top gardens that absorb rainwater)
- Infiltration trenches/soakaways (underground reservoirs that collect and filter rainwater)
- Grass swales (open vegetated channels that slow stormwater, promote infiltration and trap and treat pollutants)
- Permeable pavement (concrete or asphalt that allows water to drain through and infiltrate into soil

Total Phosphorus

Total phosphorus (TP) includes phosphorus that is dissolved in water and insoluble phosphorus that binds to organic and inorganic material in water. In many aquatic systems, phosphorus is the nutrient that limits plant growth. When phosphorus is added to the system, the first response may be increased plant and algae growth. These conditions can result in aesthetic concerns, especially along shorelines and public beaches. Nutrient over-enrichment can result in excess plant growth and algal blooms, which can negatively impact aquatic life and further impede recreational waters. The Government of Ontario established a Provincial Water Quality Objective (PWQO) for TP of 0.030 mg/L to prevent eutrophication (excessive algae and aquatic plant growth, shortened food chains, changes in the aquatic plant and animal communities) (MOEE 1994).

Concentrations of TP ranged from 0.031 mg/L at Colina (August 21) to 0.126 mg/L at Delevan (August 16) (Table 2). The PWQO for TP was exceeded at all three sites for all sampling dates (dry and event), however, most concentrations of TP ranged from approximately 0.03 to 0.06 mg/ for both dry and event sampling. The one exception was after an event sampling on August 16 when all outfalls had higher TP concentrations. Bayfield did however receive 75 mm of rain within the 3 days prior to sampling on this date.

Dry sampling geometric mean TP concentrations varied from concentrations of 0.041 mg/L at Tuyll to 0.056 mg/L at Delevan (no samples for Colina during dry sampling). Event sampling geometric mean concentrations ranged from 0.046 mg/L at Tuyll to 0.066 mg/L at Delevan (Figure 3). All dry and event sampling geometric mean TP concentrations exceeded the water quality objective. A geometric mean for Colina was not calculated as there were only two samples collected after rain events.

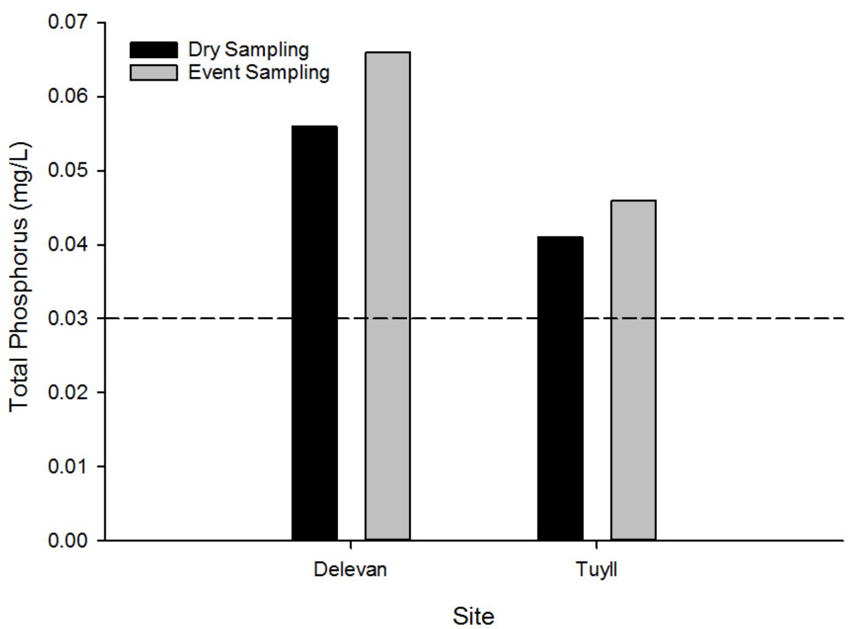

Figure 3. Dry (n=7) and event (n=6) sampling geometric mean total phosphorus concentrations in mg/L at three stormwater monitoring sites draining into Lake Huron along the shoreline of Bayfield, Ontario in 2016. Dashed line indicates Provincial Water Quality Objective of 0.030 mg/L.

Soluble Reactive Phosphorus

Soluble reactive phosphorus (SRP), also known as phosphate, is the portion of phosphorus that is readily available to aquatic plants. This fraction of TP can stimulate algal growth and contribute to algal blooms, and the increased loading of SRP has been cited as the main cause of the recent blooms in Lake Erie (IJC 2014).

