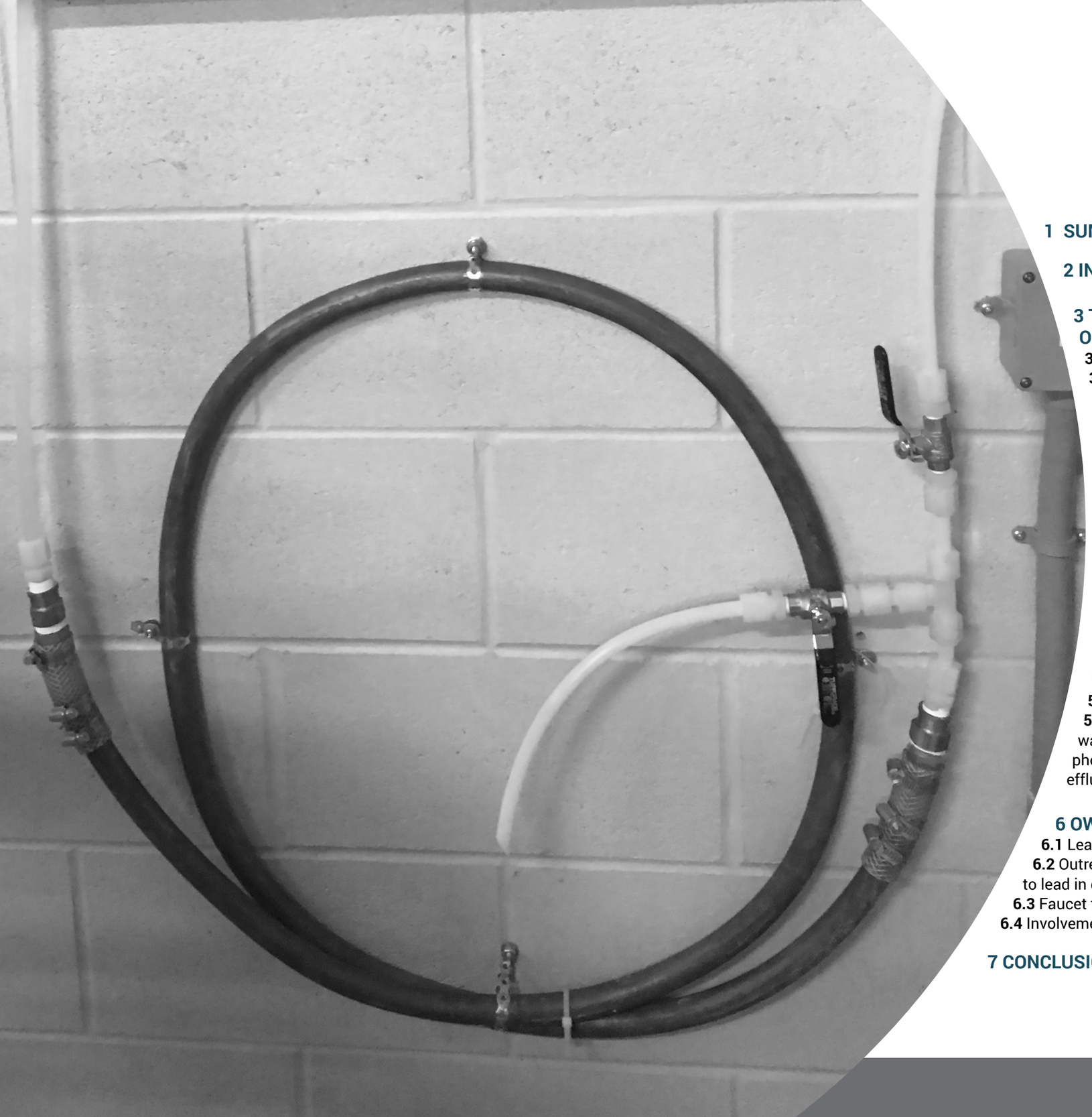
CITY OF HAMILTON
CORROSION CONTROL PROGRAM

ANNUAL EVALUATION REPORT ASSESSING THE EFFECTIVENESS OF THE CORROSION CONTROL MEASURES

2021

WOODWARD AVE DRINKING WATER SUBSYSTEM
MARCH 2022

Hamilton



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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 2021 calendar year. It highlights the following:

