2022

CITY OF HAMILTON
CORROSION CONTROL PROGRAM

ANNUAL EVALUATION REPORT ASSESSING THE EFFECTIVENESS OF THE CORROSION CONTROL MEASURES

Hamilton

WOODWARD DRINKING WATER SUBSYSTEM
MARCH 2023


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CONTENTS

1 SUMMARY

This annual evaluation report is provided as per Section 6.6 of Schedule C of the City of Hamilton's (COH's) Municipal Drinking Water Licence (MDWL) Number: 005-101 Issue 9, dated October 16, 2020; as per Part V of the Safe Drinking Water Act, 2002 (SDWA). This report assesses the effectiveness of the Corrosion Control Program (CCP) within the COH's Woodward Avenue Drinking Water Subsystem (DWSS). It outlines the activities undertaken by the COH and covers the 2022 calendar year. It highlights the following:

- Lead results and a summary of any key corrosion control parameters
- A technical evaluation of the effectiveness of corrosion control measures
- A summary of lead levels and other metals monitored since implementation of corrosion control, and comparison to pre-implementation levels
- An evaluation of secondary impacts as a result of corrosion control implementation
- Summary of results of all other aspects of the COH's lead mitigation strategy

The COH began addition of phosphoric acid on November 8, 2018, with 2022 being the fourth full year of program operation. Throughout 2022, operating conditions were stable at the Water Treatment Plant (WTP) with inhibitor concentrations consistently observed at the ends of the distribution system.

The Schedule 15.1 Community Lead Sampling Program was reinstated in 2018 for the Woodward Avenue DWSS under a reduced sampling schedule to monitor the effectiveness of corrosion control measures put into place. Two sampling rounds, Round 29 (Winter) and Round 30 (Summer) were completed in 2022 for a total of eight rounds completed since the implementation of the Corrosion Control Program in 2018. Round 29 received COVID-19 Regulatory Relief from premise (at-the-tap) sampling and only distribution samples were collected. Reduced sampling resumed for Round 30 whereby both premise and distribution samples were collected. A summary of results, as seen at the end of 2022, are included in this report.

2 INTRODUCTION

At the November 25, 2015 COH Council Meeting, Report 15-015, the CCP for the Woodward Avenue DWSS was approved. The primary recommendation of the report was to implement corrosion control within the Woodward Avenue DWSS using a phosphate-based treatment approach with orthophosphate as the method for corrosion control, and phosphoric acid as the treatment additive. On November 8, 2018, the COH began adding phosphoric acid completing the pre-implementation requirements and moving into post-implementation and ongoing activities. The 2022 evaluation report highlights the post-implementation sampling and monitoring activities in 2022, illustrating the observed effectiveness of this program.

3 TECHNICAL EVALUATION OF THE EFFECTIVENESS OF CORROSION CONTROL MEASURES

3.1 Key Milestones of Post-Implementation Sampling and Monitoring

With 2022 bringing the COH into the fourth year of the CCP, post-implementation sampling and monitoring continues to be one of the main ways of evaluating the program's goal of reducing lead concentrations observed at the tap (premise). Post-implementation sampling, as per Schedule C of the MDWL, was performed including two rounds of the legislated Community Lead Sampling Program. The COH received Regulatory Relief from sampling at residential taps for Round 29 - Winter 2022 (December 15, 2021- April 15, 2022) because of the COVID-19 Pandemic. This relief was granted because the samples are collected at the tap inside residents' homes and it posed a health risk to both staff and homeowners. Reduced sampling resumed in Round 30 - Summer 2022 (June 15, 2022 - October 15, 2022) at both residential and non-residential establishments and allowed for resumption of data collection of premise samples. Despite the lack of data from Round 29, the three lead pipe loops installed in 2017 in the Woodward DWSS remained in place as an additional tool to monitor the effectiveness of the program. These three lead pipes were installed at 293 Highland Road West, Hamilton (7-15); 460 Parkside Drive, Waterdown (16-4); and 21 Queen Street, Dundas (21-1) as controlled study sites to monitor the effect of the orthophosphate on the pipes. The sampling results from the lead pipe loops continue to show a decreasing trend in lead levels.

Ongoing proactive and reactive flushing of the distribution system took place throughout 2022. This ensured the movement of orthophosphate throughout the distribution system, reduced secondary impacts, as well as addressed water age.

The Plant Optimization Study commenced in 2019 to study the Water Treatment Plant's dosing system for orthophosphate and ammonia, with the goal of ensuring it is not creating adverse situations in the distribution system and is effectively delivering the chemicals. The study was put on-hold due to the COVID-19 Pandemic and subsequent Regulatory Relief from Schedule 15.1 Community Lead premise sampling that began in Summer of 2020. The Optimization Study will be continued once further data is collected from the Lead Sampling Program, likely into 2024.

A review meeting was held with Hamilton Water staff and the contracted consultant in September 2022 and Corrosion Control Key Findings and Recommendations were presented. This presentation wrapped up a study of corrosion control, nitrification, and water age in the DWSS. Recommendations focused on improving the tracking of corrosion control performance and signs of secondary impacts. For example, dissolved orthophosphate was suggested to be added as a parameter to track precipitation. The three lead pipe loop locations were suggested to be leveraged to supplement routine monitoring and additional test parameters at the loops were recommended to provide a more comprehensive data set.

Secondary impacts stemming from the addition of orthophosphate continued to be observed in the distribution system. Although pre-filter orthophosphate dosing has contributed significantly toward reducing treated water aluminum levels, precipitation of orthophosphate with aluminum was observed within the distribution system. This impact was controlled through flushing and did not contribute to aesthetic impairment noticeable to customers. Other secondary impacts (such as release of bacteria from temporary cast iron scale destabilization) were minor and manageable through flushing. System-wide sampling continued in 2022 and provided valuable monitoring data for the entire distribution system. This branch of the monitoring program allows for surveillance of orthophosphate levels and potential secondary impacts. In the event of an elevated orthophosphate, colour, or turbidity result, further sampling occurs to determine the cause of any anomaly and appropriate action is taken.

The key Post-Implementation activities are summarized in Table 1 (p.6).

Table 1: 2022 CCP Post-Implementation Monitoring Plan

TASK	STATUS
Water Distribution System Flushing	On-going • 2489 hydrants flushed in 2022. • Proactive flushing continues in 2023.
Post-Implementation monitoring	On-going • Sampling as per Schedule C of the MDWL completed in 2022 and continues in 2023. • Monthly sampling at the three lead pipe loop locations within the distribution system. • Additional system-wide monitoring program introduced in Q3 2021 to measure key corrosion control parameters within the distribution system. Resumed May 2022.
Plant Optimization Study	Resumed • Study to optimize the Water Treatment Plant's dosing system for orthophosphate and ammonia, ensuring it is not creating adverse situations in the distribution system and is effectively delivering the chemicals - Commenced Q4 2019. • Study was on-hold due to the COVID-19 pandemic and subsequent Regulatory Relief. Study has resumed now that residential tap sampling started again in Summer 2022. Consultant to analyze data after one year of data is acquired.
Distribution System Study	Study Complete • Study to monitor the effectiveness of the orthophosphate in creating a protective film within the distribution system, while monitoring secondary effects such as biofilm and nitrification – Commenced Q3 2020. • Distribution system Water Quality data review - Completed Q3 2021. • Lead Service Line Scale Analysis - Completed Q3 2021. • Completion of study - Q3 2022. • Recommendations are being considered/implemented in 2023.