SRP varied from 0.025 mg/L at Colina (August 21) to 0.102 mg/L at Delevan (August 16) (Table 2). SRP as a percentage of TP was 100 percent for both Tuyll and Delevan for dry sampling dates (Figure 4). No change was observed at either Tuyll or Delevan in percentage of SRP following rain events (event sampling). SRP as a percentage of TP was not calculated for the Colina as there were only two samples collected after rain events.

These SRP percentages indicate there is potential for eutrophication and algal blooms to occur along the shoreline if other required conditions (*e.g.*, temperature) are also met.

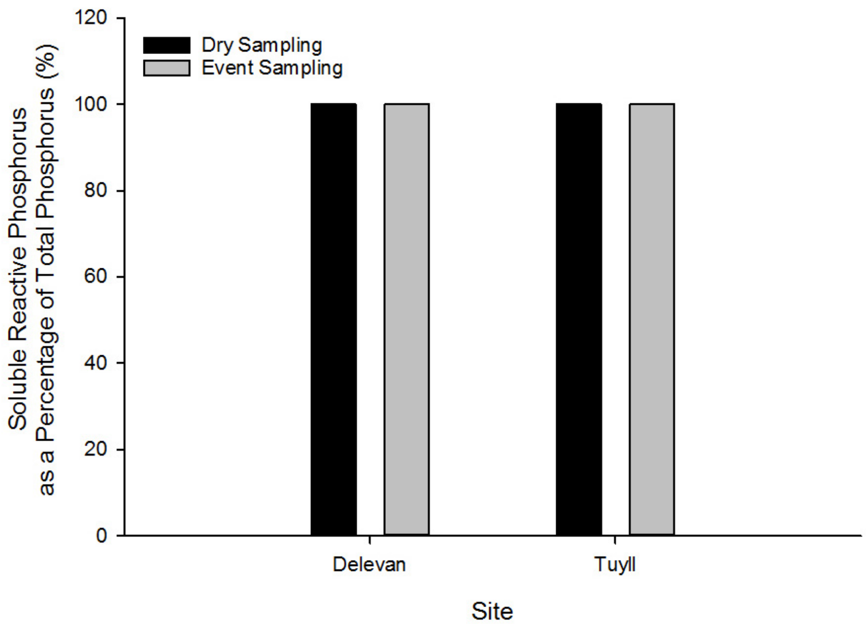

Figure 4. Soluble reactive phosphorus as a percentage of total phosphorus at three stormwater monitoring sites draining into Lake Huron along the shoreline of Bayfield, Ontario in 2016.

Non-point sources of phosphorus in urban areas can originate from construction sites, lawn and garden activities, leaves and animal waste (IJC 2014). In order to improve water quality at the beach and prevent algal blooms, the following actions can be taken to reduce phosphorus inputs to stormwater systems:

- Protect and create more naturalized areas
- Establish ground covers or use mulch on bare soil to prevent runoff
- Plant native plants, which require less fertilizer and water
- Install rain barrels
- Install filter strips, grass swales and rain gardens to slow water and increase filtration
- Reduce or eliminate the use of fertilizers containing phosphorus
- Leave lawn clippings and mulch leaves as opposed to piling leaves on the curb sides
- Clean eavestroughs and install gutter guards
- Properly dispose of pet waste
- Use designated car wash centres to wash vehicles
- Use permeable pavement to increase filtration

Next Steps

1. Continue to monitor water quality, specifically *E. coli*, total phosphorus and soluble reactive phosphorus at the Colina, Tuyll and Delevan stormwater outfall sites.
2. As part of the stormwater master plan for the village of Bayfield, gain a better understanding of the watershed drained by the Tuyll outfall.
3. Engage the local community with information about stormwater management and low impact development technologies (*e.g.*, rain barrels, rain gardens) through outreach activities of the Main Bayfield Watershed Plan.
4. Continue to support community actions such as demonstration rain gardens.
5. Assist the Municipality of Bluewater in implementing low impact development technologies (*e.g.*, permeable pavement, grass swales, rain gardens) for existing infrastructure and proposed developments.

