Report for

City of Watertown, Wisconsin

Corrosion Control Treatment Study

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SECTION 1
INTRODUCTION AND ABBREVIATIONS

1.01 INTRODUCTION

On July 29, 2021, the Wisconsin Department of Natural Resources (WDNR) required that the City of Watertown (City) conduct a Corrosion Control Treatment (CCT) Study. The WDNR requested that the CCT Study be completed and submitted to WDNR by January 31, 2023. The requirement for the CCT Study was the result of a 2021 Lead Action Level Exceedance (ALE) and WDNR's response to the City's CCT Recommendation, dated April 30, 2021. A proposal outlining the proposed CCT Study was submitted to the WDNR on January 31, 2022.

According to the July 29, 2021, correspondence from WDNR, the CCT Study must include the following:

1. A demonstration-type study.
2. An evaluation of the efficacy of all treatments described in Wisconsin Administrative Code (WAC) NR 809.543(3).
    a. Alkalinity and pH adjustment
    b. Calcium hardness adjustment
    c. Addition of corrosion inhibitors
3. An evaluation of listed CCTs using either pipe rig or loop tests, metal coupon tests, or partial system tests.
4. Written recommendations for implementation of CCT (including proposed doses and chemicals) that optimizes lead and copper levels at consumer's tap.
5. A detailed schedule for treatment implementation.

On December 9, 2022, the WDNR confirmed to the City that the submission of the demonstration study was no longer required, as the most recent rounds of lead and copper testing had shown that the City had returned to compliance with the existing rule.

The City has elected to complete the study and summarize the results in this report. The study will be maintained in the event that future testing would result in the need for submission of a demonstrative study.

1.02 PURPOSE

CCT Studies are used by WDNR to review the existing water distribution system and evaluate the alternatives recommended for treatment of corroding lead and copper lines. This document presents the CCT Study and required information requested by the WDNR's July 29, 2021, letter. Demonstration testing of calcium, alkalinity, and pH adjustment were not performed as Strand Associates, Inc.® (Strand) believes these processes would be largely ineffective as a primary Optimal CCT in this application. The correspondence with the WDNR and the components of a desktop study are presented in entirety in Appendix A.

1.03 ABBREVIATIONS AND DEFINITIONS

AL	Action Level
ALE	Action Level Exceedance
$CaCO_3$	calcium carbonate
CCT	Corrosion Control Treatment
City	City of Watertown, Wisconsin
CY	Cubic Yards
°C	degrees Celsius
DI	ductile iron
DIC	Dissolved Inorganic Carbon
WDNR	Wisconsin Department of Natural Resources
EP	Entry Point
ft	feet
fps	feet per second
gpm	gallon per minute
in	inch
L	Liter
LCR	Lead and Copper Rule
LSL	Lead Service Lateral
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MG	million gallons
µg/L	microgram per liter
mg/L	milligrams per liter
mL	milliliters
ND	Non-Detect
NO_2-N	Nitrite
NO_3+NO_2	Nitrate-Nitrite
OCCT	Optimal Corrosion Control Treatment
OWQP	Optimal Water Quality Parameters
PVC	polyvinyl chloride
PSCW	Public Service Commission of Wisconsin
ppm	parts per million
Strand	Strand Associates, Inc.®
S.U.	Standard Units
TDS	total dissolved solids
USEPA	United States Environmental Protection Agency
WDNR	Wisconsin Department of Natural Resources
WQP	Water Quality Parameter
WTP	water treatment plant

SECTION 2
EXISTING WATER SUPPLY AND DISTRIBUTION SYSTEM

2.01 GENERAL SYSTEM DESCRIPTION

The City obtains its raw water from groundwater sources. The water supply is pumped from nine wells throughout the City, with reported depths ranging from 700 to 960 feet below ground surface. The wells pump the raw water from a sandstone aquifer. Well Nos. 1, 3, 4, 5, and 6 deliver water to the Central Water Treatment Plant (WTP). Well Nos. 7 and 9 deliver water to the West WTP. Well Nos. 8 and 10 deliver water to the Northeast WTP. All three WTPs use an aeration and pressure filtration system for iron removal. The water is also disinfected with chlorination and fluoridated for public health. The City had previously dosed with sodium hydroxide for pH adjustment, but has stopped since March 7, 2022, due to the minimal effect it had on the pH and, in some cases, decreases seen in pH. Justification for the removal of the caustic soda feed was presented in the CCT proposal and approved by the WDNR to stop feeing in January 2022.

The system pressure is regulated by pumps at each WTP, a southern booster pump station, and four elevated tanks. The southern booster station is not used regularly and is described as storage for fire flow.

2.02 GENERAL WATER QUALITY

The water quality is generally similar at each well. Calcium and hardness levels from laboratory analysis indicate the raw water has high hardness. For all the wells, the reported calcium concentration was 75 milligrams per liter (mg/L) on average, and the hardness levels were 350 mg/L on average. Alkalinity is high in the raw water and averages 312 mg/L. There are minor levels of chloride and sulfate in the raw water. The laboratory pH results for the raw well water ranged from 7.03 to 7.47, with an average value of 7.21. The most recent pH results collected in in 2020 and 2021 were all equal to or less than this average value. Iron and manganese concentrations were elevated in the raw well water. Raw water quality from the City's wells is presented in Table 2.02-1.

Table 2.02-1 Well Samples

		Well No. 1					Well No. 3					Well No. 4					Well No. 5					Well No. 6				
	Units	6/5/2019	12/4/2019	5/6/2020	12/22/2020	6/16/2021	6/5/2019	12/4/2019	5/6/2020	12/22/2020	6/16/2021	6/5/2019	12/4/2019	5/6/2020	12/22/2020	6/16/2021	6/5/2019	12/4/2019	5/6/2020	12/22/2020	6/16/2021	6/5/2019	12/4/2019	5/6/2020	12/22/2020	6/16/2021
Alkalinity	mg/L	310.00	290.00	350.00	260.00	330.00	290.00	290.00	290.00	270.00	280.00	310.00	310.00	300.00	320.00	280.00	280.00	290.00	300.00	310.00	300.00	310.00	310.00	330.00	320.00	310.00
Calcium	mg/L	72.00	70.00	82.00	69.00	91.00	69.00	69.00	68.00	67.00	70.00	70.00	71.00	69.00	72.00	70.00	68.00	70.00	70.00	71.00	77.00	74.00	75.00	72.00	78.00	76.00
Chloride	mg/L	10.00	5.00	41.00	3.80	66.00	2.10	2.30	2.20	2.70	5.20	3.40	3.30	4.30	3.30	5.20	3.40	3.10	13.00	2.10	29.00	2.30	2.10	1.90	3.80	2.50
Fluoride	mg/L	0.19	0.23	0.18	0.24	0.16	0.19	0.23	0.22	0.22	0.21	0.17	0.20	0.22	0.17	0.21	0.19	0.24	0.20	0.16	0.19	0.17	0.21	0.18	0.16	0.18
Hardness	mg/L	340.00	320.00	390.00	310.00	440.00	310.00	300.00	300.00	300.00	310.00	320.00	330.00	310.00	340.00	310.00	300.00	310.00	320.00	330.00	360.00	330.00	340.00	330.00	360.00	340.00
Iron	mg/L	1.10	0.92	1.10	1.00	2.00	0.74	0.77	0.76	0.75	0.81	1.20	1.30	1.00	1.40	0.97	0.85	0.87	0.92	1.40	0.99	0.47	0.43	0.45	0.74	0.50
Manganese	µg/L	43.00	56.00	40.00	41.00	35.00	72.00	68.00	63.00	66.00	62.00	34.00	35.00	35.00	34.00	37.00	51.00	54.00	46.00	34.00	46.00	110.00	120.00	130.00	81.00	110.00
pH, Lab	S.U.	7.41	7.36	7.15	7.14	7.03	7.43	7.47	7.28	7.11	7.11	7.35	7.36	7.17	7.06	7.13	7.41	7.40	7.21	7.16	7.13	7.33	7.30	7.17	7.06	7.09

Note: Lab=laboratory
µg/L=micrograms per liter
S.U.=standard units

		Well No. 7					Well No. 8					Well No. 9					Well No. 10				
	Units	6/5/2019	12/4/2019	5/6/2020	12/22/2020	6/16/2021	6/5/2019	12/4/2019	5/6/2020	12/22/2020	6/16/2021	6/5/2019	12/4/2019	5/6/2020	12/22/2020	6/16/2021	6/5/2019	12/4/2019	5/6/2020	12/22/2020	6/16/2021
Alkalinity	mg/L	330.00	330.00	340.00	320.00	330.00	320.00	320.00	350.00	310.00	320.00	320.00	320.00	340.00	320.00	340.00	310.00	310.00	340.00	-	320.00
Calcium	mg/L	85.00	83.00	83.00	87.00	86.00	74.00	74.00	72.00	75.00	74.00	78.00	79.00	80.00	78.00	83.00	74.00	74.00	74.00	-	74.00
Chloride	mg/L	19.00	17.00	18.00	22.00	23.00	3.10	3.40	3.20	4.50	3.00	12.00	12.00	14.00	12.00	13.00	2.40	2.50	1.90	-	2.00
Fluoride	mg/L	0.16	0.19	0.17	0.15	0.16	0.16	0.19	0.18	0.18	0.16	0.18	0.20	0.18	0.17	0.16	0.18	0.21	0.18	-	0.17
Hardness	mg/L	410.00	390.00	400.00	420.00	410.00	340.00	340.00	330.00	340.00	340.00	360.00	360.00	370.00	480.00	380.00	330.00	330.00	340.00	-	330.00
Iron	mg/L	0.00	0.06	0.14	0.00	0.00	0.96	0.89	0.94	0.96	0.99	0.44	0.31	0.44	0.40	0.50	1.20	1.20	1.30	-	1.30
Manganese	µg/L	39.00	47.00	47.00	34.00	44.00	61.00	66.00	59.00	58.00	64.00	66.00	72.00	68.00	69.00	75.00	46.00	47.00	49.00	-	49.00
pH, Lab	S.U.	7.31	7.29	7.15	7.07	7.08	7.30	7.32	7.11	7.05	7.06	7.33	7.33	7.18	7.11	7.04	7.35	7.32	7.16	-	7.06

Water quality data collected from the entry points to the distribution system is presented in Table 2.02-2. There are three entry point sample locations, with each representing a different WTP. The three WTPs in the City's system are labeled the Central WTP, West WTP, and Northeast WTP, based on their geographic locations within the City. The water quality at all three WTPs was generally similar. The iron and manganese are effectively removed and listed as nondetect for all samples. The pH is increased through the WTP as a result of air stripping to an average of 7.8, making it less acidic than the raw water samples. Increasing the pH is often beneficial from a corrosion control perspective, as solubility of lead and copper in the water general declines as the pH is increased. The change in pH also impacts calcium solubility, which results in calcium precipitation and deposition in the downstream piping system. The water utility has noted issues with calcium precipitation within the WTP and in the distribution system, which is likely the result of the current pH adjustment practices. Since the termination of sodium hydroxide addition at the WTP calcium deposition (at least within the plan piping) has reportedly been largely eliminated.