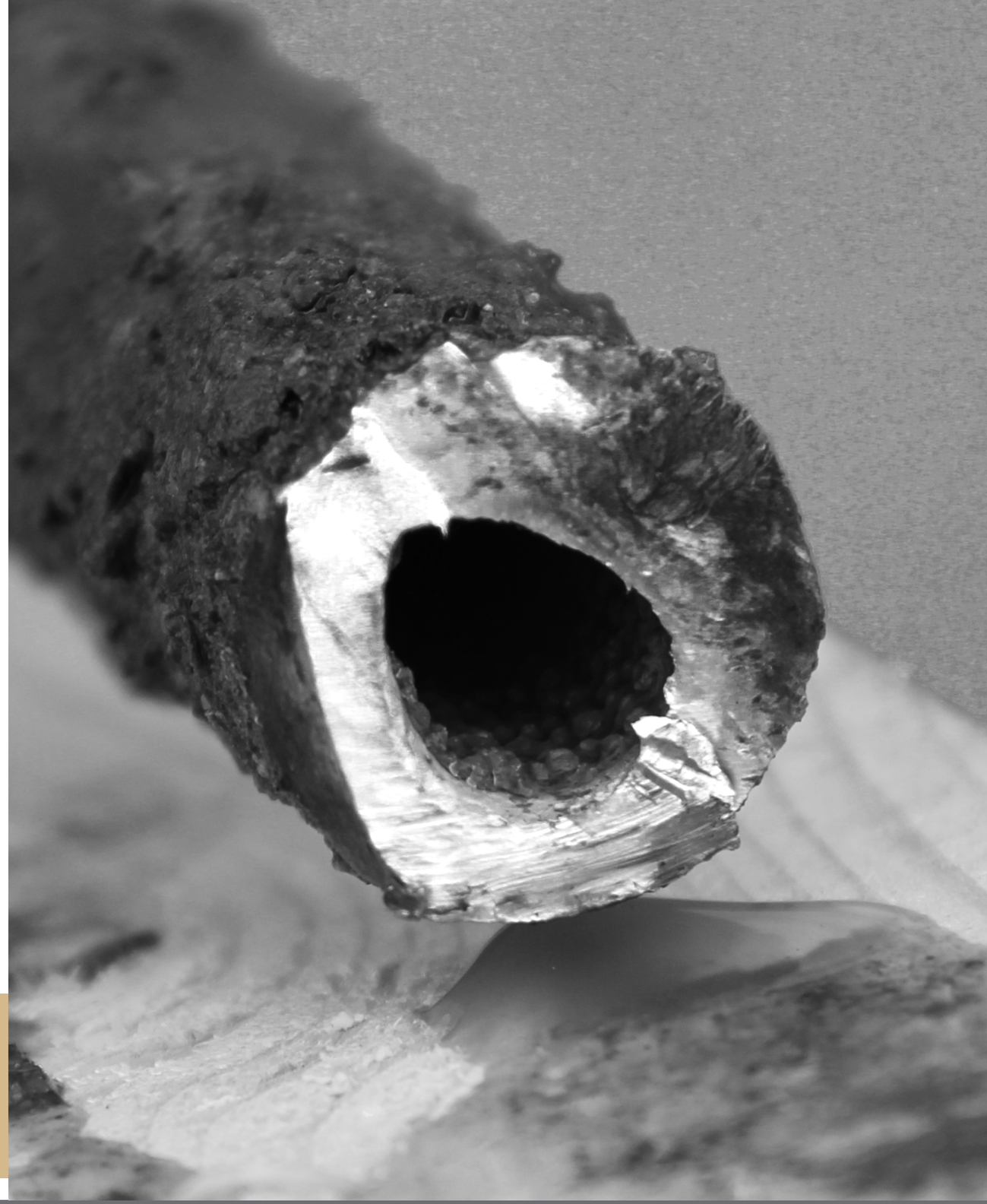
- Lead results and a summary of any key corrosion control parameters
- A technical evaluation of the effectiveness of corrosion control measures
- A summary of lead levels and other metals monitored since implementation of corrosion control, and comparison to Pre-Implementation levels
- An evaluation 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 2021 being the third year of program operation. Throughout 2021, operating conditions were steady at the Water Treatment Plant (WTP) with inhibitor concentrations 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 after a period of Regulatory Relief from sampling. Two sampling rounds, round 27 (Winter) and round 28 (Summer) were scheduled for 2021 with a total of six rounds completed since the implementation of the corrosion control program in 2018. Both rounds in 2021 received COVID-19 Regulatory Relief from premise (at-the-tap) sampling and only distribution samples were collected. This relief was granted province-wide as the samples are collected at the tap inside residents' homes and it posed a health risk to both staff and homeowners. A summary of results, as seen at the end of 2021, 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 2021 evaluation report highlights the Post-Implementation sampling and monitoring activities, 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 2021 bringing the COH into the third year of the CCP, Post-Implementation sampling and monitoring continues to be one of the main ways of evaluating our programs 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 27 - Winter 2020 (December 15–April 15, 2021), and round 28 - Summer 2021 (June 15-October 12, 2021), as a result of the COVID-19 Pandemic. This relief was granted because the samples are collected at-the-tap (premise) inside residents' homes and it posed a health risk to both staff and homeowners. Despite the lack of additional data from these sampling rounds, the three Lead Pipe Loops installed in 2017 in the Woodward Sub-System remained an additional tool to monitor the effectiveness of the program. These three pipes containing lead material were installed at 293 Highland Road West, 460 Parkside Drive, Waterdown and 21 Queen Street, Dundas 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 distribution system flushing took place throughout 2021, ensuring the movement of water containing orthophosphate throughout the distribution system and reduction of secondary impacts as well as 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 premise sampling that began in Summer of 2020. The study will resume when additional data is obtained upon removal of the Regulatory Relief.