3.2 Equipment Malfunction or Upset Conditions

No equipment malfunctions or upset conditions occurred in 2022.

A summary of the continuously monitored parameters, at the Point of Entry, are included in Table 2. These values are recorded every 15 minutes to ensure prompt intervention when upset conditions are observed. The MDWL also requires additional parameters to be measured at the Point of Entry annually, quarterly, and monthly. The results from these grab samples are summarized in Table 3. Pre- and post-implementation comparison of these parameters illustrates minimal change in water quality as a result of the addition of phosphoric acid to the drinking water.

Table 2: Summary of Continuously Monitored Parameters at the Point of Entry

DATES	POINT OF ENTRY Continuous Monitoring Values (Range)			
	pH	Temperature Raw Water (°C)	Orthophosphate (mg/L)	Turbidity (NTU)
08-Nov-18 to 31-Dec-18	7.58 - 8.17	1.50 - 6.66	0.02 - 3.39	0.03 - 0.54
01-Jan-19 to 31-Dec-19	6.67 - 7.64	-1.03 - 20.47	0.20 - 7.81	0.02 - 0.33
01-Jan-20 to 31-Dec-20	6.66 - 7.64	0.63 - 23.35	0.84 - 3.46	0.02 - 0.27
01-Jan-21 to 31-Dec-21	6.74 - 7.60	-0.53 - 23.29	0.96 - 5.33	0.02 - 0.86
01-Jan-22 to 31-Dec-22	6.22 - 7.71	-0.48 - 22.5	0.68 - 6.38	0.009 – 0.282

Table 3: Summary of Corrosion Control Related Parameters at the Point of Entry

DATES	POINT OF ENTRY Average (Range)								
	Lead (µg/L)	Iron (µg/L)	Copper (µg/L)	Alkalinity (mg/L)	TDS (mg/L)	Colour (apparent) CU	Chloride (mg/L)	Sulphate (mg/L)	Ortho-phosphate (mg/L)
Pre-Implementation 04-Feb-08 to 22-May-18	<1	<10 (<10-59)	<2 (0.39-<2)	85 (82-99)	188 (156-252)	<2 (<2-4)	30.8 (30.0-31.5)	26.4 (24.2-28.2)	<0.15
Q4 2018 01-Oct-18 to 31-Dec-18	<0.1	<3	0.2	85	178	<2	30.8 (30.0-31.5)	24.2 (23.7-24.7)	2.07 (<0.15-3.80)
2019 01-Jan-19 to 31-Dec-19	<0.1 (<0.1)	<3 (<3-4)	0.4 (0.3-0.6)	86 (83-88)	198 (160-232)	<2 (<2)	33.5 (29.1-42.6)	24.5 (22.9-27.0)	2.05 (<0.15-2.69)
2020 01-Jan-20 to 31-Dec-20	<0.1 (<0.1)	<3 (<3)	0.3 (0.2-0.4)	87 (86-88)	202 (166-228)	<2 (<2-2)	33.1 (29.2-40.3)	24.5 (23.3-26.1)	2.04 (1.60-2.48)
2021 01-Jan-21 to 31-Dec-21	<0.1 (<0.1)	<3 (<3)	0.4 (0.2-0.8)	86 (86)	202 (170-248)	<2 (<2-2)	32.2 (29.1-43.4)	23.8 (22.6-25.7)	2.07 (1.20-2.89)
2022 01-Jan-22 to 31-Dec-22	<0.1	<3	0.32 (0.3-0.4)	87 (80-91)	181 (162-202)	<2 (<2-2)	32.3 (28.4-44.0)	23.8 (22.5-25.1)	2.13 (1.48-2.85)

3.3 Ability to maintain operating conditions and inhibitor concentrations in the distribution system and premise plumbing (residential & non-residential)

The ability to maintain operating conditions and inhibitor concentrations within the distribution system was monitored as required by the MDWL. Orthophosphate concentrations, as well as other related parameters were measured at the ends of the distribution system. In addition, these parameters were also measured at locations throughout the distribution system (system-wide samples).

As illustrated in Table 4 (p.9), orthophosphate, which was not observed in the distribution system prior to implementation, began to be observed at the ends of the distribution system shortly after the start date of November 8, 2018. Inhibitor concentrations continued to be observed consistently in 2022 demonstrating consistent operating conditions and the effective delivery of orthophosphate throughout the system, including the ends of the distribution system.

The addition of the inhibitor did not upset the aesthetic appearance of the water as was illustrated by the pre and post-implementation turbidity values also summarized in Table 4 (p.9).

Although operating conditions and orthophosphate concentrations are not measured in premise plumbing, Section 4 discusses the levels of lead and other metals as seen in premise plumbing, because of operating conditions and inhibitor concentrations.

Table 4: Comparison of Pre-Implementation and Post-Implementation Orthophosphate Residuals and Turbidity in the Distribution System

PERIOD	DATES	NUMBER OF SAMPLES	DISTRIBUTION RESULTS	
			Orthophosphate (mg/L) Average (Range)	Field Turbidity (NTU) Average (Range)
PRE-IMPLEMENTATION				
1	01-Jul-16 to 30-Sept-16	98	<0.15	0.25 (0.05-3.49)
2	01-Nov-16 to 30-Jan-17	79	<0.15	0.29 (0.09-3.10)
3	01-Mar-17 to 30-Jun-17	82	<0.15	0.23 (0.07-0.71)
POST-IMPLEMENTATION				
1	05-Nov-18 to 27-Dec-18	80	1.57 (<0.15-2.55)	0.16 (0.06-1.10)
2	01-Jan-19 to 31-Dec-19	524	1.88 (0.22-2.42)	0.14 (0.05-1.16)
3	01-Jan-20 to 31-Dec-20	531	1.98 (1.72-3.53)	0.15 (<0.05-1.67)
4	01-Jan-21 to 31-Dec-21	522	2.01 (1.43-6.54)	0.20 (<0.05-5.04)
5	01-Jan-22 to 31-Dec-22	759*	2.07 (1.76-10.0*)	0.24 (0.05-9.87*)

*Notes:

- Number of samples for 2022 includes 521 mandatory weekly end of distribution samples and 238 system-wide samples.
- Orthophosphate result of 10.0 mg/L was resampled after flushing and 1.95 mg/L was obtained.
- Field Turbidity result of 9.87 NTU was resampled after flushing and 0.22 NTU was obtained.

3.4 Ability to achieve reduction in lead levels and other corrosion related parameters in the distribution system and premise plumbing (residential & non-residential).