Additional parameters used to analyze the water quality information in Table 2.02-2 are the corrosive indices and precipitation potential. The three corrosive indices (Langelier, Ryznar, and Aggressiveness) and precipitation potential are calculated using a TetraTech computer model. These indices are measures of calcium stability and are used to help predict the corrosive capabilities of water. The following are the desired ranges for these indices:

- Langelier Index: greater than -0.25
- Ryznar index: less than 7
- Aggressiveness index: greater than 12
- Precipitation Potential: 4 to 10

Table 2.02-2 Entry Point Samples

		806 South First Street (Central WTP)				1000 West Street (West WTP)				137 Hospital Drive (Northeast WTP)			
	Units	7/28/2020	10/27/2020	11/30/2021	12/6/2021	7/28/2020	10/27/2020	11/30/2021	12/6/2021	7/28/2020	10/27/2020	11/30/2021	12/6/2021
Field pH	S.U.	7.69	7.73	7.68	7.77	7.85	7.88	7.90	7.98	7.69	7.90	7.69	7.71
Field Temperature	°C	13.40	11.70	11.00	10.70	13.50	10.80	10.40	9.80	14.30	11.30	11.30	10.40
Alkalinity	mg/L	380.00	280.00	290.00	270.00	360.00	310.00	330.00	320.00	350.00	300.00	310.00	310.00
Calcium (Ca)	mg/L	72.00	71.00	68.00	72.00	82.00	82.00	81.00	85.00	73.00	73.00	70.00	76.00
Chloride (Cl)	mg/L	13.00	7.50	6.80	7.50	17.00	19.00	20.00	20.00	4.90	4.70	3.70	7.50
Chlorine (Free)	mg/L	0.88	0.84	0.76	0.79	0.94	0.95	0.91	0.86	0.86	0.85	0.83	0.79
Chlorine (Total)	mg/L	0.94	0.97	0.82	0.97	1.10	1.10	1.00	0.95	0.92	1.00	0.89	0.97
Sulfate	mg/L	17.00	14.00	14.00	14.00	31.00	33.00	34.00	33.00	17.00	16.00	15.00	14.00
TDS	mg/L	429.10	417.20	387.80	422.80	493.50	521.50	484.40	537.60	425.60	442.40	408.80	534.80
Langlier Index		0.63	0.5	0.44	0.52	0.81	0.73	0.77	0.84	0.61	0.70	0.50	0.52
Ryznar Index		6.44	6.73	6.79	6.74	6.23	6.42	6.36	6.3	6.47	6.49	6.70	6.68
Aggressiveness Index		12.53	12.43	12.37	12.46	12.72	12.68	12.72	12.81	12.50	12.64	12.42	12.48
Precipitation Potential	mg/L	48.04	28.52	26.91	27.61	55.1	42.44	47.04	47.75	43.82	37.75	31.96	33.41

Note: °C=degrees Celsius
TDS=total dissolved solids

The distribution system water quality samples are presented in Table 2.02-3. The water quality throughout the distribution system is generally similar. The exception to this is that there are four locations that reported very low calcium levels. These locations were 1173 North Fourth Street, 900 West Main Street, 1222 Perry Way, and 1731 South Church Street. The calcium at these locations ranged from nondetect to 25 mg/L, whereas the other locations in the distribution system had concentrations ranging from 68 to 82 mg/L. Strand suspects the samples collected at these locations may be softened.

Table 2.02-3 Distribution System Samples

	Units	1021 South 3rd Street			
		7/28/2020	10/27/2020	11/30/2021	12/6/2021
Field pH	S.U.	7.70	7.69	7.68	7.70
Field Temperature	°C	24.00	14.40	10.00	9.30
Alkalinity	mg/L	360.00	290.00	300.00	280.00
Calcium (Ca)	mg/L	71.00	71.00	68.00	67.00
Chloride (Cl)	mg/L	10.00	7.40	6.40	6.90
Chlorine (Free)	mg/L	0.66	0.82	0.75	0.94
Chlorine (Total)	mg/L	0.73	0.90	0.90	1.10
Sulfate	mg/L	16.00	14.00	14.00	13.00
TDS	mg/L	417.90	426.30	393.40	419.30
Langlier Index		0.76	0.52	0.44	0.41
Ryznar Index		6.17	6.65	6.8	6.88
Aggressiveness Index		12.51	12.4	12.39	12.37
Precipitation Potential	mg/L	53.62	30.99	27.79	23.6

	Units	860 West Street			
		7/28/2020	10/27/2020	11/30/2021	12/6/2021
Field pH	S.U.	7.84	7.83	7.82	7.86
Field Temperature	°C	16.90	17.00	13.90	15.60
Alkalinity	mg/L	360.00	310.00	330.00	320.00
Calcium (Ca)	mg/L	81.00	82.00	81.00	80.00
Chloride (Cl)	mg/L	18.00	18.00	20.00	20.00
Chlorine (Free)	mg/L	1.10	0.97	0.92	0.90
Chlorine (Total)	mg/L	1.20	1.10	1.00	1.00
Sulfate	mg/L	31.00	33.00	34.00	33.00
TDS	mg/L	488.60	518.00	489.30	531.30
Langlier Index		0.85	0.77	0.74	0.78
Ryznar Index		6.15	6.28	6.33	6.29
Aggressiveness Index		12.7	12.63	12.64	12.67
Precipitation Potential	mg/L	57.12	45.82	47.44	46.47

	Units	1173 North Fourth Street			
		7/28/2020	10/27/2020	11/30/2021	12/6/2021
Field pH	S.U.	7.85	7.77	7.68	7.84
Field Temperature	°C	18.50	14.10	13.20	12.50
Alkalinity	mg/L	350.00	300.00	310.00	310.00
Calcium (Ca)	mg/L	0.57	0.11	ND	ND
Chloride (Cl)	mg/L	5.00	4.70	3.70	3.70
Chlorine (Free)	mg/L	0.74	0.74	0.65	0.62
Chlorine (Total)	mg/L	0.79	0.79	0.80	0.76
Sulfate	mg/L	16.00	16.00	15.00	14.00
TDS	mg/L	440.30	459.20	431.20	467.60
Langlier Index		-1.28	-2.21		
Ryznar Index		10.4	12.18		
Aggressiveness Index		10.55	9.69		
Precipitation Potential	mg/L	-12.27	-16.36	-19.79	-15.18

	Units	900 West Main Street			
		7/28/2020	10/27/2020	11/30/2021	12/6/2021
Field pH	S.U.	7.82	7.89	7.80	7.83
Field Temperature	°C	21.20	14.90	12.90	11.40
Alkalinity	mg/L	350.00	310.00	330.00	320.00
Calcium (Ca)	mg/L	0.23	0.25	ND	ND
Chloride (Cl)	mg/L	17.00	19.00	20.00	20.00
Chlorine (Free)	mg/L	0.74	0.94	0.84	0.83
Chlorine (Total)	mg/L	0.80	1.10	0.89	0.92
Sulfate	mg/L	31.00	33.00	33.00	32.00
TDS	mg/L	501.20	539.00	503.30	548.10
Langlier Index		-1.67	-1.72		
Ryznar Index		11.16	11.32		
Aggressiveness Index		10.12	10.18		
Precipitation Potential	mg/L	-12.82	-13.14	-16.25	-16.02

	Units	1222 Perry Way			
		7/28/2020	10/27/2020	11/30/2021	12/6/2021
Field pH	S.U.	7.87	7.92	7.92	8.00
Field Temperature	°C	20.50	13.50	13.40	13.80
Alkalinity	mg/L	360.00	320.00	340.00	320.00
Calcium (Ca)	mg/L	0.50	6.20	25.00	1.40
Chloride (Cl)	mg/L	18.00	19.00	20.00	20.00
Chlorine (Free)	mg/L	0.81	0.94	0.87	0.65
Chlorine (Total)	mg/L	0.87	1.00	1.00	0.72
Sulfate	mg/L	30.00	33.00	33.00	32.00
TDS	mg/L	510.30	538.30	499.10	558.60
Langlier Index		-1.3	-0.3	0.3	0.3
Ryznar Index		10.4	8.5	7.3	7.4
Aggressiveness Index		10.5	11.6	12.3	12.2
Precipitation Potential	mg/L	-11.5	-6.1	12.3	8.6

	Units	1731 South Church Street			
		7/28/2020	10/27/2020	11/30/2021	12/6/2021
Field pH	S.U.	7.73	7.82	7.73	7.65
Field Temperature	°C	20.70	16.70	15.50	14.10
Alkalinity	mg/L	310.00	290.00	300.00	290.00
Calcium (Ca)	mg/L	9.10	7.70	11.00	14.00
Chloride (Cl)	mg/L	12.00	8.20	10.00	11.00
Chlorine (Free)	mg/L	0.47	0.65	0.61	0.54
Chlorine (Total)	mg/L	0.57	0.68	0.78	0.71
Sulfate	mg/L	18.00	15.00	19.00	18.00
TDS	mg/L	433.30	441.00	423.50	462.70
Langlier Index		-0.21	-0.28	-0.22	-0.24
Ryznar Index		8.16	8.39	8.17	8.13
Aggressiveness Index		11.58	11.57	11.65	11.66
Precipitation Potential	mg/L	-5.57	-6.31	-6.27	-7.88