Key milestones were completed in the Distribution system study that commenced in 2020 with the goal of monitoring the effectiveness of orthophosphate in creating a protective film within the distribution system, while also monitoring for secondary effects of its addition. A delay in the study occurred due to the COVID-19 pandemic and the study resumed in 2021. Results from the study showed that lead levels have been observed to decrease rapidly to levels nearing compliance with Ontario's Maximum Acceptable Concentration (MAC) of 10 µg/L. Phosphate-based lead scale was also confirmed to be present in lead service lines. It is also expected that lead levels will continue to decrease as the scale thickens and strengthens from continued exposure to orthophosphate.

Secondary impacts stemming from the addition of orthophosphate were also 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. An additional system-wide corrosion control sampling program was introduced to help better understand the behaviour of orthophosphate throughout the distribution system.

The key Post-Implementation activities are summarized in Table 1 (page 7).

Table 1: 2021 CCP Post-Implementation Monitoring Plan

TASK	STATUS
Water Distribution System Flushing	On-going: • 1862 hydrants flushed in 2021. • Proactive flushing continues in 2022.
Post-Implementation monitoring	On-going: • Sampling as per Schedule C of the MDWL completed in 2021and continues in 2022. • Monthly sampling at the three lead pipe loop locations within the distribution system. • Post-Implementation sampling continues in 2022. • Additional system-wide monitoring program introduced in Q3 2021 to measure key corrosion control parameters within the distribution system.
Plant Optimization Study	On-hold: • 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 • On-hold due to the COVID-19 pandemic and subsequent Regulatory Relief. Study to resume when residential tap sampling resumes.
Distribution System Study	Ongoing: • 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. • Target completion of study - Q3 2022.

3.2 Equipment Malfunction or Upset Conditions

No equipment malfunctions or upset conditions occurred in 2021.

A summary of the continuously monitored parameters, at the Point of Entry, are included in Table 2 (page 8). 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 (page 8). 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

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)
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)

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 inhibitor concentrations, as well as other related parameters were measured at the ends of the distribution system.

As illustrated in Table 4 (page 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 2021 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 (page 9).

