2019 Watershed Overview of Wastewater Treatment Plant Performance

By Mark Anderson, Simion Tolnai and Kelly Hagan

Grand River Conservation Authority

September 2020

Glossary of Terms

ADF

Average daily flow

cBOD

Carbonaceous 5 day biochemical oxygen demand

GRCA

Grand River Conservation Authority

MECP

Ontario Ministry of the Environment, Conservation and Parks

TAN

Total ammonia nitrogen

TBOD

Total 5 day biochemical oxygen demand

TKN

Total Kjeldahl nitrogen

TP

Total phosphorus

TSS

Total suspended solids

UIA

Un-ionized Ammonia

WWOP

Watershed-wide Wastewater Optimization Program

WWTP

Wastewater treatment plant

Executive Summary

Since 2010, the Grand River Conservation Authority (GRCA) has been working collaboratively with municipal partners and the Ministry of the Environment, Conservation and Parks (MECP) to develop a Watershed-wide Wastewater Optimization Program (WWOP). A key program activity is the preparation of an annual report of effluent quality and plant loading for treatment facilities discharging in the Grand River watershed. The first annual report was produced for data collected in 2012. Year-to-year variations are used to evaluate the success of the program and track WWTP impacts on the Grand River. Available performance and loading data for 26 of 30 municipal wastewater treatment plants were voluntarily reported in 2019. These results were summarized in terms of treatment performance, data integrity, impacts on the Grand River, plant loading and bypasses and overflows and compared to results from previous years.

Treatment Performance

Table 1 shows the total average day flow for all the reporting plants from 2012 to 2019, as well as the corresponding reported population for each year. From 2012-2019 the reported population increased by 7.8% (or 1.1% per year). Total plant flow shows greater year-to-year variations reflecting the impact of year-to-year variations in precipitation.

Table 1: Total reported WWTP average daily flow and population from 2012-2019

Year	ADF	Population
2012	265,861	819,782
2013	294,226	819,119
2014	303,426	825,198
2015	271,612	830,244
2016	278,426	835,137
2017	292,378	837,708
2018	283,005	859,568
2019	283,275	883,739

Despite the increase in population, flow-weighted concentrations and loadings of TP and TAN have steadily decreased. Table 2 shows the final effluent TP flow-weighted average concentrations, total TP loading, and flow-weighted concentration target from 2012 to 2019.

Table 2: TP Flow-weighted concentrations, total loading and targets

Year	TP flow-weighted concentration (mg/L)	Total Loading (tonnes per year)	TP flow-weighted concentration target (mg/L)
2012	0.37	35.9	0.24
2013	0.35	37.6	0.24
2014	0.33	36.8	0.24
2015	0.37	36.5	0.24
2016	0.33	33.8	0.24
2017	0.30	32.5	0.24
2018	0.30	30.6	0.24
2019	0.26	27.1	0.24

With respect to the TP concentrations and loads in Table 2, the following observations can be made:

- From 2018 to 2019, the TP flow-weighted concentration decreased by 13% and the TP load decreased by 11%; and
- From 2012 to 2019, the TP flow-weighted concentration decreased by 30% and the TP load by 25%

Table 3 shows the final effluent TAN flow-weighted average concentrations (for both winter and summer), total TAN loading, and concentration targets (for both summer and winter) from 2012 to 2019.

Table 3: Flow-weighted summer and winter TAN concentrations and total loading

Year	Winter TAN flow-weighted concentration (mg/L)	Summer TAN flow-weighted concentration (mg/L)	Summer Target (mg/L)	Winter Target (mg/L)	Total Loading (tonnes per year)
2012	5.5	4.3	1	2	951
2013	3.9	3.2	1	2	773
2014	4.6	3.1	1	2	855
2015	3.6	2.1	1	2	560
2016	2.2	1.3	1	2	347
2017	1.7	0.7	1	2	259
2018	0.9	0.5	1	2	146
2019	1.1	0.4	1	2	149

With respect to Table 3 showing the TAN loads and concentrations, the following comments are applicable:

- From 2018 to 2019 the summer TAN decreased by 38% and winter TAN increased by 21%. TAN total loading increased 3% compared to the previous year.
- From 2012 to 2019, overall the total TAN flow-weighted concentration decreased by 85% and the total loading by 84%.

Data Integrity Checks

A sludge accountability analysis compares the annual amount of sludge reported by a mechanical plant to the amount of sludge projected based on plant loadings and removal. Conducting this analysis can help to determine if monitoring is truly representative. In 2019, sludge accountabilities were reported for 20 plants in the watershed. For ten of the plants, the accountability “closed” within ± 15%. In 2018, 23 plants reported sludge accountability and 8 plants “closed” within ± 15%.