	Units	112 Hall Street			
		7/28/2020	10/27/2020	11/30/2021	12/6/2021
Field pH	S.U.	7.68	7.75	7.62	7.75
Field Temperature	°C	20.00	16.50	15.10	13.90
Alkalinity	mg/L	350.00	300.00	310.00	310.00
Calcium (Ca)	mg/L	73.00	73.00	74.00	76.00
Chloride (Cl)	mg/L	4.90	5.00	3.70	3.70
Chlorine (Free)	mg/L	0.73	0.73	0.52	0.43
Chlorine (Total)	mg/L	0.91	0.79	0.55	0.60
Sulfate	mg/L	16.00	15.00	15.00	15.00
TDS	mg/L	420.70	447.30	409.50	447.30
Langlier Index		0.69	0.63	0.51	0.63
Ryznar Index		6.31	6.48	6.6	6.5
Aggressiveness Index		12.49	12.49	12.38	12.52
Precipitation Potential	mg/L	48.67	37.28	34.79	38.94

	Units	210 North Montgomery Street			
		7/28/2020	10/27/2020	11/30/2021	12/6/2021
Field pH	S.U.	7.82	7.84	7.68	7.73
Field Temperature	°C	22.00	13.90	11.90	10.70
Alkalinity	mg/L	350.00	290.00	300.00	290.00
Calcium (Ca)	mg/L	72.00	73.00	71.00	74.00
Chloride (Cl)	mg/L	9.90	9.00	7.60	9.00
Chlorine (Free)	mg/L	0.67	0.72	0.69	0.69
Chlorine (Total)	mg/L	0.77	0.81	0.82	0.73
Sulfate	mg/L	16.00	18.00	15.00	17.00
TDS	mg/L	419.30	450.10	399.70	445.20
Langlier Index		0.85	0.67	0.49	0.52
Ryznar Index		6.12	6.5	6.7	6.7
Aggressiveness Index		12.62	12.56	12.41	12.46
Precipitation Potential	mg/L	53.9	35.86	30.92	30.75

	Units	821 North Church Street			
		7/28/2020	10/27/2020	11/30/2021	12/6/2021
Field pH	S.U.	7.60	7.80	7.65	7.62
Field Temperature	°C	22.80	16.70	15.30	12.50
Alkalinity	mg/L	350.00	300.00	310.00	310.00
Calcium (Ca)	mg/L	74.00	73.00	72.00	76.00
Chloride (Cl)	mg/L	5.20	5.00	3.70	3.70
Chlorine (Free)	mg/L	0.48	0.59	0.53	0.60
Chlorine (Total)	mg/L	0.50	0.64	0.60	0.65
Sulfate	mg/L	16.00	16.00	15.00	15.00
TDS	mg/L	419.30	443.80	413.00	445.90
Langlier Index		0.65	0.69	0.53	0.47
Ryznar Index		6.29	6.43	6.59	6.67
Aggressiveness Index		12.41	12.54	12.4	12.39
Precipitation Potential	mg/L	49.1	38.92	34.92	32.98

	Units	101 Oakridge Court			
		7/28/2020	10/27/2020	11/30/2021	12/6/2021
Field pH	S.U.	7.74	7.73	7.69	7.61
Field Temperature	°C	18.50	14.60	13.30	11.70
Alkalinity	mg/L	340.00	300.00	310.00	310.00
Calcium (Ca)	mg/L	73.00	73.00	72.00	75.00
Chloride (Cl)	mg/L	5.20	4.80	3.70	3.70
Chlorine (Free)	mg/L	0.83	0.82	0.86	0.81
Chlorine (Total)	mg/L	0.88	0.97	0.86	0.83
Sulfate	mg/L	16.00	16.00	15.00	15.00
TDS	mg/L	420.70	443.10	409.50	447.30
Langlier Index		0.71	0.58	0.54	0.45
Ryznar Index		6.32	6.56	6.61	6.72
Aggressiveness Index		12.53	12.47	12.44	12.37
Precipitation Potential	mg/L	47.26	35.26	34.77	31.24

Throughout the distribution system, the water had high alkalinity, hardness, and exhibited a likelihood of calcium precipitation, based upon calcium precipitation indices. Chloride concentrations throughout the system were not at levels anticipated to cause concern. Free chlorine was generally stable throughout the distribution system. The pH was high, and calcium was low in the locations with corrosion risk, but acceptable throughout.

2.03 DISTRIBUTION SYSTEM DESCRIPTION AND MATERIAL INVENTORY SUMMARY

The City's water distribution system includes approximately 630,000 feet of water main ranging up to 16 inches in diameter. The piping is reported as primarily metal piping, mostly consisting of a mix of cast or ductile iron pipe. No lead is reported in the water distribution mains. Lead is reported in services only. As of the 2020 Public Service Commission of Wisconsin (PSCW) report, 556 utility-owned lead services were reported, and 1,405 privately owned lead services were reported. The remaining utility-owned service lines are listed as "unknown–does not contain lead" in the PSCW report. The City is in the process of refining this inventory to better identify actual materials in preparation for future compliance with the revised Lead and Copper Rule (LCR).

A. Current Lead Service Laterals Removal

The City is currently working towards removing all galvanized and lead service laterals (LSL) within its distribution system. Based upon the City's latest material inventory at the time of this study, there are approximately 933 private lead, 25 private galvanized, and 504 private unknown material service laterals remaining. Additionally, there are 445 public lead service laterals and 183 public unknown material service laterals remaining. These service laterals are tentatively scheduled to be removed by the year 2026. Of these 1,500, approximately 1,000 are considered private side LSLs, and approximately 500 are complete private and public side LSLs.

2.04 LCR HISTORICAL RESULTS

Lead and copper monitoring data was obtained from the WDNR public drinking water system database Web site. Action levels for lead are currently 15 µg/L and 1,300 µg/L for copper. The system exceeded the lead action level in 2020 and 2021 and reached action level in 2008 and 2011. The City did not reach or exceed the copper action level during the same time period. Based on a review of the sampling locations, the location of the elevated lead levels appears to be more of a function of sampling locations. It does not appear to be associated with any specific area of the system. Potential water quality differences between specific entry points or dead ends might be related to water age.

The latest two rounds of sampling in May and October 2022 have shown a decrease in lead below the action level. These latest 90th percentile results indicate that the City is in compliance of lead and copper regulations. The City's compliance determination was confirmed by the WDNR based on these results.

A summary of the 90th percentile results for sampling since 2002 is presented in Table 2.04-1.

Year	Lead (µg/L)	Copper (µg/L)
2022	14	120
2022	12	110
2021	16[a]	120
2021	14	130
2020	16[a]	100
2017	14	120
2014	14	140
2011	15[b]	130
2009	11	140
2008	15[b]	160
2005	9	150
2002	12	114

[a]Denotes samples higher than the associated AL.
[b]Denotes samples at the associated AL.

Table 2.04-1 Lead and Copper 90th Percentiles

SECTION 3
DEMONSTRATION STUDY

3.01 INTRODUCTION

As indicated in the CCT Study Proposal, demonstration testing of alkalinity, pH, and calcium adjustment was not performed. Alkalinity, pH, and calcium adjustment usually involves an increase in these water quality parameters to reduce the potential for lead and copper corrosion. The existing raw water supplies for the City already exhibit high alkalinity and calcium hardness. The use of alkalinity, pH, and calcium adjustment are generally not appropriate for use in a very high alkalinity, high-hardness water such as those found in the City. Further increases in pH (to decrease lead solubility) would result in increased calcium hardness precipitation, lead to calcium precipitation, and scaling problems within the distribution system. The existing calcium stability indexes support the anecdotal observations made by the City. As a result, further alkalinity or pH adjustment is ineffective and impractical.

While the City is observing calcium precipitation in the treated water, maintaining some level of pH adjustment is desirable. The raw well water was reported to be less than 7.2, which is relatively low when considering typical lead solubility and effective ranges for inhibitors such as phosphates. Adjustment of pH occurs in the current treatment process as water passes through the air strippers before filtration. Aeration removes carbon dioxide and results in an increase in pH.

The treatment technology tested was the addition of blended polyorthophosphates doses to the existing treated well water at the current adjusted pH range of 7.6 to 7.8. This is not entirely consistent with guidance found in *Optimal Corrosion Control Treatment Evaluation Technical Recommendations for Primacy Agencies and Public Water Systems*, which would recommend using of straight orthophosphate when iron removal is performed. The intent of the use of a blended phosphate is to use the sequestering capability of the polyphosphate portion to help control the precipitation of calcium from the pH feed and provide some level of sequestering protection for any breakthrough of iron and manganese that may occur. The proposed dose presented is based upon the fixed polyphosphate doses to sequester these constituents while varying the poly- and orthophosphate percentage to achieve different orthophosphate and total phosphate levels. The orthophosphate portion is expected to develop phosphate-based scales on the internal surfaces of the lead pipes, resulting in a reduction in soluble lead in the water.

For this study, the use of silicate-based corrosion control chemicals was considered. The effectiveness of silicates in waters of this character is somewhat unknown but have been used with variable success in other systems to accomplish similar levels of corrosion treatment. United States Environmental Protection Agency (USEPA) generally suggests using phosphates over silicate inhibitors because of higher costs and the higher doses required to accomplish the same result for silicate inhibitors. For this reason, the preference is to evaluate alternative forms of phosphate-based CCT.

A description of the demonstrative CCT testing, chemicals, apparatus, and schedule is presented in the following sections.

3.02 CHEMICAL ADDITION

The chemicals tested in this demonstrative study included two different blended polyphosphates. The data sheets for these chemicals are found in Appendix B.

The blended polyphosphates are Carus™ 8500 and Carus™ 8600.

The Carus™ 8500 product is a 50-percent orthophosphate and 50 percent polyphosphate blend. The dosage for Loop 1 was 3 mg/L as total phosphate, with an orthophosphate dose of 1.5 mg/L. The dose was approximately 6.3 parts per million (ppm) as product.

The Carus™ 8600 product is a 70-percent orthophosphate, 30 percent polyphosphate blend. The dosage for Loop 2 was 5 mg/L as total phosphate, with an orthophosphate dose of 3.5 mg/L. The dose was approximately 11 ppm as product.

The treatment chemicals, dosing, and percentages of ortho- and polyphosphates are presented in Table 3.02-1.