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

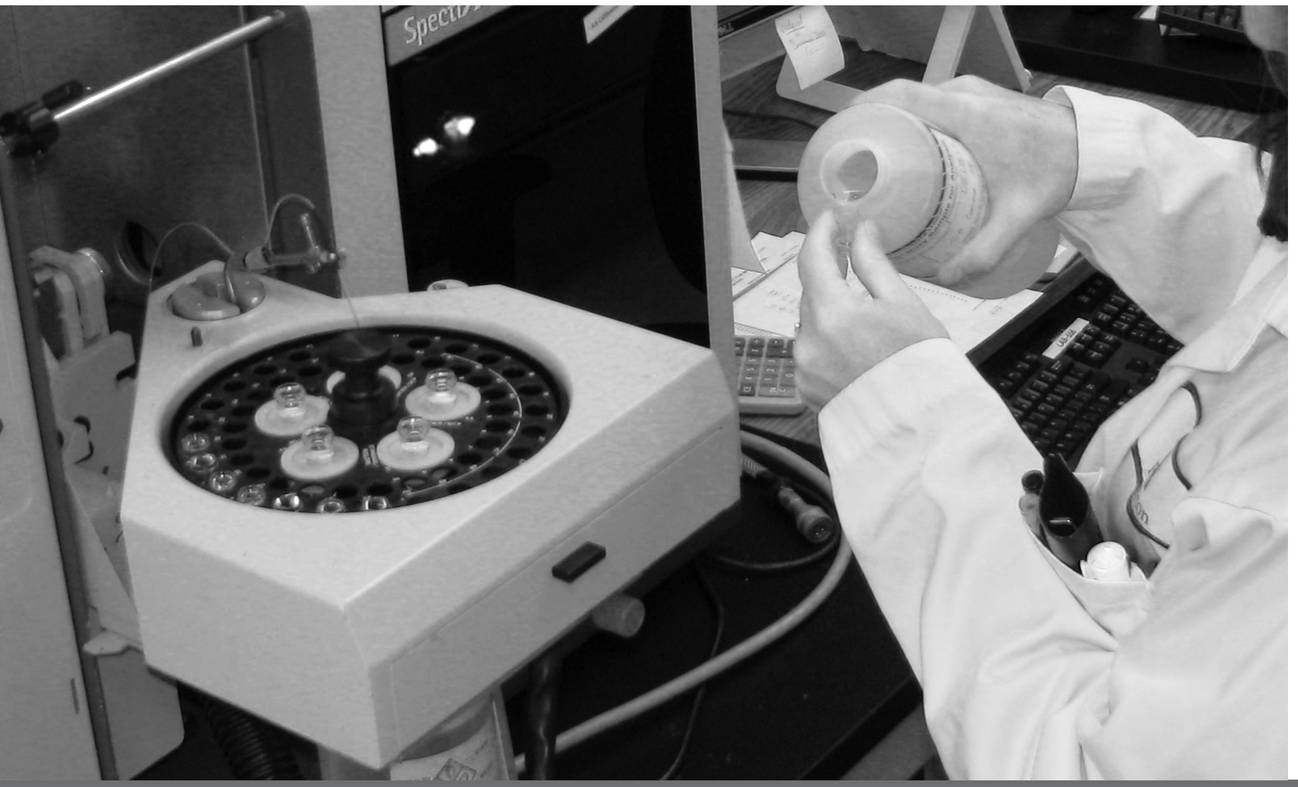
3.4 Ability to achieve reduction in lead levels and other corrosion related parameters in the distribution system and premise plumbing (residential & non-residential).

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 27 (Winter) and round 28 (Summer) were scheduled for sampling in 2021. Regulatory Relief from premise (at-the-tap) sampling was granted for both rounds and only distribution samples were collected. A summary of all the results are 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 seen in Chart 1 (page 14).

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 an additional way of observing the effectiveness of the CCP. Charts 2, 3 and 4 (pages 16, 17), illustrate the reduction in lead levels as observed at the lead pipe loops. The three Lead Pipe Loops are pipes containing lead material and were installed at 293 Highland Road West, 460 Parkside Drive, Waterdown and 21 Queen Street, Dundas as controlled study sites to monitor the effect of the orthophosphate on the pipes.



4 SUMMARY OF LEAD LEVELS AND OTHER METALS

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

Tables 5, 6 and 7 (pages 11, 12 and 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%
26-28	15-June-20 to 15-Oct-21	COVID Regulatory Relief for lead sampling (premise)					

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%
26-28	15-June-20 to 15-Oct-21	COVID Regulatory Relief for lead sampling (premise)					