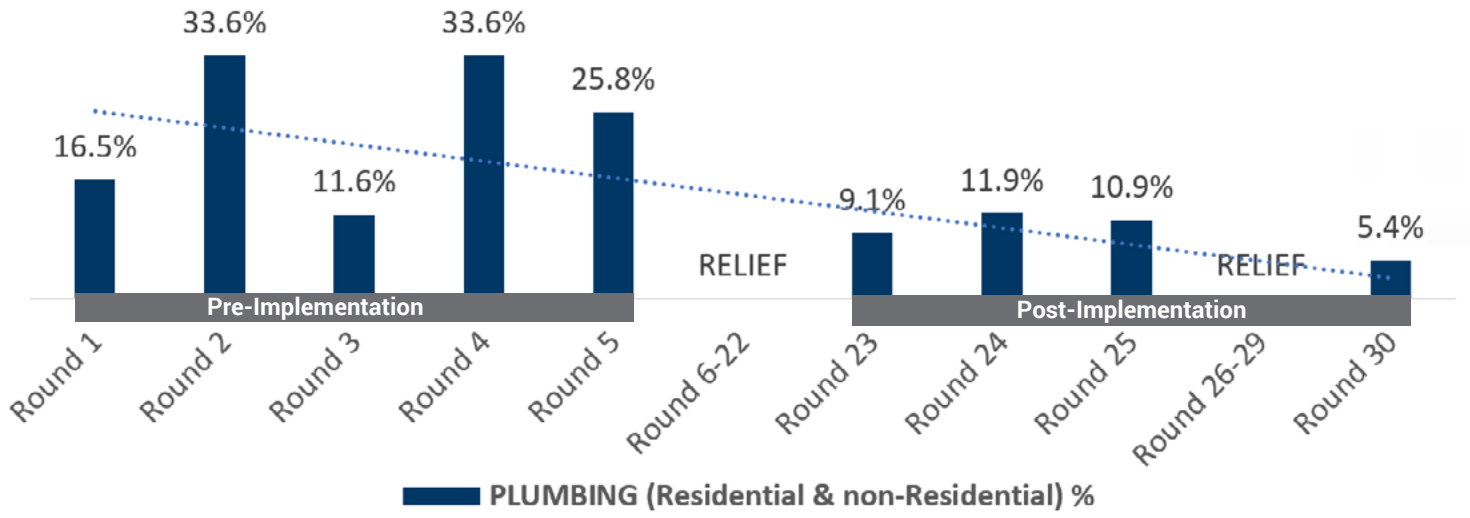
Lead levels and other corrosion control related parameters are monitored primarily through the Schedule 15.1 Community Lead Sampling Program, under O. Reg. 170/03 of the SDWA. Prior to the inhibitor addition in the Woodward Avenue DWSS, the MDWL contained a Condition of Lead Regulatory Relief - Schedule D.

Upon addition of the inhibitor, the Schedule 15.1 sampling program was resumed under a reduced sampling plan as specified in the Woodward Avenue DWSS MDWL. Round 29 (Winter) and Round 30 (Summer) were scheduled for sampling in 2022. Regulatory Relief from premise (at-the-tap) sampling was granted for Round 29 and only distribution samples were collected. Round 30 saw the reduced sampling schedule resume whereby premise and distribution samples were collected. A summary of the results is found in Section 4 of this report.

An overall decline in lead levels at the tap has been observed. The percentage of samples with results above the Maximum Acceptable Concentration (MAC) for lead (10ug/L) is observed to be in a decline as summarized in Chart 1.

In addition to the Schedule 15.1 Community Lead Sampling Program, the COH installed three lead pipe loops within the distribution system in 2017 as controlled study sites to monitor the effect of the orthophosphate on lead pipes. Charts 2 (p.17), 3 (p.17) and 4 (p.18), illustrate the continued reduction of observed lead levels.

Chart 1: Percent (%) of Total Premise Samples with Lead above the MAC (10ug/L) - Residential & non-Residential



4 SUMMARY OF LEAD LEVELS AND OTHER METALS

4.1 Schedule 15.1 Community Lead Sampling under Ontario Regulation 170/03

Tables 5, 6 (p.12) and 7 (p.13) illustrate the pre- and post-implementation results from the Schedule 15.1 sampling rounds for the Woodward Avenue DWSS as seen at premise plumbing (residential and non-residential), as well as in the distribution system.

Table 5: Pre- and Post-Implementation Results from the Schedule 15.1 Sampling for the Woodward Avenue DWSS – PREMISE (RESIDENTIAL)

ROUND	DATES	NUMBER OF SAMPLES		RESULTS			Percent (%) of Samples with Lead >10ug/L
		Total	Lead >10ug/L	Lead (range) (µg/L)	Copper (range) (µg/L)	Field pH avg. (range)	
RESIDENTIAL							
1	20-Feb-08 to 2-Apr-08	105	18	<1-56	n/a	7.19 (6.17-7.80)	17%
2	2-Sep-08 to 9-Oct-08	106	36	<1-239	n/a	7.50 (7.12-7.92)	34%
3	26-Feb-09 to 21-Mar-09	100	10	<1-11.8	n/a	7.17 (6.94-7.41)	10%
4	26-Sept-09 to 15-Oct-09	103	35	<1-33.9	n/a	7.50 (6.97-8.01)	35%
5	15-Dec-09 to 15-Apr-10	110	28	<0.5-35.3	n/a	7.59 (7.25-8.00)	26%
6-22	Regulatory Relief						
23	15-Dec-18 to 15-Apr-19	50	5	<0.1-22.6	2.0-63.3	7.52 (7.34-7.65)	10%
24	15-June-19 to 15-Oct-19	53	5	<0.1-33.1	2.1-93.1	7.52 (6.77-7.81)	9%
25	15-Dec-19 to 15-Apr-20	50	4	<0.1-18.9	1.7-54.9	7.58 (7.25-7.89)	8%
26-29	COVID Regulatory Relief for lead sampling (premise)						
30	15-Jun-22 to 15-Oct-22	51	2	<0.1-15.2	1.2-50.1	7.52 (7.38-7.64)	4%

Table 6: Pre- and Post-Implementation Results from the Schedule 15.1 Sampling for the Woodward Avenue DWSS – PREMISE (NON-RESIDENTIAL)

ROUND	DATES	NUMBER OF SAMPLES		RESULTS			Percent (%) of Samples with Lead >10ug/L
		Total	Lead >10ug/L	Lead (range) (µg/L)	Copper (range) (µg/L)	Field pH avg. (range)	
NON-RESIDENTIAL							
1	20-Feb-08 to 2-Apr-08	10	1	<1-27	n/a	7.15 (6.94-7.30)	10%
2	2-Sep-08 to 9-Oct-08	10	3	<1-25	n/a	7.48 (7.39-7.58)	33%
3	26-Feb-09 to 21-Mar-09	12	3	<1-50.2	n/a	7.17 (6.82-7.72)	25%
4	26-Sept-09 to 15-Oct-09	10	3	<1-48.9	n/a	7.56 (7.46-7.65)	33%
5	15-Dec-09 to 15-Apr-10	10	3	<0.5-40.7	n/a	7.55 (7.35-7.76)	33%
6-22	Regulatory Relief						
23	15-Dec-18 to 15-Apr-19	5	0	0.4-9.2	5.8-46.9	7.52 (7.41-7.72)	0%
24	15-June-19 to 15-Oct-19	6	2	0.6-20.1	4.2-46.8	7.53 (7.48-7.65)	33%
25	15-Dec-19 to 15-Apr-20	5	2	0.4-29.8	1.4-63.3	7.68 (7.48-7.89)	40%
26-29	COVID Regulatory Relief for lead sampling (premise)						
30	15-Jun-22 to 15-Oct-22	5	1	<0.1-33.0	4.0-90.6	7.55 (7.40-7.63)	20%