Chemical	Dosage Total Phosphate (mg/L)	Polyphosphate		Orthophosphate	
		Percent	Dose (mg/L)	Percent	Dose (mg/L)
Carus™ 8500	3	50	1.5	50	1.5
Carus™ 8600	5	30	1.5	70	3.5

Table 3.02-1 Chemical Additions

3.03 TEST APPARATUS

The test apparatus was loosely based upon the apparatus used by USEPA's Office of Research and Development for testing lead pipe segment exhumed in Flint, Michigan. The test sections used in the apparatus were 4-foot-long exhumed lead services from the existing system and similar 4-foot-long new copper piping. The additional line of copper was new material and not exhumed from the existing system. Additionally, one bypass loop was placed of new polyvinyl chloride (PVC) pipe. All other piping and valves were nonmetallic, except the fittings. PVC fittings could not be obtained in a timely manner and metal fittings were substituted.

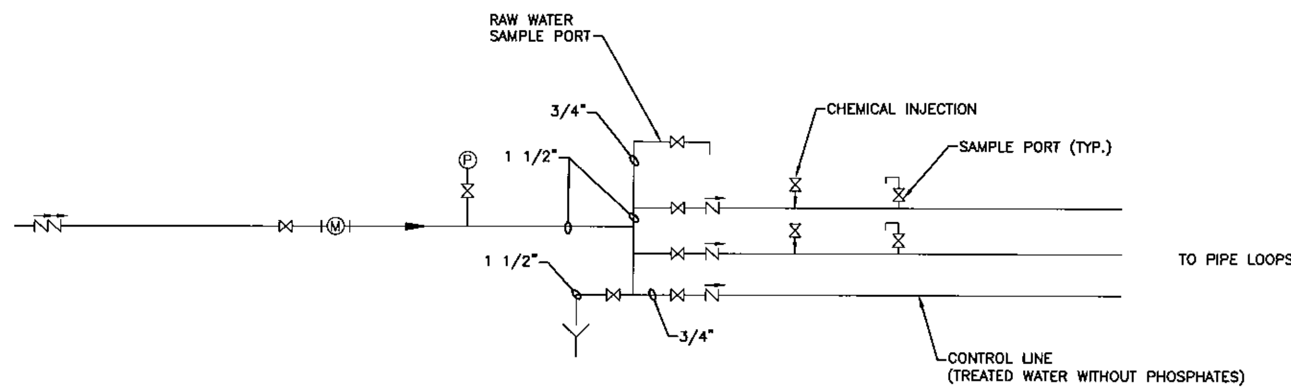
The sampling apparatus was designed with one loop consisting of three lead pipes and three copper pipes in series. Two loops were treated with a chemical as described previously, with the third loop exposed to the existing treated water. The exposed loop was used for evaluating the effectiveness of the polyphosphates to sequester calcium, control precipitation, and deposition on piping components. Flow through the pipe loops was controlled by an electrically actuated solenoid valve operated off a programable timeclock. Chemical metering pumps for the corrosion control chemical feeds were controlled by the same timeclock. Chemical injection was provided for the CCT chemicals. A schematic of the test apparatus is shown in Figure 3.03-1.

GENERAL NOTE:

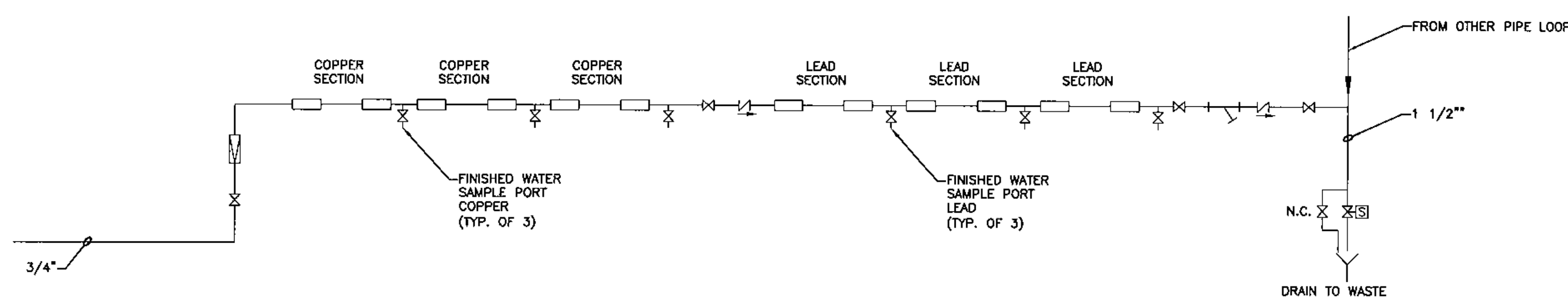
1. THERE WILL BE A HIGHPOINT ALONG EACH LOOP. IF POSSIBLE, INSTALL A SAMPLE TAP AT HIGHPOINT TO BLEED AIR OUT OF LOOP OR ADD A TEE AND ISOLATION VALVE TO DO THIS.

SYMBOLS

- VARIABLE AREA FLOWMETER
- VALVE
- FLOOR DRAIN TO SANITARY
- CHECK VALVE
- TOTALIZING FLOWMETER
- PRESSURE GAGE
- PIPE COUPLING
- REDUCER/INCREASER
- INLINE MIXER
- SOLENOID VALVE
- BACKFLOW PREVENTER
- Y – STRAINER



SUPPLY SCHEMATIC



TYPICAL LOOP SCHEMATIC (3 TOTAL)

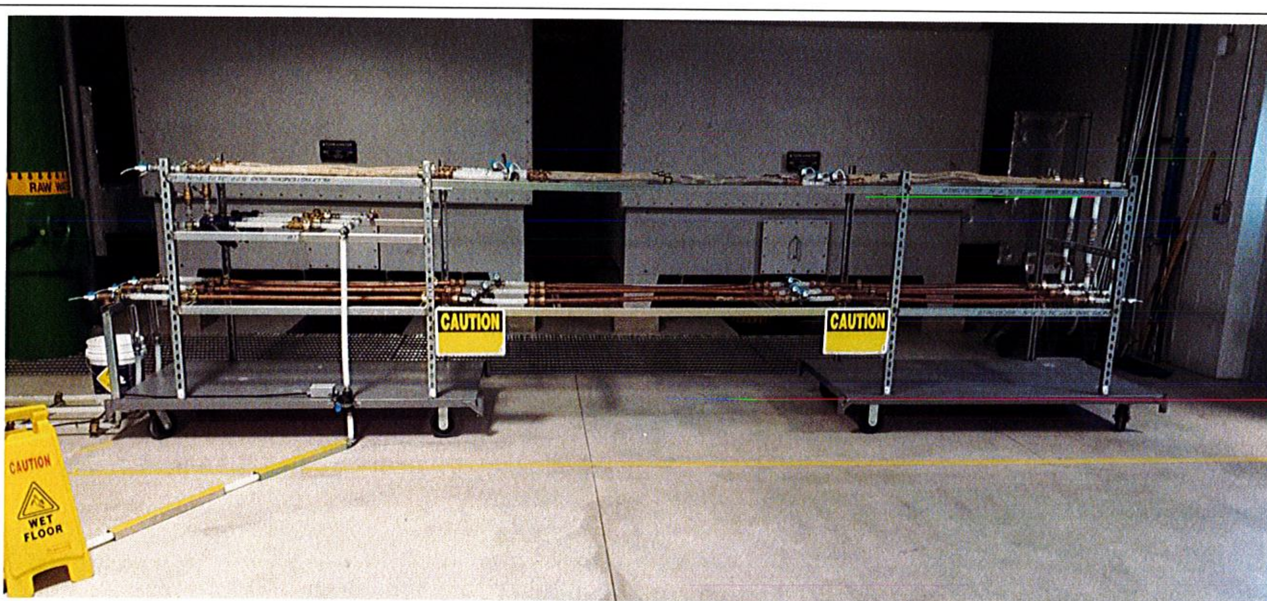
PIPE LOOP SCHEMATIC

CORROSION CONTROL STUDY
CITY OF WATERTOWN
WATERTOWN, WISCONSIN

STRAND ASSOCIATES®

FIGURE 3.03-1
1550.008

Sample taps were located on the raw water line, after chemical injection on each loop, and following each copper and lead section of the loop. Water was discharged to a floor drain. Totalizing flow meters and variable area flow meters were used. Photographs of the final design apparatus are presented in Figures 3.03-2 and 3.



Source: City of Watertown
Note: Lead lines on top and copper lines on bottom

Figure 3.03-2 Test Apparatus

Source: City of Watertown
Note: Lead lines on top and copper lines on bottom

Figure 3.03-3 Test Apparatus–Sample Taps

Daniel Williams, a physical scientist for USEPA's Office of Research and Development, has published and provided the recommended standard procedures for harvesting lead pipe. The City harvested a retired lead service in accordance with these procedures, which are listed Appendix C.

A. Location

The demonstration testing was conducted at the Central WTP filter room. This location provided adequate space for housing all testing equipment and the testing apparatus. The water used from this WTP for the study was fully treated finished water.

B. Apparatus operation

The test apparatus was intended to simulate the operation of a typical City household service throughout the duration of a day. Table 3.03-1 presents the repeating pattern of operation used to simulate this usage throughout the day. The repeating cycle included a 530-minute period (8 hours, 50 minutes) ending at 8:20 A.M. to allow for an 8-hour stagnation sample to be collected. The flow rates proposed are 2 gallons per minute (gpm), which is representative of the typical flow rate for a kitchen sink. This would be a flow velocity of approximately 2.75 feet per second (fps) in a 0.5-inch line and 1.5 fps in a 0.75-inch line.

Time	Cycle Mode	Stagnation Time (minutes)	Running Time (minutes)	Flow Rate per Pipe (gpm)	Volume (gallons)
8:20	ON	530	10	2	20
8:30	OFF				
11:20	ON	170	10	2	20
11:30	OFF				
14:20	ON	170	10	2	20
14:30	OFF				
17:20	ON	170	10	2	20
17:30	OFF				
20:20	ON	170	10	2	20
20:30	OFF				
23:20	ON	170	10	2	20
23:30	OFF				
Totals			60		120

Table 3.03-1 Test Apparatus Operation Schedule

The removal, cutting, and installation of the lead pipe services (even following the recommended USEPA standard operating procedures) was expected to significantly disturb the existing scales found on the interior of the existing lead services. To attempt to reestablish the scales and flush any particles created from the exhumation and rack construction process from the system, treated water from the existing well was passed through the piping. The flow was maintained from July 13 to August 24, 2022, (approximately 43 days) and operated using the timed flow pattern in Table 3.03-1, before initiating the chemical feed and sampling plan described in Table 3.04-1 in the next section.