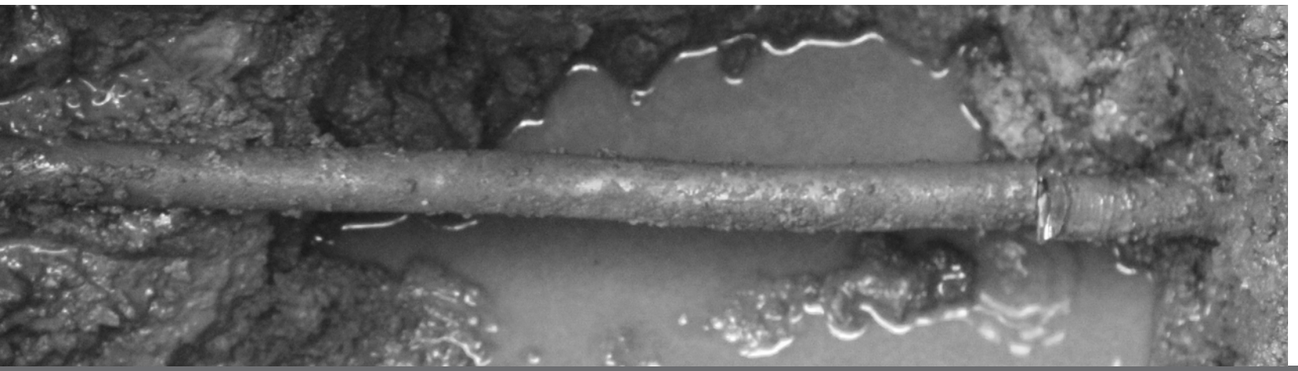


Table 7: Pre and Post-Implementation Results from the Schedule 15.1 Sampling for the Woodward Avenue DWSS – DISTRIBUTION SYSTEM

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%

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

As required by the MDWL, copper is now measured at residential and non-residential premise plumbing during the Schedule 15.1 Community Lead sampling period. This metal was not measured as part of the Schedule 15.1 Community Lead Sampling program prior to the implementation of the CCP. However, as part of COH's baseline study copper was measured throughout the distribution system over 3 sampling periods.

The copper readings observed at the tap are as 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 (page 14) and show copper results remaining below the AO guideline.

Chart 1: Percent (%) of Premise Samples with Lead above the MAC (10µg/L)

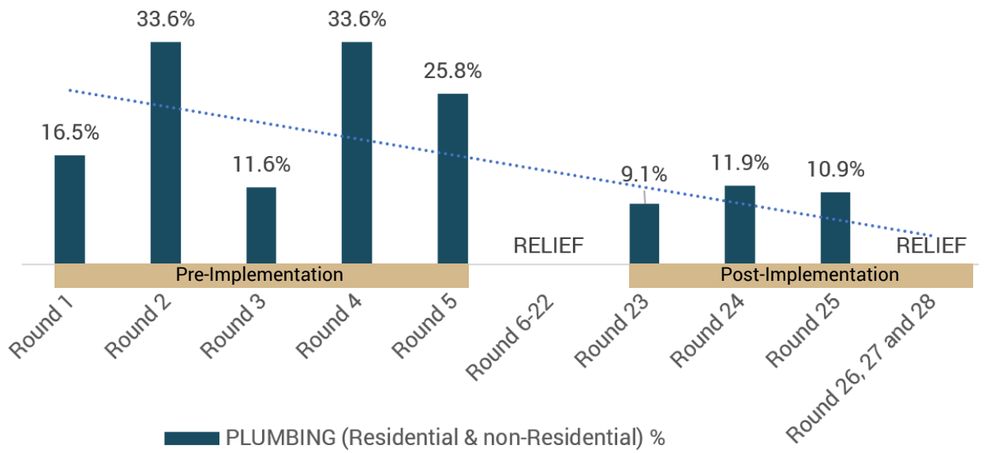


Table 8: Pre and Post-Implementation Results of Copper in the Distribution System

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
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-20	COVID Regulatory Relief for sampling (premise)	

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 on a monthly basis. Table 9 (page 15) illustrates a summary of some key CCP parameters measured at the three loops. The range of lead and copper values shows an overall decreasing trend, as is also seen in Charts 2, 3 and 4 (page 16 and 17). Throughout 2021, the lead values remained below the MAC of 10 µg/L at all three locations and in all cases observed to be below the Health Canada limit of 5 µg/L

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

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)