Table 7: Pre- and Post-Implementation Results from the Schedule 15.1 Sampling for the Woodward Avenue DWSS – DISTRIBUTION SYSTEM

ROUND	DATES	NUMBER OF SAMPLES		RESULTS			Percent (%) of Samples with Lead >10ug/L
		Total	Lead >10ug/L	Lead (range) (µg/L)	Field pH avg. (range)	Alkalinity avg. (range) (mg/L)	
DISTRIBUTION SYSTEM							
1	20-Feb-08 to 2-Apr-08	20	0	<1 – 1	7.2 (6.10-8.00)	85 (82-87)	0%
2	2-Sep-08 to 9-Oct-08	21	0	<1 – 2	7.40 (7.20-7.60)	82 (80-85)	0%
3	26-Feb-09 to 21-Mar-09	20	0	<1 – 4	7.00 (6.10-7.60)	86 (84-88)	0%
4	26-Sept-09 to 15-Oct-09	20	0	<1 – 2	7.50 (7.20-7.70)	84 (77-90)	0%
5	15-Dec-09 to 15-Apr-10	23	0	<0.5-2.7	7.75 (7.57-8.03)	85 (83-88)	0%
6-22	Regulatory Relief						
23	15-Dec-18 to 15-Apr-19	10	0	0.1-2.5	7.47 (7.36-7.66)	86 (82-89)	0%
24	15-June-19 to 15-Oct-19	11	1*	<0.1-44.4	7.5 (7.35-7.87)	87 (82-90)	9%
25	15-Dec-19 to 15-Apr-20	10	0	<0.1-1.2	7.60 (7.40-8.01)	85 (84-87)	0%
26	15-June-20 to 15-Oct-20	10	0	<0.1-0.3	7.51 (7.42-7.65)	87 (85-88)	0%
27	15-Dec-20 to 15-Apr-21	10	0	<0.1-1.8	7.48 (7.39-7.60)	87 (86-88)	0%
28	15-June-21 to 15-Oct-21	10	0	<0.1-0.3	7.36 (7.23-7.45)	85 (83-86)	0%
29	15-Dec-21 to 15-Apr-22	10	0	<0.1-0.6	7.68 (7.47-7.87)	88 (87-90)	0%
30	15-Jun-22 to 15-Oct-22	10	0	<0.1-0.3	7.31 (7.47-7.59)	89 (86-93)	0%

*Hydrant was found to contain a lead port. Resampling and analysis at the same hydrant had a lead result of <0.1ug/L

Copper is monitored, as required by the MDWL, at residential and non-residential premise plumbing during the Schedule 15.1 Community Lead sampling events. Copper was not measured prior to the implementation of the CCP; however, it was measured throughout the distribution system over 3 sampling periods as part of the COH's Corrosion Control baseline study.

The copper readings observed at the tap are a result of leaching from copper-containing components in the distribution and plumbing systems and should be monitored in a water system using orthophosphate for corrosion control. (Health Canada, 2018). The Ontario Drinking Water Standards, Objectives and Guidelines have an Aesthetic Objective (AO) guideline of 1,000 µg/L for copper. Pre- and post-implementation sampling results are illustrated in Table 8 and show copper results remaining below the AO guideline.

Table 8: Pre- and Post-Implementation Results of Copper in the System

DATES	NUMBER OF SAMPLES	COPPER RESULTS (range) (µg/L)
DISTRIBUTION		
Pre-Implementation 01-Jul-16 to 30-Sept-16	98	<2-62
Pre-Implementation 01-Nov-16 to 30-Jan-17	79	<2-90
Pre-Implementation 01-Mar-17 to 30-Jun-17	82	<2-42
RESIDENTIAL AND NON-RESIDENTIAL PREMISE		
Post-Implementation 01-Jan-19 to 31-Dec-19	114	2.0-93.1
Post-Implementation 01-Jan-20 to 31-Dec-20	55	1.7-63.3
Post-Implementation 01-Jan-21 to 31-Dec-21	COVID Regulatory Relief for sampling (premise)	
Post-Implementation 01-Jan-22 to 31-Dec-22	56	1.2-90.6

4.2 Lead Pipe Loops Installed in the Distribution System

Three lead pipe loops installed in the Woodward Avenue DWSS are an additional tool used by the COH to monitor the effectiveness of the CCP and are sampled monthly. Table 9 (p.16) illustrates a summary of the key CCP parameters measured at the three loops. The range of lead and copper values shows a consistent decreasing trend, as is also seen in Charts 2 (p.17), 3 (p.17) and 4 (p.18). Throughout 2022, the lead values remained below the Ontario Regulation 169/03 MAC of 10 µg/L at all three locations and in all cases, results are observed to be below the Health Canada limit of 5 µg/L. Two unusual high lead results were observed at HD024 Upcountry Estates Pumping Station, 460 Parkside Drive, Waterdown (16-4) in July and August 2022. Investigation concluded no definitive reason for the anomalous results; however, the batteries in the auto-flushers were replaced and results returned to expected values after the subsequent sampling event. These unusual results were excluded from the range summary.

Table 9: Pre- and Post-Implementation Summary of Lead, Copper and pH Values as Observed at the Three Lead Pipe Loops

DATES	LOCATIONS	RESULTS		
		LEAD (range) (µg/L)	COPPER (range) (µg/L)	pH Average
PRE-IMPLEMENTATION				
09-Sept-17 to 09-Sept-18	7 - 15	9.5 - 105	14 - 84	7.89
	16 - 4	11.6 - 208	44 - 148	7.96
	21 - 1	6.9 - 84.8	5 - 100	7.93
POST-IMPLEMENTATION				
2018	7 - 15	3.0 - 7.1	23 - 41	7.85
	16 - 4	2.8 - 9.8	42 - 57	7.83
	21 - 1	2.6 - 8.8	5 - 6	7.86
2019	7 - 15	1.5 - 5.6	18.9 - 67.5	7.79
	16 - 4	1.4 - 7.3	56.2 - 156	7.82
	21 - 1	0.3 - 7.1	1.5 - 14.4	7.81
2020	7 - 15	0.8 - 5.1	8.6 - 68.0	7.70
	16 - 4	0.8 - 6.2	53.0 - 254	7.67
	21 - 1	0.3 - 2.7	1.8 - 2.9	7.68
2021	7 - 15	0.6 - 2.3	16.4 - 46.4	7.74
	16 - 4	0.5 - 2.9	31.8 - 98.5	7.76
	21 - 1	0.2 - 1.5	1.2 - 2.1	7.78
2022	7 - 15	0.6 - 4.6	15.9 - 199	7.69
	16 - 4	0.5 - 1.4	23.2 - 99.0	7.73
	21 - 1	0.2 - 0.6	1.3 - 2.6	7.75