Helpful Links

Sustainable Stormwater Planning
http://www.conservation-ontario.on.ca/what-we-do/planning-regulations/sustainable-stormwater-planning

Stormwater Management
http://www.trca.on.ca/the-living-city/water-flood-management/storm-water-management.dot

Low Impact Development for Existing Development
http://www.lsrca.on.ca/programs/rainscaping/LID-retrofits.php

Low Impact Development
http://www.creditvalleyca.ca/low-impact-development/

Low Impact Development Stormwater Management Planning and Design Guide
http://www.creditvalleyca.ca/low-impact-development/low-impact-development-support/stormwater-management-lid-guidance-documents/low-impact-development-stormwater-management-planning-and-design-guide/

Acknowledgements

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References

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CVC (Credit Valley Conservation). 2015. LID FAQs and Resources. Retrieved February 18, 2015, from: http://www.creditvalleyca.ca/low-impact-development/low-impact-development-support/lid-faqs-and-resources/#whatislid

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Mallin, M.A., K.E. Williams, E. C. Esham and R.P. Lowe. 2000. Effect of Human Development on Bacteriological Water Quality in Coastal Watersheds. Ecological Applications. 10(4): 1047-1056.

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Appendix

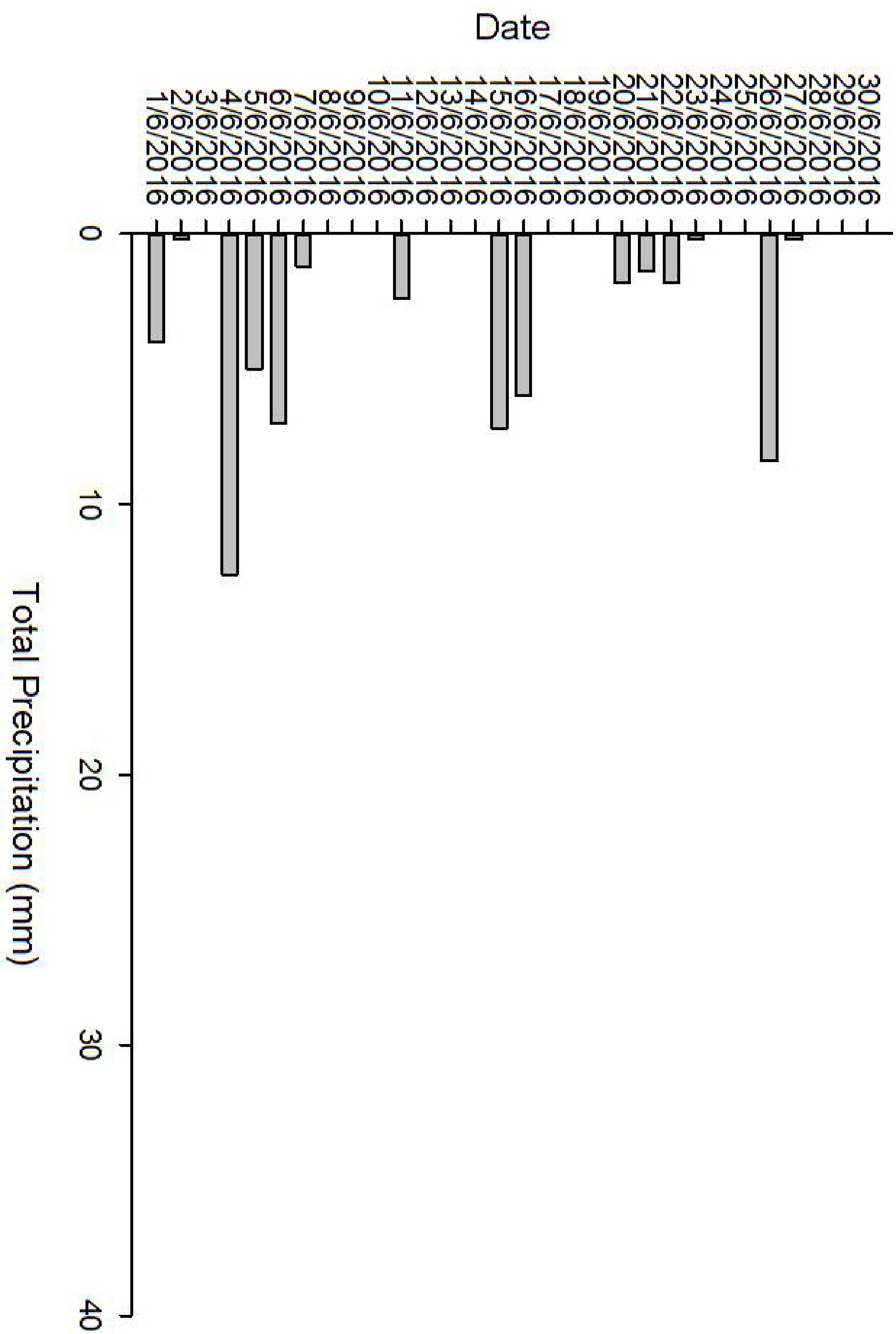

Figure A1. Total daily precipitation at Bayfield, Ontario during June 2016.

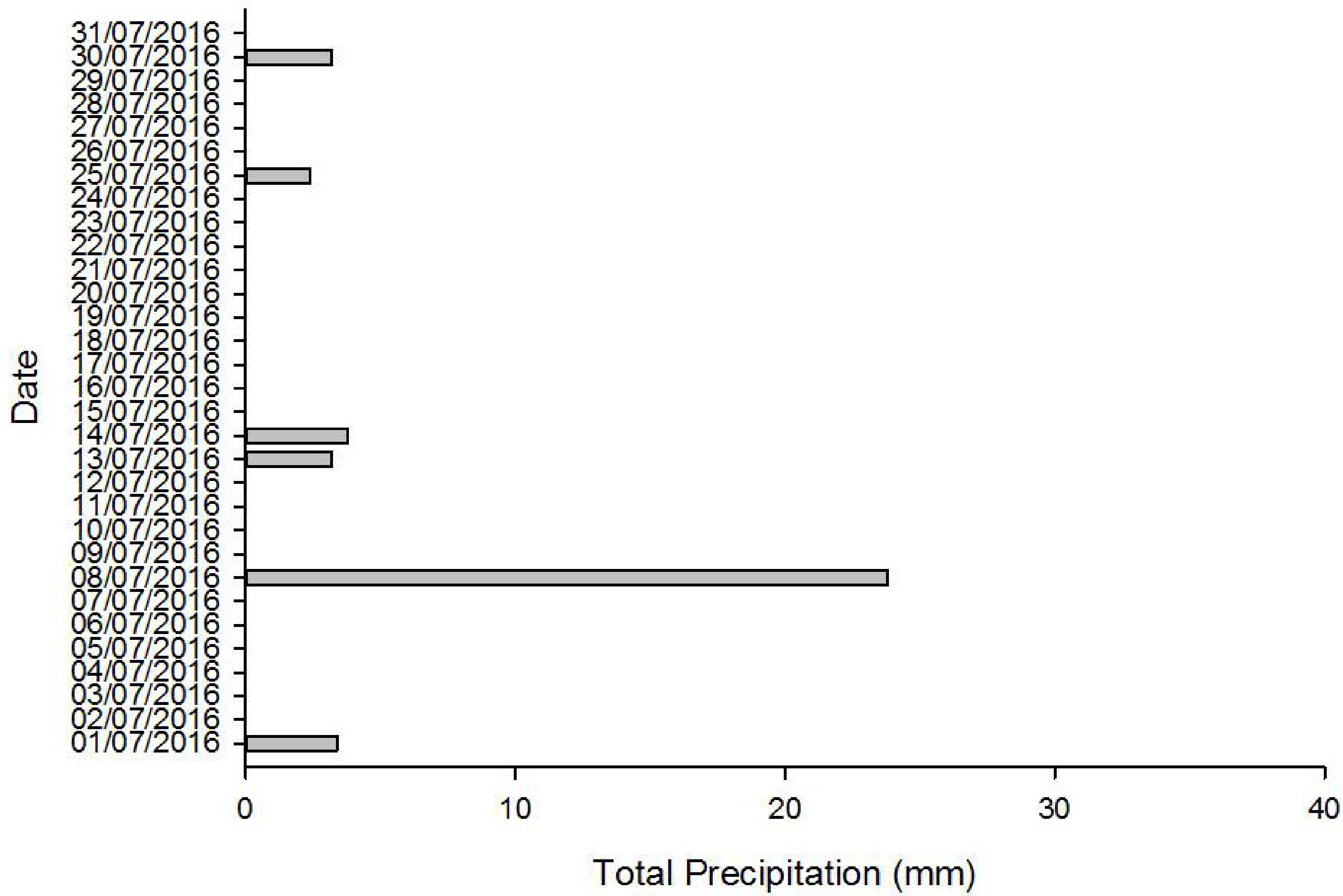

Figure A2. Total daily precipitation at Bayfield, Ontario during July 2016.