Stagnation samples for lead and copper were collected once per week from each pipe loop to evaluate the effectiveness of the pipe conditioning period.

3.04 SAMPLING PLAN

The sampling plan and data collection frequency that was complete are shown in Table 3.04-1.

The sampling frequency was divided into three phases:

1. Phase 1 (First Week)–Daily samples were collected for field parameters with a weekly sample for laboratory parameters. The primary objective of the first week of sample collection was to establish stable system operation in chemical feed rate, flow rates, break tank operation, and collect field measurements of the raw water quality.

2. Phase 2 (Next Three Weeks)–Sampling was shifted to weekly sampling for both field and laboratory data. The intent of this sampling was to continue to monitor the stability of the operation of the system, reliability of field instruments, and to validate the stability of the raw water characteristics. Daily checking of the system, including recording totalizing meter values and observing V-notch flow rates, occurred. Observations of the flow rates through the V-notch meters were recorded if the system is "on" during the observation period but were not necessarily required.

3. Phase 3 (Beginning on the Fifth Week and Continuing for the Remainder of the Demonstration Period)–Sampling shifted to weekly samples on all field measurable characteristics and finished lead and copper. Monthly samples were collected on remaining laboratory parameters to verify continued stability of the raw water samples and check accuracy of field instrument observations.

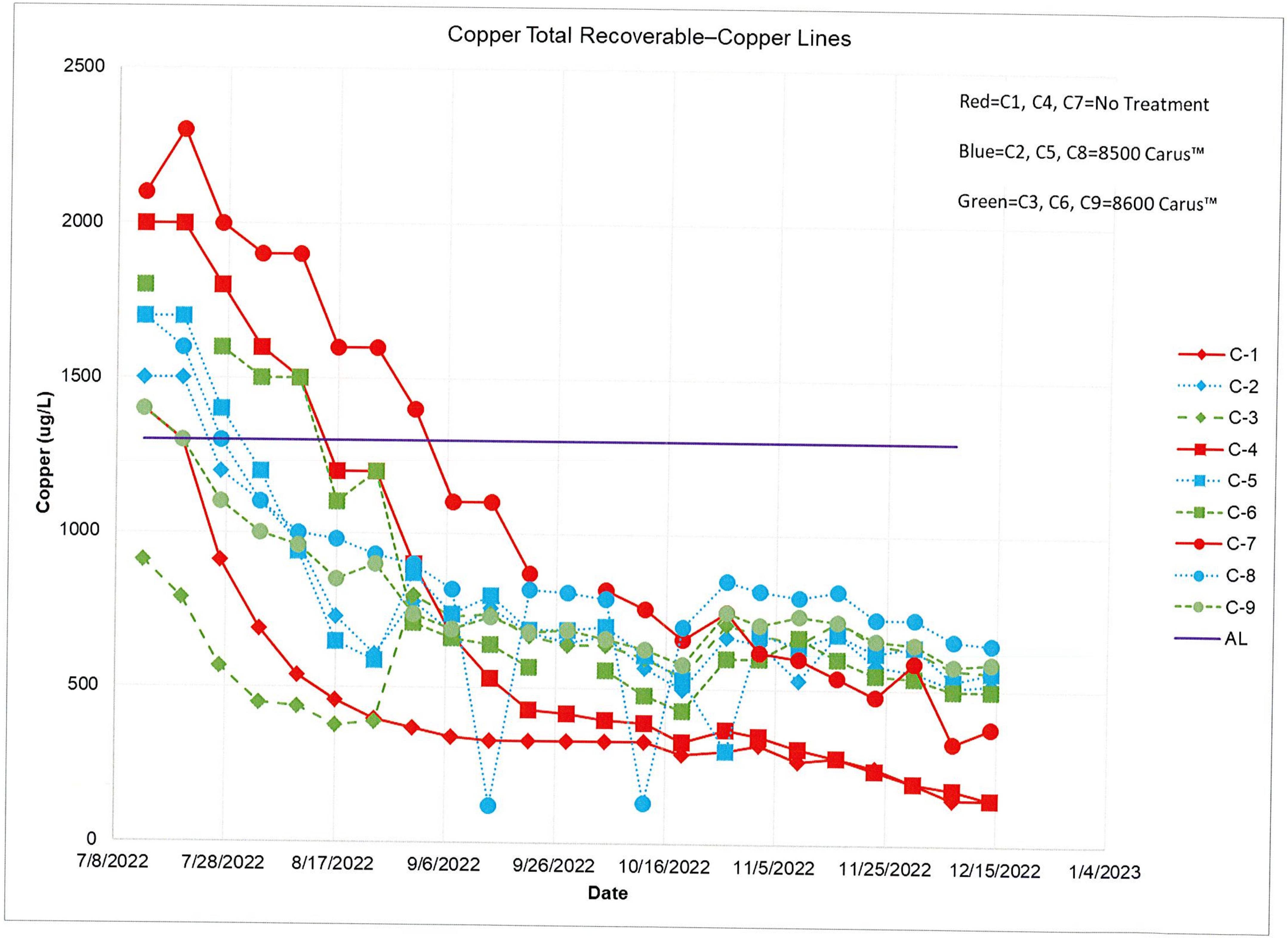
Samples from the finished water simulated "first draw" samples. The samples were collected following a minimum 8-hour stagnation period. Samples were drawn with the valve fully open and consisted of a minimum sample size of 250 milliliters (mL) from the copper section and 250 mL from the lead section. By maintaining consistency in piping between loops, it is expected that the relative performance of the various treatment options can be compared, and a preferred alternative identified.

This section presents the data collected from the demonstration study and provides analysis and discussion for each parameter. The discussion will refer to the various chemical treatments by their associated loop number. Section 3.02–Chemical Additions detailed the loop numbers and the chemical associated with the loop.

4.01 COPPER

Copper samples were collected from July 13 to December 14, 2022, for both dissolved and total copper from the copper sections of the test apparatus. The dissolved and total copper concentrations were generally very consistent throughout the period, with a majority of the copper observed (greater than 90 percent) being dissolved. The results of the copper sampling for total copper are presented in Figure 4.01-1.

Figure 4.01-1 Total Copper Concentration from Copper Sections (July 13 to December 14, 2022)



From Figure 4.01-1, the copper results exhibited similar trends for all three loops. All three loops presented an initial value that would be their maximum value in copper concentrations by the end of the study. These initial values were all greater than the AL before eventually declining to a level well below the AL. None of the copper samples were greater than AL since early September 2022 with one of the no treatment loops being the last to decrease below it. The two loops with chemical additions were similar in results throughout and varying in concentration as samples were taken in the series. For the no treatment lines, the results generally followed the order the samples were taken in from the series with the lowest concentration coming from C-1, second lowest from C-4, and third lowest as C-7. There is a consistent increasing dilution effect that carries through each downstream line segment. As a result, it is more important to look at the trends on the individual samples on a given segment, versus trying to compare values across the data sets. The statistics from the copper results after the conditioning period (August 31 to December 14, 2022) are presented in Table 4.01-1.

Copper Section	Chemical	Average (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Standard Deviation (µg/L)
C-1	None	462	150	1,400	276
C-4					
C-7					
C-2	8500 Carus™	655	120	900	161
C-5					
C-8					
C-3	8600 Carus™	637	430	800	81
C-6					
C-9					

Note: AL for copper is 1,300 µg/L.

Table 4.01-1 Copper Total Values Post Conditioning Period

The three loops generally indicate that addition of orthophosphates will have a negative impact on dissolved copper. The two loops that were treated with the chemical exhibited similar greater copper concentrations than the untreated loop. The two treated loops were generally in the 500 to 700 µg/L range, which is one-third to one-half the AL. This was not unexpected, as orthophosphates have been known to increase copper concentrations in high dissolved inorganic carbon (DIC) waters. In general, all three copper loops were exhibiting declining copper levels upon completion of the testing and were all well below the action level.

4.02 LEAD

Following the same sampling schedule as copper, lead samples were collected from July 13 to December 14, 2022. Both dissolved and total lead concentrations were tested from the lead sections of the apparatus. The results of the lead sampling for total lead are presented in Figure 4.02-1.