NOTE: 7-15 - HD007 Pumping Station, 293 Highland Road West, Hamilton
16-4 - HD024 Pumping Station, 460 Parkside Drive, Waterdown
21-1 - HD020 Pumping Station, 21 Queen Street, Dundas

Chart 2: Summary of Lead Values at Lead Pipe Loop (7-15)

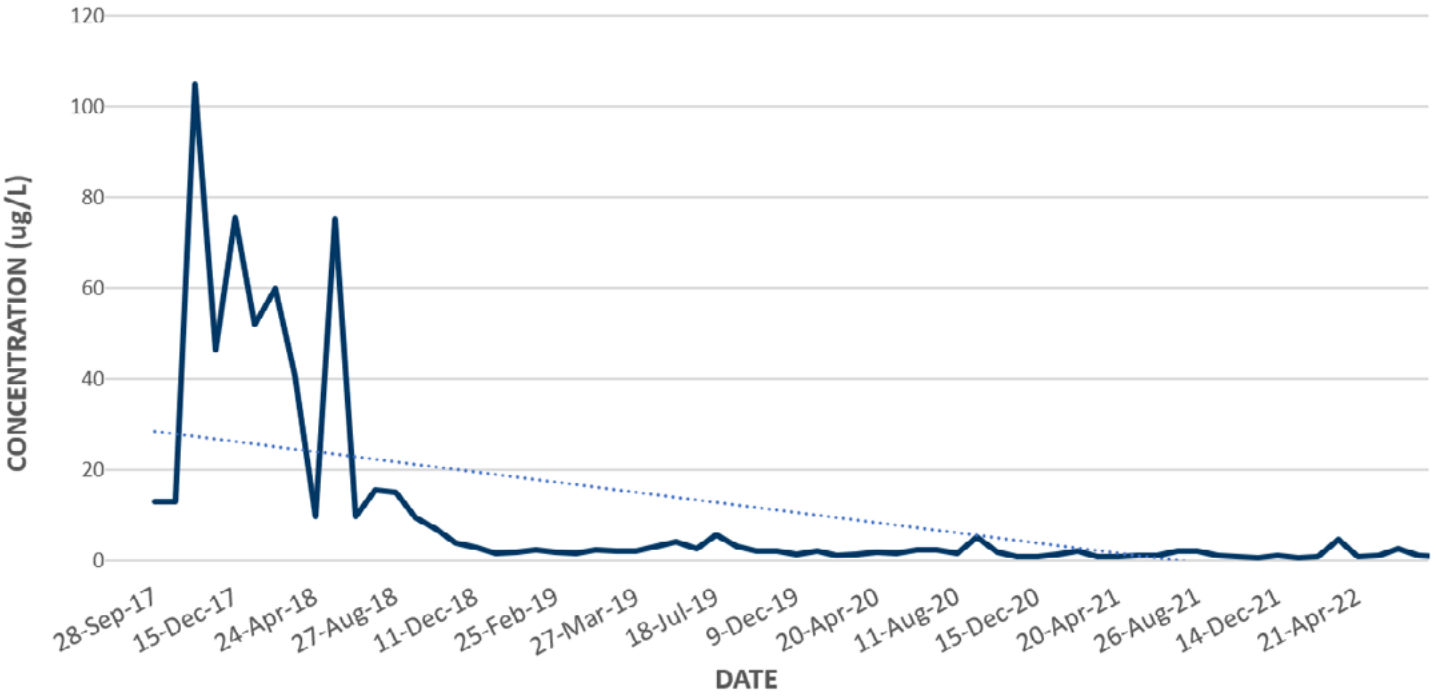


Chart 3: Summary of Lead Values at Lead Pipe Loop (16-4)

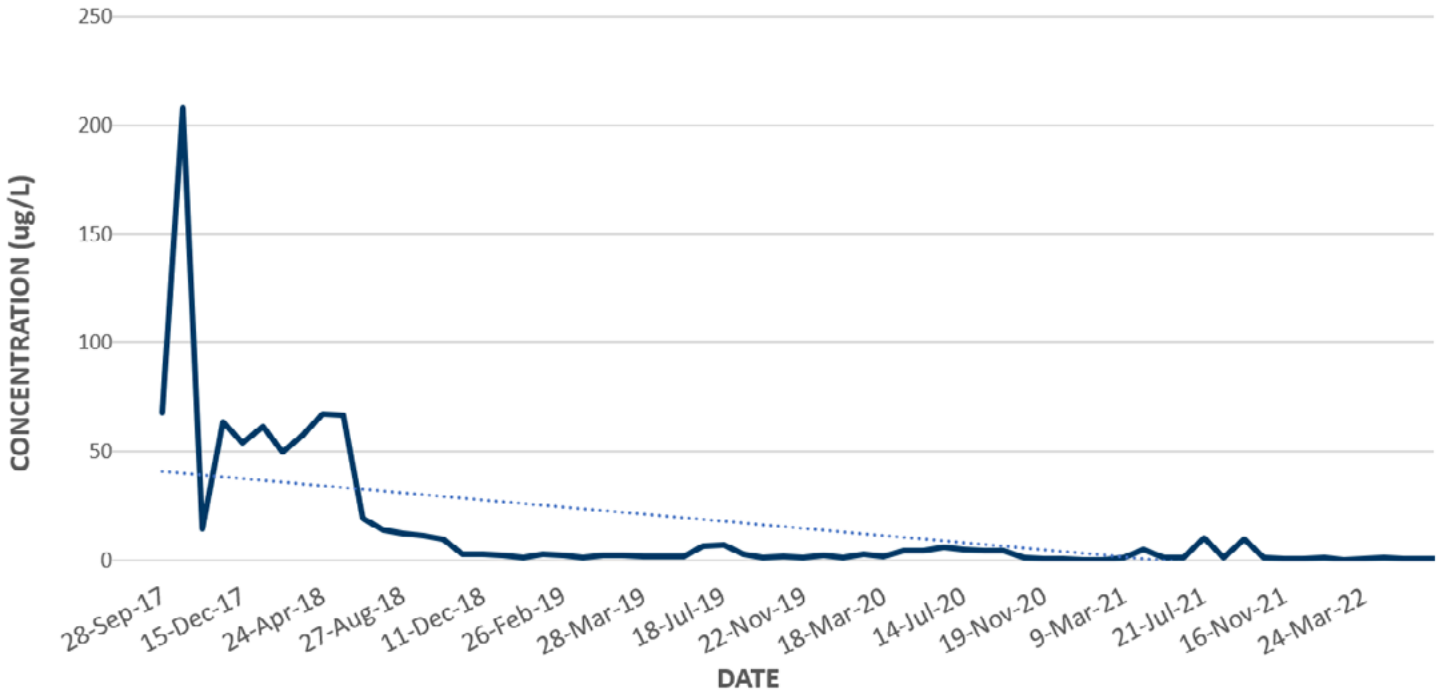
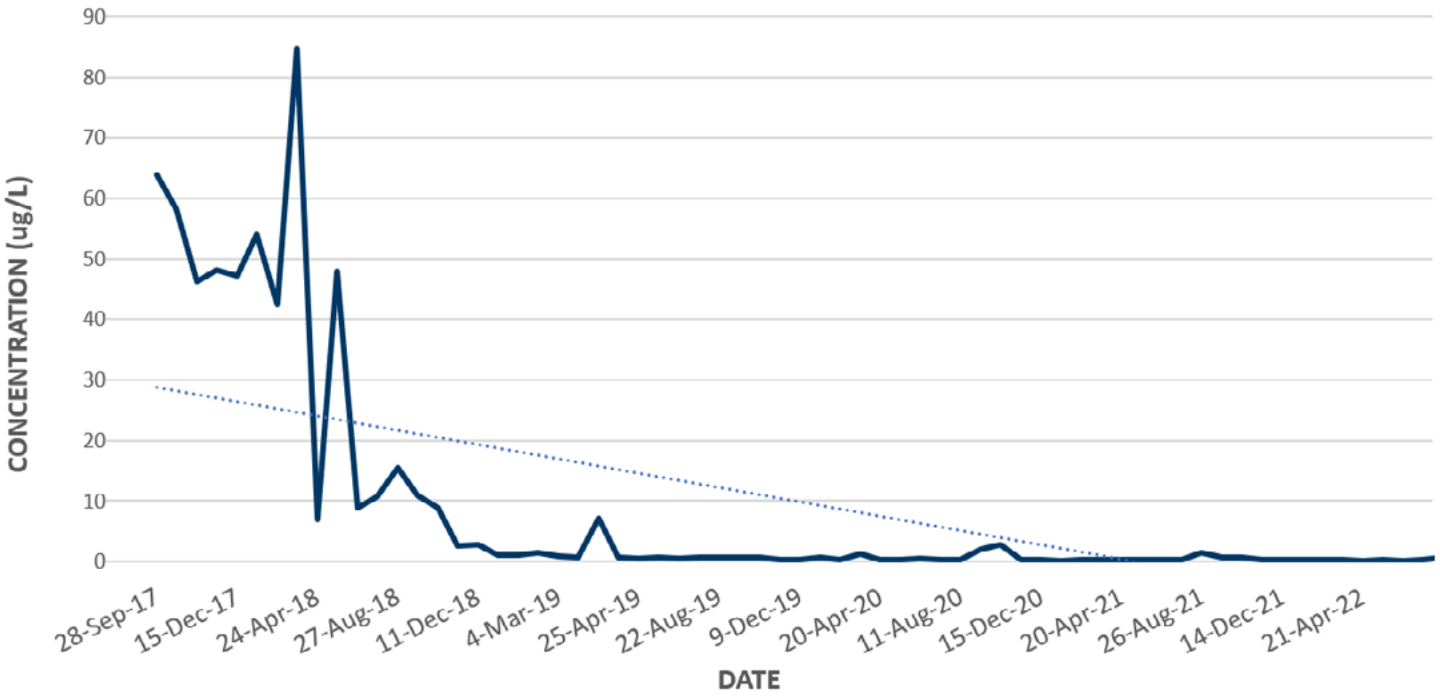