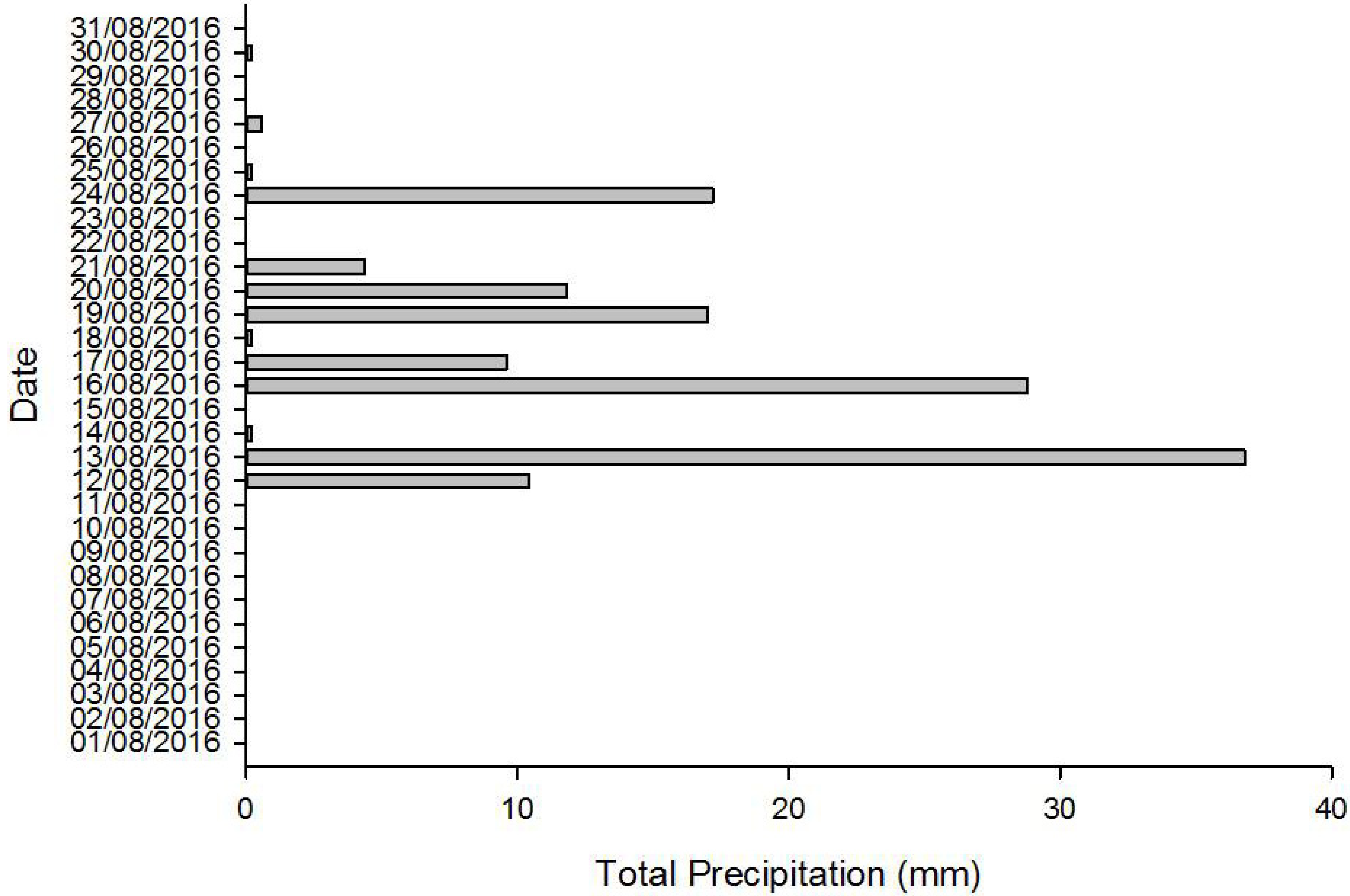

Figure A3. Total daily precipitation at Bayfield, Ontario during August 2016.