A water balance analysis compares the annual amount of measured net precipitation on the surface area of a lagoon system to the annual amount of projected net precipitation using lagoon level measurements, total influent and total effluent flows of a lagoon system. This analysis can help to determine if the flow measurement devices at a lagoon are accurate. In 2019, water balances were reported for 3 lagoon systems in the watershed. Two of these analyses did close within ±15%.

Grand River Impacts

Table 4 summarizes the impact of total annual average discharge of effluent from wastewater treatment plants to the total flow in the Grand River.

Table 4: WWTP Effluent flow as a percentage of Grand River total flow

Parameter	2012	2013	2014	2015	2016	2017	2018	2019
% Annual Average Flow	6.8%	3.1%	2.6%	5.0%	4.7%	3.5%	3.6%	3.6%
% August Average Flow	13.9%	5.4%	9.5%	11.5%	9.0%	7.3%	8.7%	10.3%

The year to year variations in Table 4 are largely a function of precipitation and weather in the watershed in any given year. The percent of flows in August is also shown, as

August is typically the month when flows in the river are the lowest and treated wastewater makes up a larger portion of river flow. In 2017 and 2019, precipitation was above average. In 2014 and 2018, precipitation was close to the long-term average. In 2012, 2015 and 2016 precipitation was near the lower end of typical. In 2013, the watershed generally experienced higher than normal precipitation across its central and northern portions.

Some improvements in the water quality of the Grand River have been noted due to recent WWTP upgrades and optimization efforts. For example, optimization activities at the Hespeler WWTP resulted in lower concentrations of TAN in the lower Speed River in the summer and winter of 2018 (LGL Limited, 2019). Additionally, upgrades at the Kitchener and Waterloo WWTPs have allowed the plants to nitrify, resulting in lower concentrations of TAN, UIA and nitrite in the Grand River. Data from 2018 demonstrated a statistically significant reduction in these parameters compared to previous years. Data also demonstrated a statistically significant reduction in TP downstream of both plants in the summer of 2019 compared to previous years.

Plant Loading

Table 5 summarizes key process loading metrics for 2019 as well as typical values and the range of median reported values from 2012 to 2018. The results in the table enable municipalities to compare loadings at their facilities to those at other plants in the watershed, which can be used to determine the impact of industrial discharges and may highlight concerns with unrepresentative sampling of raw influent. For plants that do not measure TBOD in the raw influent it was assumed to be 20% higher than the cBOD measurement.

Table 5: Summary of 2012 to 2019 watershed WWTP loading measures

Loading Measure	Watershed Median 2012-2018 (min-max)	Watershed Median 2019	Typical Value
Per capita flow (L/person/day)	294 - 351	**321**	350 - 500
ADF as % of Nominal Design	51% - 66%	**61%**	N/A
Peak day: Annual average flow	2.25 - 2.75	**2.32**	2.5 – 4.0
Per capita TBOD loading (g/person/day)	65 - 77	**63**	80
Per capita TSS loading (g/person/day)	69 - 93	**82**	90
Per capita TKN loading (g/person/day)	13 - 14	**14**	13
Per Capita TP loading (g/person/day)	1.6 – 2.0	**1.7**	2.1
Raw TSS:TBOD ratio	1.01 - 1.25	**1.20**	0.8 - 1.2
Raw TKN:TBOD ratio	0.17 - 0.22	**0.23**	0.1 - 0.2

Year-to-year variations in per capita flow, the average day flow as a percentage of the design flow and the ratio of the average day to peak day flow from Table 5 are largely due to differences in inflow and infiltration (I&I) related to precipitation.

Bypasses and Overflows

Bypasses and overflows are terms used to describe events that result in sewage reaching natural water bodies (Grand River Municipal Water Managers Working Group, 2009). Bypasses occur when parts of a treatment process are bypassed and wastewater flows discharge to the environment via WWTP effluent outfall. Overflows occur when sewage enters the environment at a location other than the effluent outfall. Bypasses/overflows can be classified as low, medium or high according to the level of risk to downstream users. Overall the total number of bypasses decreased 17% from 66 in 2013 to 55 in 2019. The total volume of bypasses has decreased 86% from 1,156,707 m^3 in 2013 to 91,348 m^3 in 2019. Many of the bypasses are due to wet weather conditions.

Contact

Further information on the Grand River Watershed-wide Optimization Program can be obtained from the Grand River wastewater optimization web page, or by contacting Kelly Hagan, Optimization Extension Specialist at 519-621-2761 Ext. 2295 or Mark Anderson, Water Quality Engineer at 519-621-2761 Ext. 2226.