Chart 4: Summary of Lead Values at Lead Pipe Loop (21-1)



5 EVALUATION OF SECONDARY IMPACTS

5.1 Customer feedback or water quality complaints, since implementation of corrosion control, with analysis of reasons

The COH collected and reviewed customer feedback as well as water quality complaints throughout 2022, to ensure customer safety and satisfaction. Two specific customer inquiries were received asking for further information regarding the CCP. The first caller requested more information on the CCP in Greensville and the surrounding watershed and response involved educating the resident that CCP doesn't affect the rural well communities and links to the Wells information on the COH website were provided. The second caller asked for additional information about general information on the CCP and the NSF lead filter kits. They were also referred to the COH website and were provided with contact information to contact the Project Manager, Regulatory Monitoring should they wish to discuss further. Section 6.2 summarizes the outreach and education performed by the COH in relation to the CCP and Lead Awareness.

5.2 Impacts on secondary disinfection, including biofilm formation

The COH monitors secondary disinfection through the measurement of chlorine residuals throughout the distribution system, with biofilm formation monitored through the Heterotrophic Plate Count (HPC) test.

Table 10 (p.19) summarizes both chlorine residuals and HPC as seen before and after orthophosphate addition. There were no significant changes observed with the chlorine residuals observed within the distribution system. As noted previously in 2019 and 2021, an increase in the HPC was observed at specific locations. COH investigated locations with elevated HPC as part of their due diligence HPC resampling program.

5.2 Impacts on secondary disinfection, including biofilm formation (continued)

It was discovered that internal building plumbing was the cause of the increase, as these locations had very little or no water use. By increasing water use at these locations, the HPC returned to baseline levels. In 2022, due diligence HPC resampling continued as a proactive means of acting on water quality indicators. Locations that returned slightly elevated HPC counts were identified as either dead-end areas or locations with very little water use. Flushing these areas of concern and resampling returned expected HPC results.

There were also two instances where the orthophosphate residual measured in the distribution system exceeded the desired range of 1.8-3.0mg/L. Flushing was performed in both areas and subsequent repeat sampling showed a return to normalized concentrations of orthophosphate. The recently implemented system-wide corrosion control sampling program enhances the data to better understand the behaviour of orthophosphate throughout the entire distribution system and not just at the ends of the system. In addition, a difference of ≥ 0.5 mg/L between total and dissolved orthophosphate can be indicative of precipitation in the distribution system and proactive flushing is performed if this occurs. There were 3 instances in 2022 where this difference exceeded a 0.5 mg/L tolerance. In all cases, resampling occurred post flushing, and results returned to expected values. In the event of an elevated orthophosphate, colour or turbidity result, further sampling (tier 2) occurs to determine the cause of any anomaly and appropriate action is taken.

Table 10: Summary of Chlorine Residuals and HPC values Pre- and Post-Implementation

DATES	DISTRIBUTION RESULTS	
	Combined Chlorine Average (range) (mg/L)	HPC Average (range)
Pre-Implementation 01-Jan-18 to 07-Nov-18	1.92 (0.64-2.8)	1 (0-98)
Post-Implementation 08-Nov-18 to 31-Dec-18	1.85 (0.93-2.8)	2 (0-64)
Post-Implementation 01-Jan-19 to 31-Dec-19	1.79 (0.51-3.06)	29 (0-1010)
Post-Implementation 01-Jan-20 to 31-Dec-20	1.74 (0.11-2.81)	13 (0-2200)
Post-Implementation 01-Jan-21 to 31-Dec-21	1.73 (0.19-2.85)	3 (0-1720)
Post-Implementation 01-Jan-22 to 31-Dec-22	1.68 (0.51-2.95)	3 (0-810)

5.3 Impacts on wastewater treatment plants receiving treated water from the Owner, including estimates of increases in phosphorous loadings to the receiver, and comparison to effluent limits.