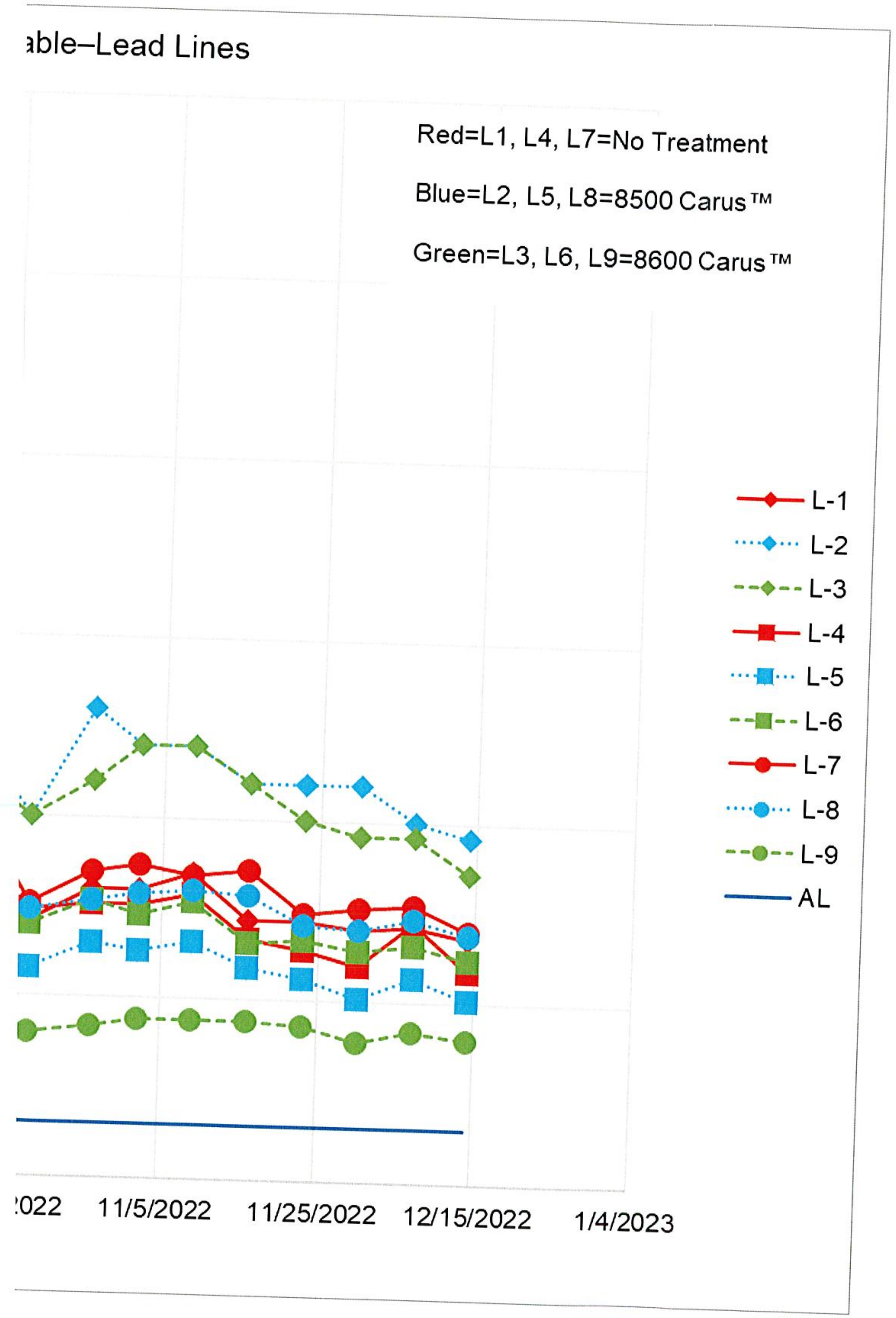


Figure 4.02-2 Total Lead Results–No Treatment

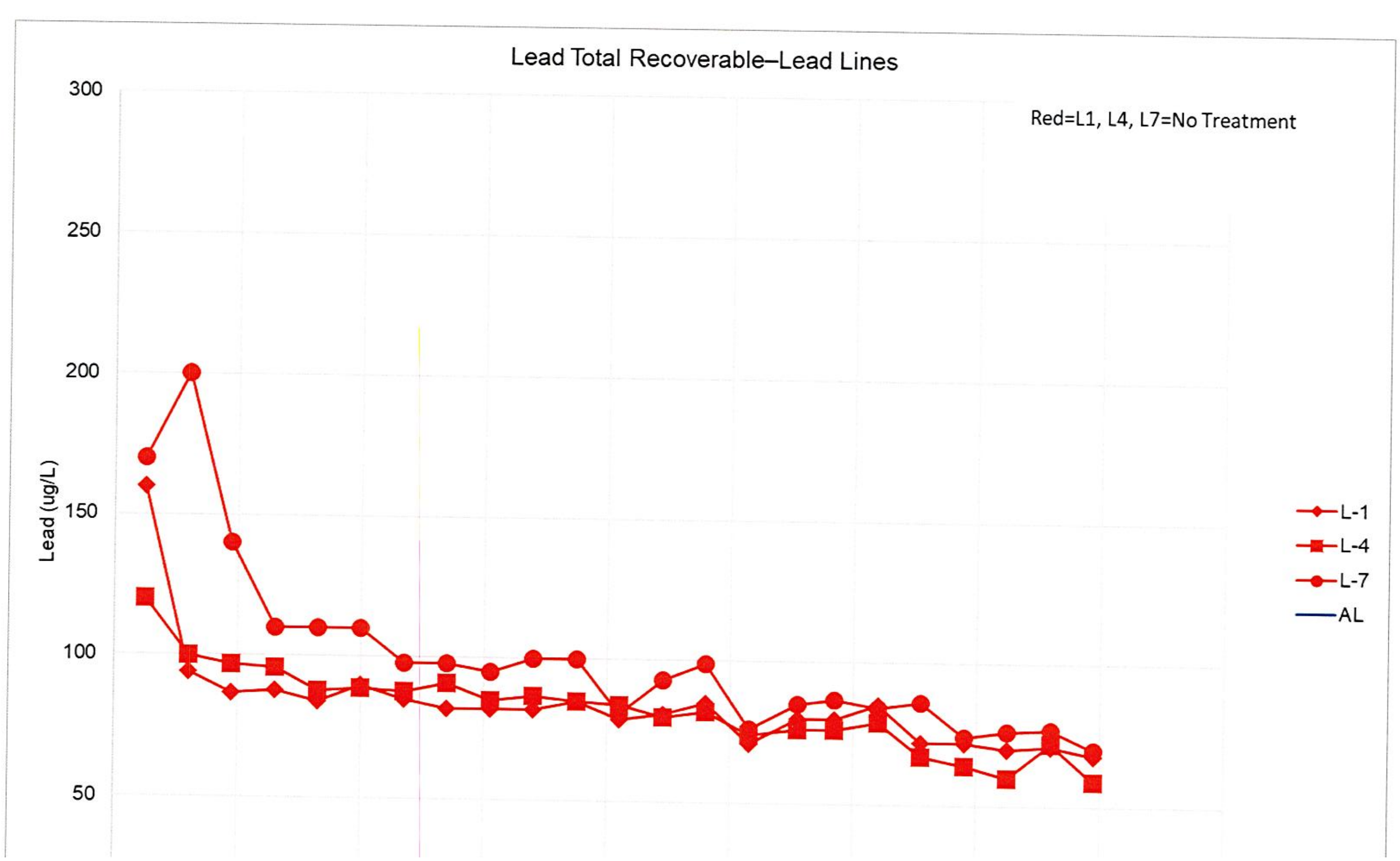


Figure 4.02-3 Total Lead Results–8500 Carus

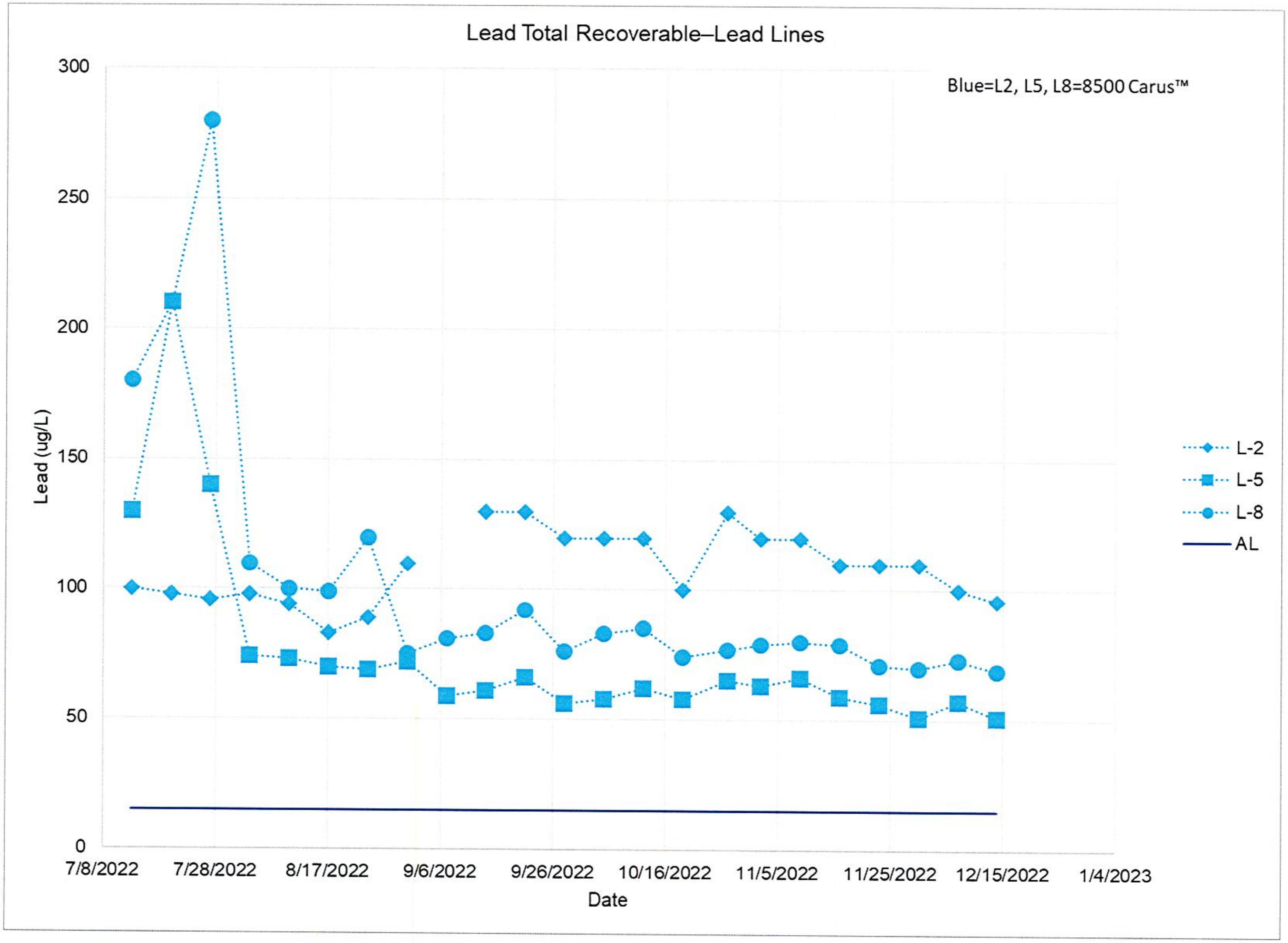
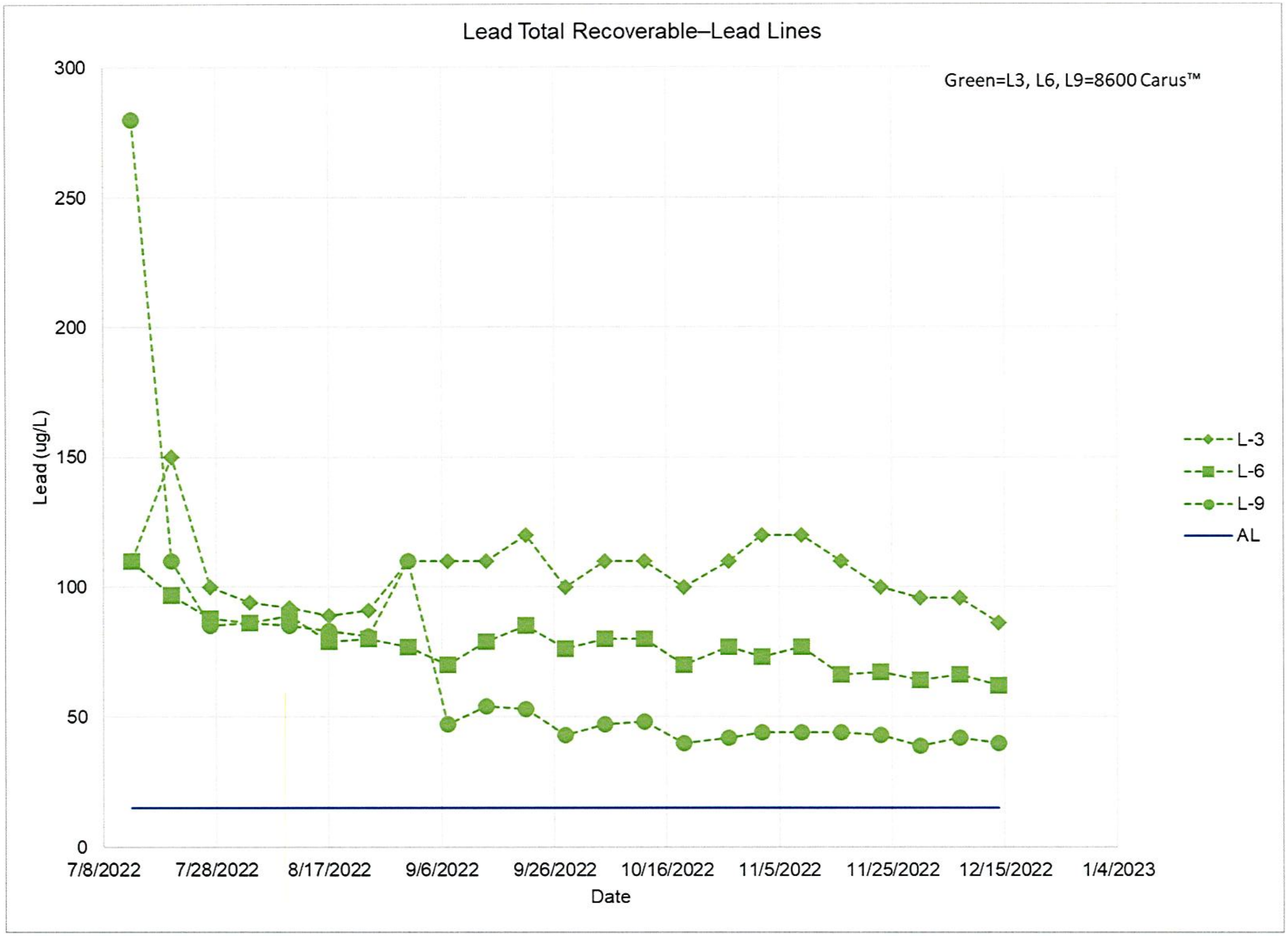