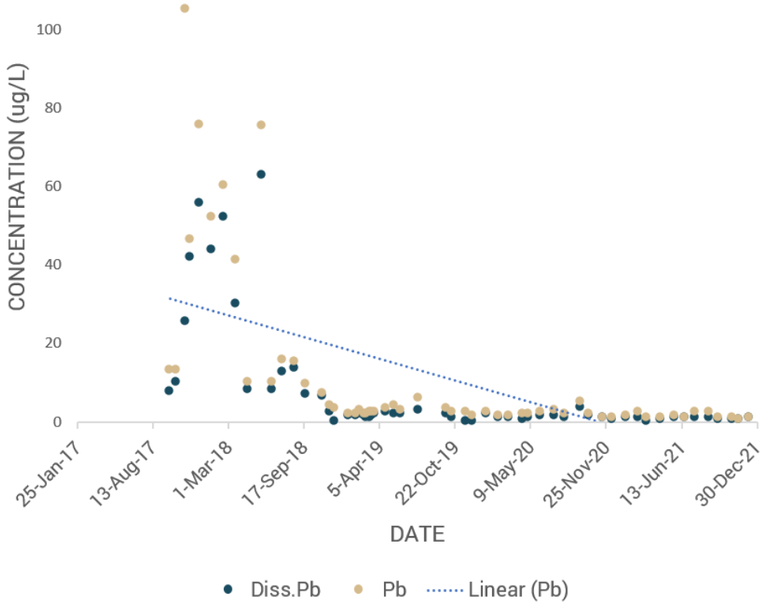


Chart 3: Summary of Lead Values at Lead Pipe Loop (16-4)

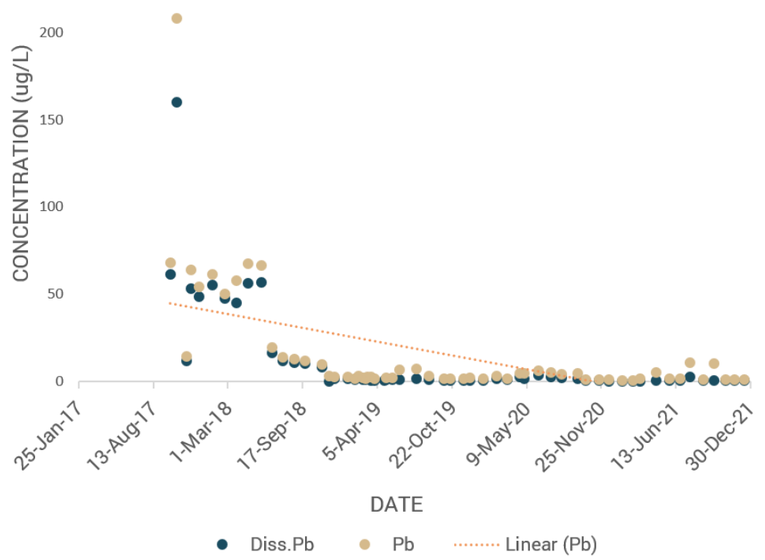
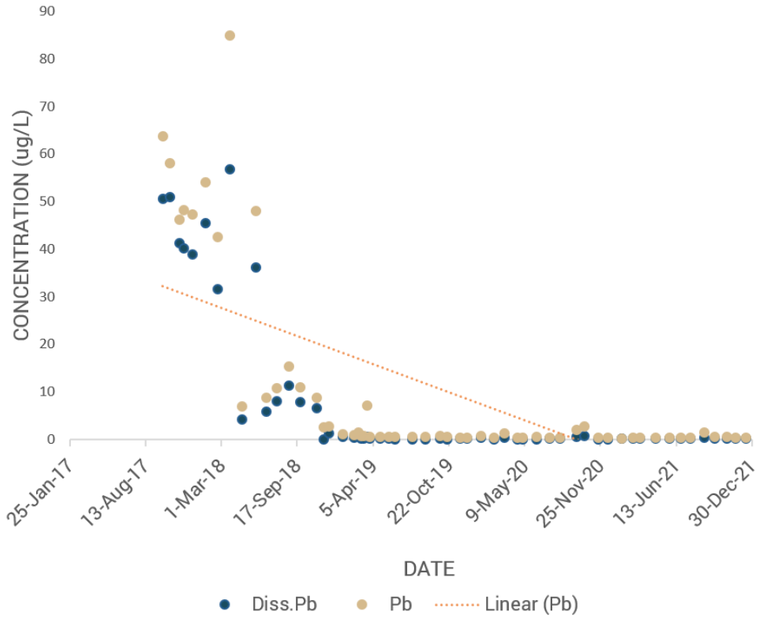


Chart 4: Summary of Lead Values at Lead Pipe Loop (21-1)



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 2021, to ensure customer safety and satisfaction. Most customer feedback received throughout 2021 was related to general inquiries and requests for more information on the CCP and the monitoring program. Section 6b summarizes the outreach and education performed by the COH in relation to the CCP and Lead Awareness.