The COH operates both the Woodward Avenue and Dundas Wastewater Treatment Plants (WWTPs). A comparison of raw influent total phosphorus concentrations, loadings, and pH, before and after inhibitor addition, show a minimal change and thus negligible impacts on the WWTPs as a result of the CCP. Although the same comparison on the final effluent concentrations and loadings shows a slight increase, the values remain below the effluent limits set by the Environmental Compliance Approvals (ECA)/Certificate of Approval (CofA); Woodward Avenue WWTP ECA Number 9410-B65QRT, dated May 14, 2019 and Dundas WWTP CofA Number 3101-89PNRC, dated October 6, 2010. Additionally, this increase is relatively small and cannot be attributed solely to the CCP and is below the threshold of causing a significant impact to the receiving waters. These summaries are illustrated in Tables 11 and 12 (p.21).

Table 11: Summary of Raw Influent Concentrations and Loadings Pre- and Post-Implementation

DATES	AVERAGE RESULTS					
	WOODWARD AVENUE WWTP			DUNDAS WWTP		
	TP (mg/L)	Lab pH	TP Daily Loadings (Kg/day)	TP (mg/L)	Lab pH	TP Daily Loadings (Kg/day)
Pre-Implementation Jan-Oct 2018	4.83	7.74	1484	3.24	7.66	40
Post-Implementation Nov-Dec 2018	5.55	7.72	1897	3.29	7.71	44
Post-Implementation Jan-Dec 2019	4.25	7.69	1560	3.22	7.67	42
Post-Implementation Jan-Dec 2020	5.49	7.61**	1611	3.39	7.65	40
Post-Implementation Jan-Dec 2021	4.87	7.59	1344	3.41	7.62	37
Post-Implementation Jan-Dec 2022	5.23	7.58	1332	3.76	7.61	38

NOTE: TP - Total Phosphorus as P

**For samples collected from May 29, 2021 to December 31, 2021, use lab pH results with caution as an electrode malfunction may have impacted the results.

Table 12: Summary of Final Effluent Concentrations and Loadings Pre- and Post-Implementation

DATES	AVERAGE RESULTS					
	WOODWARD AVENUE WWTP*			DUNDAS WWTP		
	TP (mg/L)	Lab pH	TP Daily Loadings (Kg/day)	TP (mg/L)	Lab pH	TP Daily Loadings (Kg/day)
Pre-Implementation Jan-Oct 2018	0.443	7.85	138	0.052	7.70	0.65
Post-Implementation Nov-Dec 2018	0.341	7.77	116	0.054	7.75	0.72
Post-Implementation Jan-Dec 2019	0.504	7.76	194	0.083	7.76	1.07
Post-Implementation Jan-Dec 2020	0.572	7.62**	171	0.108	7.45**	1.27
Post-Implementation Jan-Dec 2021	0.573	7.54	162	0.131	7.52	1.45
Post-Implementation Jan-Dec 2022	0.437	7.54	116	0.129	7.51	1.25

NOTE: TP - Total Phosphorus as P

Woodward Avenue ECA Limits for TP = 0.80mg/L; TP Loadings = 327Kg/day; pH = 6.0 to 9.5 inclusive
Dundas CofA Limits for TP = 0.50mg/L; TP Loadings = 9.1Kg/day; pH = 6.0 to 9.5 inclusive

*Woodward Avenue WWTP Data is an average of Final Effluent North and South. Starting October 2022, the data is an average of Final Effluent 1 and 2 autosamplers. These new autosamplers collect tertiary-treated effluent while the North/South autosamplers were on secondary effluent channels. The reported values in October are a flow-weighted average which accounts for a transitionary period in which there was flow going through both outfalls (i.e. some effluent receiving tertiary treatment and some only receiving secondary).

**For samples collected from May 29, 2021 to December 31, 2021, use lab pH results with caution as an electrode malfunction may have impacted the results.

6 OWNER LEAD MITIGATION STRATEGIES

6.1 Lead service line replacement on public and private property

The COH has estimated that there was a total of 19,000 sub-standard/lead water service lines (LWSLs) remaining within the Woodward Avenue DWSS at the end of 2022. This number is an approximation as there is no way to know an exact number due to various uncertainties and variables that make it difficult to track.

The COH's Sub-Standard Water Service Line Replacement Program has been in place for over 30 years to address customer requests related to pressure or other concerns (such as undersized services or leaks). Over the last 10 to 15 years, as the public has been made more aware of the risk associated with lead, the focus of the program has shifted from poor pressure to sub-standard/LWSL replacements.

In this program, COH replaces the sub-standard material up to the property line (public portion) when the homeowner replaces the privately-owned portion. In addition, COH has a loan program available to assist homeowners with the replacement of their privately-owned portion.

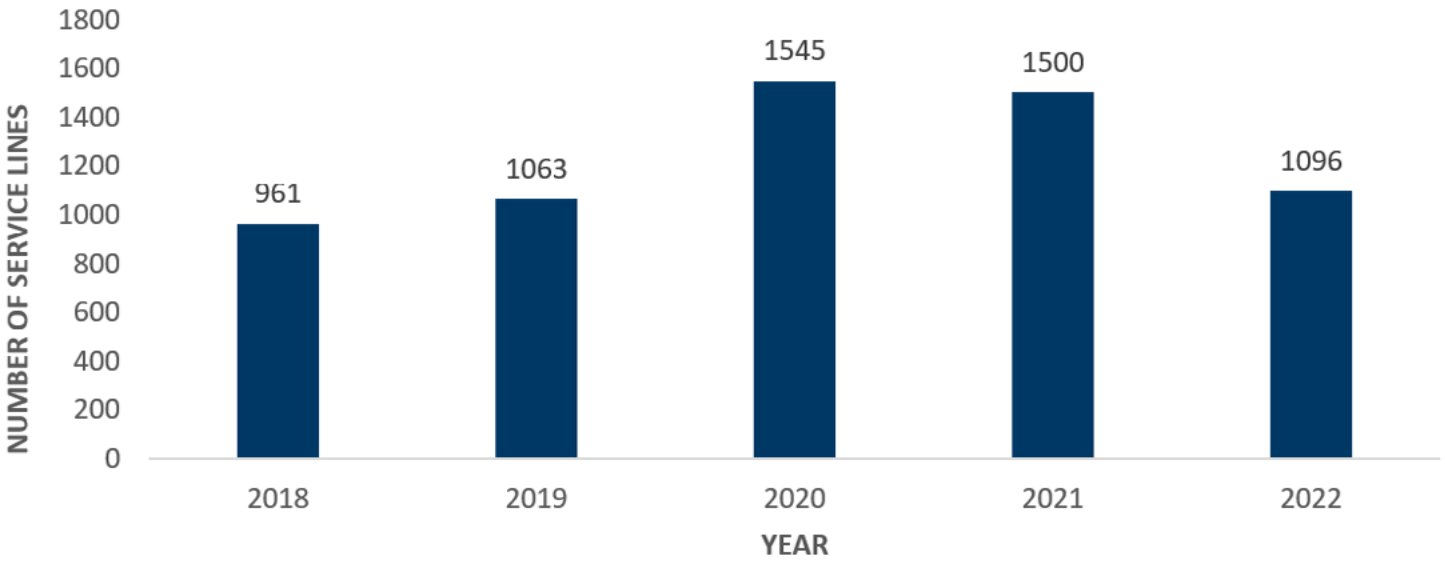
Under this program in 2022, 691 sub-standard/LWSLs replacements were completed by COH on the public portion, with 989 replacements performed on the private portion, and 59 replacements completed as part of routine watermain maintenance/rehabilitation work. It is important to note that only the public portion is replaced as part of routine watermain work as performed by capital construction. This summary is illustrated in Table 13 (p.23). A summary of the number of sub-standard service line replacement over the last five years is illustrated in Chart 5 (p.23).