Figure 4.02-4 Total Lead Results–8600 Carus



Statistics for the lead results after the conditioning period (August 31 to December 14, 2022) are presented in Table 4.02-1. The results of the testing of the three loops were relatively similar. The most consistent trend (based on the graphs presented in Figure 4.02-2) was the no treatment loop. Beyond visually appearing to be the most consistent, this loops also resulted in the lowest standard deviation for the data set. The two treatment loops exhibited greater variability resulting in greater standard deviations.

Lead Section	Chemical	Average (µg/L)	Minimum (µg/L)	Maximum (µg/L)	Standard Deviation (µg/L)
L-1 L-4 L-7	None	80	59	100	10
L-2 L-5 L-8	8500 Carus™	84	51	130	24
L-3 L-6 L-9	8600 Carus™	76	39	120	27

Note: AL for lead is 15 µg/L.

Table 4.02-1 Statistics for the Lead Total Values Post Conditioning Period

The averages for all three loops were at least five times higher the AL, with 8600 Carus™ being the lowest. While it is difficult to see due to the initial spikes in lead that occurred during testing, all lead loops appear to exhibit an overall gradual declining trend in total lead levels. No solution resulted in a total lead sample less than the AL. The trends in the results are presented in Table 4.02-2.

		July 13, 2022 (µg/L)	August 3, 2022 (µg/L)	August 31, 2022 (µg/L)	December 14, 2022 (µg/L)	Difference End of Conditioning to End of Study (µg/L)	Difference Start to End of Study (µg/L)
Lead Section	Chemical	Start of Study	First Large Drop in Lead	End of Conditioning	End of study		
L-1	None	160	88	82	68	14	92
L-4	None	120	96	91	59	32	61
L-7	None	170	110	98	70	28	100
L-2	8500 Carus™	100	98	110	96	14	4
L-5	8500 Carus™	130	74	72	51	21	79
L-8	8500 Carus™	180	110	75	69	6	111
L-3	8600 Carus™	110	94	110	86	24	24
L-6	8600 Carus™	110	86	77	62	15	48
L-9	8600 Carus™	280	86	110	40	70	240

Note: AL for lead is 15 µg/L.

Table 4.02-2 Lead Total Values Over the Study

Based upon the trends in the data over the study presented in Table 4.02-2, the chemical addition with the largest reduction in total lead was the 8600 Carus™. The results never reached below the AL but did reach the lowest of the other treatment sections.

SECTION 5
CONCLUSIONS AND RECOMMENDATIONS

5.01 CONCLUSIONS

The demonstrative study was completed from July 13 to December 14, 2022, with chemicals being added for corrosion control after week 7. During the duration of the demonstrative study, lead and copper samples were collected according to the set sampling plan. These results were analyzed to determine the most effective blended phosphate corrosion inhibitor.

The initial readings for lead and copper were both higher than the AL, with most being the maximum values for both metals. The explanation for this initial spike is the disruption caused during the pipe extraction and apparatus construction. This is to be minimized through the recommended lead line extraction strategy in Appendix C but is ultimately unavoidable. Through this process, some existing scaling in the pipe that had already been inhibiting lead or copper corrosion may have been disrupted and caused the pipe to leach out. The intent of the conditioning period is to rescale these lines before the chemicals are added.

The data collected revealed that neither treatment approach was definitively better than the other, nor were any alternative significantly better than a do-nothing approach as far as lead corrosion control was concerned. The data showed that orthophosphate addition had a negative effect on the copper levels, although the resulting levels were still well below the action levels. Assuming that a do-nothing approach to lead corrosion would not be an option, then, of the two chemicals tested, the Carus 8600 performed slightly better.

The best solution for the copper concentrations would be a do-nothing approach, but because copper is not an exceedance at this time, the lead corrosion control becomes more important. Copper levels remained less than the AL throughout the chemical treatment portion of the study after an initial spike and continued to decrease as the study progressed. Therefore, all three treatment methods were effective as needed for the purpose of copper sequestration.

5.02 RECOMMENDATIONS

As a long-term treatment plan, the water utility is completing lead service line replacement. The City has tentatively scheduled to remove the remaining lead and galvanized service laterals by 2026. For the City, the most effective CCT will be the complete removal of all known LSLs from the distribution system. This will eliminate the potential source of the lead.

During a December 9, 2022, meeting the WDNR informed the City that it is currently in compliance regarding the lead and copper regulatory standards. Therefore, the City is not required to implement another form of CCT unless a 90th percentile lead test result is greater than the AL. If a blended phosphate corrosion inhibitor is required to be added, the recommendation would be the 8600 Carus™ with the understanding that it is only slightly more effective than the 8500 Carus™ or no chemical addition options. The 8600 Carus™ was the high percentage orthophosphate option of the two chemical additions and, therefore, is generally expected to yield better lead passivation results. This inhibitor addition permits an increase in orthophosphates to form passivating scales while maintaining a relatively consistent polyphosphate dose to sequester iron and manganese found in the raw water. It is believed this should result in improved corrosion control.

APPENDIX A
WDNR CORRESPONDENCE

State of Wisconsin
DEPARTMENT OF NATURAL RESOURCES
101 S. Webster Street
Box 7921
Madison WI 53707-7921

Tony Evers, Governor
Preston Cole, Secretary
Telephone 608-266-2621
Toll Free 1-888-936-7463
TTY Access via relay - 711

July 29, 2021

Pete Hartz
Watertown Waterworks
800 Hoffman Dr
Watertown, WI 53094

Project Number:	W-2021-0568
Date Received:	April 30, 2021
DNR Region:	SCR
PWSID	12800447

SUBJECT: WDNR Response to Corrosion Control Treatment Recommendation

Dear Mr. Hartz,

This letter is to inform you of the Wisconsin Department of Natural Resources' (Department's) response to your Public Water System's (PWS) corrosion control treatment (CCT) recommendation, which was received by the Department on April 30, 2021.

In accordance with Chapter NR 809.543(1), Wis. Adm. Code Subchapter II – Control of Lead and Copper, the Department required Watertown to submit a CCT Recommendation Worksheet on August 21, 2020 after a Lead Action Level Exceedance (ALE) occurred during the 2020 lead and copper compliance monitoring period.

Department Comments on Corrosion Control Treatment Recommendation(s):

1) Watertown proposed removing 7% of known lead service lines per year until no complete or partial lead service lines remain.