The COH also received customer feedback from two residents who indicated that they had high orthophosphate residuals at their businesses, from their own testing process. Additional sampling at one of the locations by COH staff illustrated normalized values. Follow-up sampling with the other resident was unsuccessful, however City staff discussed testing methods used in the laboratory against the reagent test kits used at their business and City staff continue to provide them with monthly reports showing the orthophosphate residual in the treated water leaving the Water Treatment Plant.

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 Counts (HPC) test.

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

Table 10 (page 18) summarizes both chlorine residuals and HPC counts as seen before and after inhibitor addition. There were no significant changes observed with the chlorine residuals observed within the distribution system. An increase in the HPC counts was observed in both 2019 and 2021 at specific locations.

COH investigated locations with elevated HPC as part of their due diligence HPC resampling program. 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 count returned to baseline levels. There were also two instances where the orthophosphate residuals measured in the distribution system went above the desired range of 1.8-3.0mg/L. Repeat sampling at the locations in both cases showed normalized concentrations of orthophosphate. The cause of the increased residual was considered inconclusive at the time, however the COH implemented an additional system-wide corrosion control sampling program to help better understand the behaviour of orthophosphate throughout the distribution system. This involves sampling within the distribution system as opposed to the ends of system which is required under the MDWL. In addition, dissolved orthophosphate and apparent colour were added to the currently measured parameters of orthophosphate, Field Temperature and Field pH.

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

DATES	DISTRIBUTION RESULTS	
	Combined Chlorine Average (range) (mg/L)	HPC count 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)

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.

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

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

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 minimal 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 Approval (ECA)/Certificate of Approval; Woodward Avenue WWTP ECA Number 9410-B65QRT, dated May 14, 2019 and Dundas WWTP Certificate of Approval 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 (Pages 19 and 20).

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

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 ECA 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.

**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 20,000 sub-standard/lead water service lines (LWSLs) remaining within the Woodward Avenue DWSS at the end of 2021. 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 the privately-owned portion.

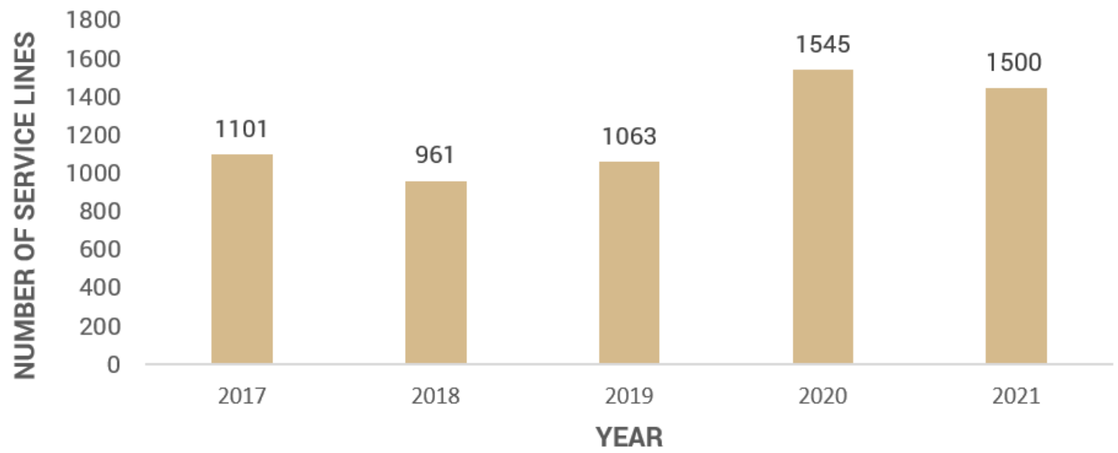
Under this program in 2021, 885 sub-standard/LWSL replacements were completed by COH on the public portion, with 1,098 replacements performed on the private portion. In addition, 402 replacements were completed on the public portion as part of routine watermain maintenance/rehabilitation work. This summary is illustrated in Table 13 (page 21). A summary of the number of sub-standard service line replacement over the last five years is illustrated in Chart 5 (page 21).

Table 13: Summary of Sub-Standard Service Line Replacements Performed In 2021

YEAR	PUBLIC	PRIVATE	Watermain Maintenance/ Rehabilitation Work	Remaining LWSL
2021	885*	1098	402	Approx. 20 000

*Not every private water service line replacement has a corresponding public water service line replacement.