Table 13: Summary of Sub-Standard Service Line Replacements Performed In 2022

YEAR	PUBLIC	PRIVATE	Watermain Maintenance/ Rehabilitation Work (Public)	Remaining LWSL
2022	691*	989	59	Approx. 19 000

*There was a backlog of 298 sub-standard/LWSLs replacements due, at the end of 2022.

Chart 5: Number of Sub-Standard Service Line Replacements 2018-2022



6.2 Outreach and education, especially to populations vulnerable to lead in drinking water

In 2022, the following outreach/education on Lead Awareness and the Corrosion Control Program was completed:

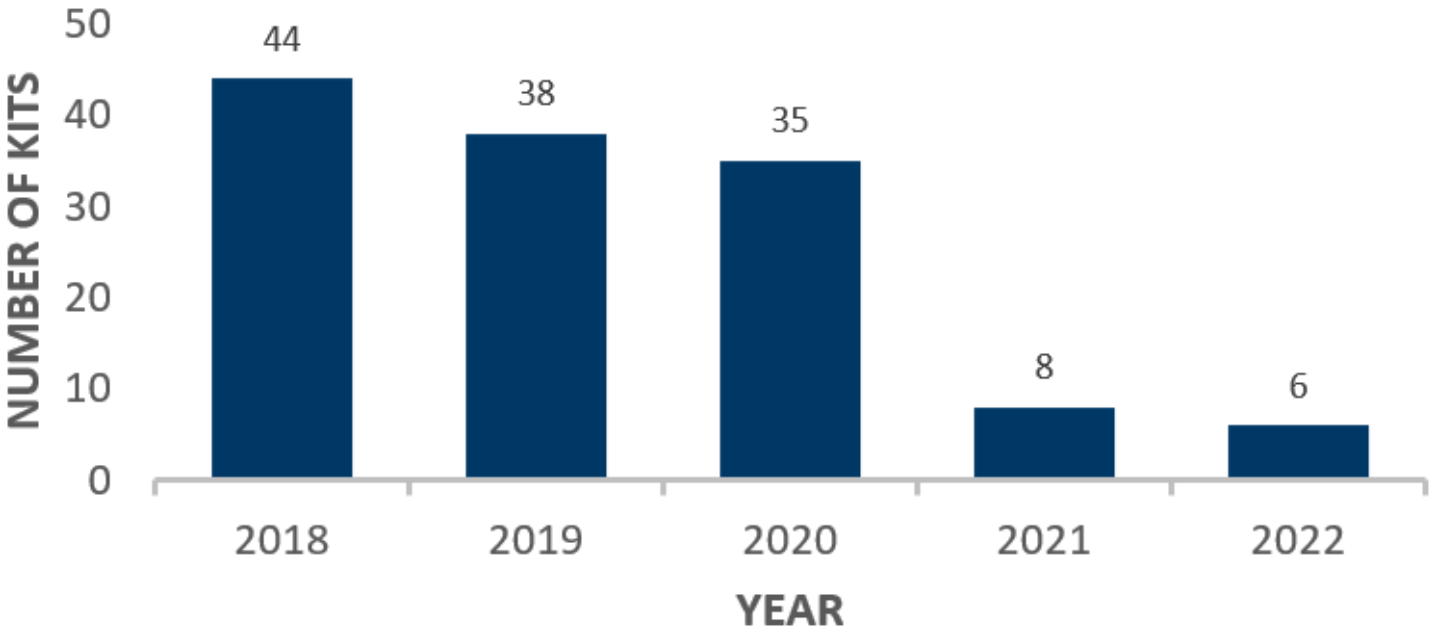
- The COH continued to maintain the Lead Awareness (www.hamilton.ca/leadpipes) and Corrosion Control (www.hamilton.ca/corrosioncontrol) websites .
- Lead Awareness Advertising – Online, newsprint, digital media board at City Hall.
- 28,042 properties were mailed Lead Awareness packages. These are sent to homes built before 1955 or properties containing lead service lines or to those with an unknown service type.
- 1,084 coordinated Roads information packages were mailed out including Public Health Lead inserts and the Lead Pipe Replacement Program details to property owners that were going to be affected by road cuts at their properties due work such as watermain replacement or road resurfacing.
- 145,000 properties within the Woodward Avenue DWSS received the Fall Newsletter via the Alectra Bill Insert. This insert included Lead Pipe Awareness messaging.

Alectra Utilities is an electricity utility and distributor that invoices water, wastewater, and stormwater charges on behalf of the COH.

6.3 Filter kit program

The COH provides filter kits certified by the National Sanitation Foundation (NSF/ANSI-53). The kit consists of a Brita jug and 3 filters. They are provided to homeowners when requested or to contractors when a permit to replace a LWSL is obtained. In 2022, a total of 6 filter kits were requested by and provided to residents. The decline in the number of kits provided since 2020 is due to the storefront closing at 330 Wentworth Street because of the COVID-19 pandemic. Permit sales pivoted to a virtual platform and as such, contractors are no longer obtaining kits. Coupons were handed out instead of kits during this time, and coupon redemption was minimal. A summary of the number of kits provided to residents over the last five years is illustrated in Chart 6.

Chart 6: Number of Filter Kits Handed out by the City of Hamilton 2018-2022



6.4 Involvement of Public Health Authorities

The COH Public Health Services (PHS) has worked in conjunction with the Hamilton Water (HW) division of the Public Works Department in the COH, from the development of the CCP to the implementation of activities related to the program.

COH PHS educate the public on the risks associated with lead exposure by maintaining a link on their website of the various sources of lead in the environment, the health risks and how the public can take steps to protect themselves from lead exposure.

The COH PHS was also involved in all Adverse Water Quality Incidents (AWQIs) that were initiated in 2022, with their input required during corrective actions. There were no lead related AWQIs in 2022. Semi-annual liaison meetings between the COH PHS and HW were held on March 31, 2022 and December 5, 2022, keeping both units informed on related activities. These semi-annual meetings and the involvement of PHS during AWQIs continues in 2023.

7 CONCLUSION

The COH began the addition of phosphoric acid in the Woodward Avenue DWSS on November 8, 2018 and in conformance with the requirements of Schedule C of the MDWL, continues to sample and monitor to evaluate the effectiveness of the program for lead control.

The post-implementation plan shows that orthophosphate inhibitor is continuing to work as expected. A reduction in lead levels has been observed throughout the system in both the lead pipe loops and the premise plumbing as seen in the Schedule 15.1 Community Lead Sampling results.

Sampling and monitoring, including the Schedule 15.1 Community Lead Sampling Program will continue in 2023.