In accordance with s. NR 809.542, Wis. Adm. Code, the Department must accept your CCT recommendation, designate optimal CCT for your system, or require your system to conduct a CCT Study. The Department reviewed and evaluated your CCT recommendation in accordance with US EPA's guidance document *Optimal Corrosion Control Treatment Evaluation Technical Guidance for Primacy Agencies and Public Water Systems*. **Based on this review of your CCT recommendation, the Department is requiring Watertown to develop and conduct a demonstrative CCT study. The completed CCT study must be submitted by January 31, 2023.** A demonstrative study requires a system to demonstrate through use of pipe-loops or other similar technologies that a given treatment will be effective in their system. The Department recommends that Watertown works with a consultant and/or treatment expert and follows EPA's Guidance: *Optimal Corrosion Control Treatment Evaluation Technical Guidance for Primacy Agencies and Public Water Systems* (online at https://www.epa.gov/sites/production/files/2016-03/documents/occtmarch2016.pdf). An additional Department resource, *Components of a Corrosion Control Study,* has been enclosed for your reference.

Your CCT study must include an evaluation of your PWS's water quality and infrastructure, and a plan to reduce lead concentrations in drinking water. CCT study requirements are described in more detail on the enclosed EPA Guidance. Although your CCT study will be specific to your system, it should include all of the following elements: an evaluation of current treatment for efficacy in reducing lead; consideration of the sources of lead in the system; consideration of other treatment options that may be more effective at reducing lead; and an evaluation of water quality parameters that can impact lead releases and corrosion control treatment efficacy. Be advised that an evaluation of the corrosivity of the water alone is not a substantial enough analysis to determine the likelihood of lead release.

The Department has established several interim deadlines to assist in the development of your CCT study. These interim deadlines and the final deadline are included on the enclosed table, *Corrosion Control Study Timeline*. The first interim deadline requires Watertown to submit a CCT study design proposal to the Department by

January 31, 2022. The proposal should outline the basic steps/components of the CCT study and the anticipated timeline for each step. Following the submittal of this proposal, the Department will schedule a time to meet with you and review the remainder of the interim deadlines and the CCT study process.

If you have any questions regarding these requirements, you may contact your DNR Representative, Sophia Stevenson, at (608) 576-4934.

Sincerely,

Ann Hirekatur
Public Water Supply Section
Bureau of Drinking Water and Groundwater
ann.hirekatur@wisconsin.gov

Enclosures:
1) *Optimal Corrosion Control Treatment Evaluation Technical Guidance for Primacy Agencies and Public Water Systems* - https://www.epa.gov/sites/default/files/2016-03/documents/occtmarch2016.pdf
2) *Components of a Corrosion Control Study*
3) *Corrosion Control Study Timeline*

cc: Terry Schultz – Water Operator, City of Watertown
Sophia Stevenson – Water Supply Engineer, DNR, Fitchburg
Eileen Pierce – SCR Supervisor, DNR, Fitchburg
Adam DeWeese – Public Water Supply Section Chief, DNR, Madison
Cathrine Wunderlich – Public Water Engineering Section Chief, DNR, Madison
Brendon Peppard – Water Supply Engineer, DNR, Madison
Colin Sinclair – Water Supply Specialist, DNR, Madison

CORROSION CONTROL TREATMENT STUDY

Components of a Desktop and Demonstrative Corrosion Control Treatment Study

The purpose of this document is to serve as a reference for systems required to conduct a Corrosion Control Treatment Study and outlines the differences between *Desktop* and *Demonstrative* studies. This may **not** encompass all the content necessary for a Corrosion Control Study but serves to highlight some of the major components and expectations for each study type. Each system's study components will depend on system specifics. Refer to the EPA's *Optimal Corrosion Control Treatment Evaluation Technical Guidance for Primacy Agencies and Public Water Systems* for additional information.

<u>Components of a CCT Study May Include:</u>

1) Evaluation of the efficacy of all treatments described in s. NR 809.543(3), as follows:
    a. Alkalinity and pH adjustment.
    b. Calcium hardness adjustment.
    c. The addition of a phosphate or silicate-based corrosion inhibitor at a concentration sufficient to maintain an effective residual concentration in all test samples.
2) For demonstrative studies systems should:
    a. Evaluate each of the corrosion control treatments listed above using either pipe rig or loop tests, metal coupon tests, partial–system tests (see *Corrosion Control Study – Demonstration Study Types* pg 3).
    b. Collect water quality data before *and* after the evaluation of a given treatment; the list of applicable WQPs will be discussed further in later correspondence.
    c. Recommendation for implementation of CCT that minimizes lead and copper at consumer's taps based a demonstrative study conducted using your system's water.
3) For desktop studies systems should:
    a. Evaluate raw, entry point, and distribution system water quality information for the determination of key water quality parameters and their potential impacts of water quality on lead and copper release and treatability.
    Note: This is not just a determination of the corrosivity of water, but an evaluation that considers all aspects of water quality and other non-corrosion control treatments.
    b. Determine primary causes of elevated lead and/or copper: review materials inventories to determine primary sources of lead and copper in drinking water as well as other materials which may contribute to lead and copper releases (i.e. galvanized services/plumbing, brass fixtures, etc.).
    c. Review customer complaint history to identify potential water quality issues that may be contributing to lead and/or copper releases.
    d. Discuss multiple corrosion control treatment types and how the selected treatment and proposed dosing aligns with EPA guidance. Note that some treatment types may require piloting before the Department can approve treatment implementation.
    e. In cases where blended phosphates are selected, discussion of the blend percentage and justification of polyphosphate in the system should be addressed.
    Note: A survey of analogous treatments at other systems will not be accepted.
4) Data and documentation collected during the study including:
    a. Water Quality Parameters impacted by given treatments.
    b. Identification of all chemical and/or physical constraints of the proposed treatment.
    c. Evaluation of the treatment's effect to other water quality treatment processes.
    d. For a detailed list, see Exhibits 4.3, 4.4, 4.5, 4.6, and 4.8 in the OCCT Guidance.
5) Proposed doses and treatment chemicals that will be used to reduced lead and copper at consumer's taps. Plan Review is required for any treatment changes.
6) A detailed schedule of the System's plan/timeline for treatment start-up.
7) See table *Desktop Study vs. Demonstrative Study Comparisons* (pg 2)

Desktop Study vs. Demonstrative Study Comparison		
Corrosion Control Study Content	Desktop Study	Demonstrative Study
Evaluate Raw, Entry Point, and Distribution system water quality parameters and how the various parameters relate to corrosion control.	✓	✓
Conduct profile sampling to determine efficacy of current Corrosion Control Treatment and generate a baseline for any proposed changes.	✓	✓
Identify causes of elevated lead and copper in the system and include an inventory of plumbing materials in the system	✓	✓
Evaluate Multiple Corrosion Control Treatment types including but not limited to phosphate addition, silicate addition, and pH adjustment.[1]	✓	✓
Identify chemical and physical constraints associated with all examined Corrosion Control Treatment types and substantiate all decisions and constraints with data and documentation.	✓	✓
Evaluate distribution system maintenance and flushing programs; determine how level of distribution system cleanliness may be contributing to lead and copper issues.	✓	✓
Conduct Pilot Scale testing to evaluate and substantiate corrosion control treatment constraints and determine the effect proposed treatments will have on system water quality.	Not Required [2]	✓
Conduct Pipe Scale Analysis to determine effectiveness of existing corrosion control treatment.	Not Required [2]	Not Required [2]
Operate a Pipe Loop to evaluate multiple Corrosion Control Treatments over an extended period of time with harvested distribution system plumbing materials to determine potential impacts a corrosion control treatment change could have on existing plumbing.	Not Required [2]	✓
Suggest corrosion control treatment dose, and timeline for implementation in final Corrosion Control Study submitted to Department for evaluation.[1]	✓	✓

[1] During evaluation and study of any blended phosphate or silicate products, which have the potential to sequester lead and copper, substantiation of the blend percentage and product will be required if proposed for Corrosion Control Treatment.

[2] These items are not required for completion of their respective Corrosion Control Studies; however, they may provide significantly more information during treatment evaluations and allow for increased confidence in Corrosion Control Treatment determinations.

Corrosion Control Study – Demonstrative Study Types

The description below are purely informational. A Corrosion Control Study must be tailored to meet the needs of each specific water system and will depend on a number of different variables including sources of lead and copper, source water, and existing treatment in place.

Water system's that will be conducting a Corrosion Control Study are advised to contact a consultant and/or treatment supplier regarding the proper construction, maintenance, and situational use of the proposed demonstration study types. It is also strongly recommended to schedule a meeting with the Department to discuss the details of a Corrosion Control Study prior to implementation.

1) **Pipe Loop Studies.** A pipe loop study includes development of a system constructed with excavated lead service lines installed in a flow through or recirculating system. Valves located throughout the loop allow for water to be circulated at various flow rates to simulate typical use. Pipe loops may require between 3 and 9 months to develop scales consistent with the water system. Lead and/or copper samples should be taken monthly until lead and/or copper level changes are less than or equal to 5%, to ensure scale stabilization. Small scale treatment modifications can be implemented in pipe loop configurations to determine the impact on the water system.
   OR
2) **Coupon Analyses/Monitoring Stations.** Coupon studies and monitoring stations use samples of lead and/ or copper (usually flat metal pieces) to mimic the exposure of system infrastructure to the system's drinking water. Coupon studies and monitoring stations that are maintained properly can provide information to help determine if treatment modifications installed at the station have the potential to decrease the release of lead and/or copper within the distribution system. Coupon studies and monitoring stations have limited uses in predicting exposure of lead and/or copper at consumer's taps given that "fresh" metal coupons lack the scale and treatment seen in consumer's service lines.
   OR
3) **Scale and Solid Analysis.** Lead services excavated from the water system and opened to examine pipe scales. Scales can be examined visually, via X-ray diffraction (XRD), X-ray fluorescence (XRF), X-ray emission spectroscopy, Raman spectroscopy, inductively coupled plasma mass spectroscopy (ICP-MS) and scanning electron microscope (SEM). Elemental analysis and images of excavated pipes can provide indications about the effectiveness and nature of corrosion control and guide recommendation decisions for corrosion control recommendations.
   OR
4) **Partial System Testing.** In hydraulically isolated areas of the distribution system, Department approved treatment modifications and accompanying monitoring for lead and/or copper and water quality parameters can help to optimize corrosion control treatment for larger systems. This partial system testing can be done in connection with a Pipe Loop Study following conditioning of pipe loops. Partial system testing should only be done in consultation with the Department, as there are substantial risks to consumers associated with modifying treatment which has not been properly tested by use of other demonstrative methods.