Chart 5: Number of Sub-Standard Service Line Replacements 2017-2021



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

In 2021, the following outreach/education for Lead Awareness and the Corrosion Control Program were completed:

- Throughout 2021 and on-going
    - The COH maintained a Lead Awareness website (www.hamilton.ca/leadpipes) and Corrosion Control website (www.hamilton.ca/corrosioncontrol).
    - Lead Awareness Advertising – Online, newsprint, digital media board at City Hall

- Mass mailing of Lead Awareness packages sent to homes built before 1955 or had known lead service lines or had an unknown service type.
    - March - November 2021 – 29,498 addresses received letters

- Mailing of the Coordinated Roads package that includes lead pipe replacement program details and Public Health insert on health impacts of lead in water.
    - January - November 2021 – 561 addresses received letters

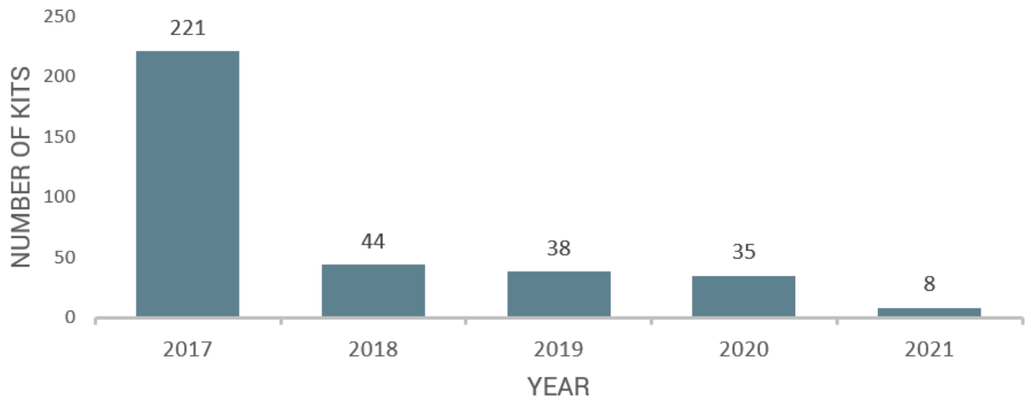
- Fall 2021 - Alectra Bill Insert.
    - Fall Newsletter - Lead Awareness Messaging (to all Woodward Avenue DWSS customers, 150,000+)

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

6.3 Faucet filter program

COH provides At-The-Tap filters approved for lead removal by the National Sanitation Foundation (NSF/ANSI-53). These lead filter kits are delivered to homeowners when requested or provided to contractors when a permit to replace a LWSL is obtained. In 2021, a total of 8 lead filter kits were provided to residents by the COH. A summary of the number of kits provided to residents over the last five years is illustrated in Chart 6 (page 22). In 2020, the COH amended the program to provide a jug and 3 filters to homeowners when a lead filter kit is requested.

Chart 6: Number of Lead Filter Kits Handed out by the City of Hamilton 2017-2021



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 2021, with their input required during corrective actions. There were no lead related AWQIs in 2021. Bi-annual liaison meetings between the COH PHS and HW were held on January 18, 2021 and June 21, 2021, keeping both units informed on related activities. These bi-annual meetings and the involvement of PHS during AWQIs continues in 2022.

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 a Post-Implementation sampling and monitoring plan to monitor the effectiveness of the program for lead control. Conditions at the Woodward WTP remained steady with orthophosphate inhibitor concentrations consistently observed at the ends of the distribution system with minimal secondary impacts and two water quality complaints logged.

In 2021, the consultant assignment assessing the maturity of the orthophosphate program in the distribution system continued. Scale analysis conducted on Lead Service Lines harvested from the distribution system confirmed the formation of phosphate-based lead scale at the pipe surface which is anticipated to thicken and strengthen, further reducing the exposure to lead. The Plant Optimization study was placed on hold due to the missing data as a result of the Regulatory Relief obtained as a result of the COVID-19 Pandemic.

The Post-Implementation sampling and monitoring 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. Although premise plumbing results from rounds 27 and 28 of Schedule 15.1 Community Lead Sampling were not conducted as a result of the COVID-19 pandemic, the lead pipe loops monthly monitoring results illustrated a decline of lead concentration towards compliance levels below 10 µg/L.

Post-Implementation sampling and monitoring, including the Schedule 15.1 Community Lead Sampling Program will continue in 2022.