EXTERNAL MEMORANDUM

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cc: Project Central File W0784.26001

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Date: September 9, 2026

Subject: Woodland West Water Users Association - PWSID CO0160285
Engineering Recommendation and Report for OCCT in response to
May 1, 2025 Notice of Action Level Exceedance for Copper

INTRODUCTION

PURPOSE OF STUDY

The Woodland West Water Users Association (WWWUA) received a notice of Action Level Exceedance (ALE) in May of 2025 due to a 90th percentile exceedance of copper, which requires a desktop study for the evaluation of corrosion control treatment in accordance with the Lead and Copper Rule and its subsequent updates. The intent of this study is to provide recommendations to reoptimize the current corrosion control treatment. Optimal Corrosion Control Treatment (OCCT) recommendations were provided in 2017 by JDS-Hydro Consultants, Inc. (now RESPEC Company, LLC) for Mid Colorado Investments (MCI) Water Company, which supplied water to WWWUA under a prior agreement. As part of this study, RESPEC has compiled water quality results, documented corrosion control treatment history, and evaluated water chemistry and corrosion control treatment strategies based upon best practices as outlined in EPA's *Optimal Corrosion Control Treatment Evaluation Technical Recommendations for Primacy Agencies and Public Water Systems*.

GENERAL SUMMARY OF EXISTING AND PENDING LCR REGULATIONS

The original Lead and Copper Rule (LCR) passed as part of the Safe Drinking Water Act in 1991. The Rule mandated tap sampling at high risk homes, 90th percentile action levels of 0.015 mg/L for lead

and 1.3 mg/L for copper, corrosion control treatment (if required), and public education in the event of exceedances. The LCR has been implemented through Regulation 11 in Colorado.

In 2021, the Lead and Copper Rule Revisions (LCRR) required service line inventories (to identify lead, galvanized, or lines of unknown material) as well as customer notification of service line material. The Revisions also mandated Tier I public notice within 24 hours for any lead exceedance and revised sampling and trigger levels. These revisions were adopted into Regulation 11 in Colorado and the compliance date for the Revisions was October of 2024.

In late 2024, the EPA built upon the LCR and LCRR when the final rule for Lead and Copper Rule Improvements (LCRI) became effective. The Improvements largely supersede the provisions of the LCRR. The LCRI update specifies mandatory full lead service line replacement within 10 years where applicable, a lower (more stringent) lead action level of 0.010 mg/L, more robust sampling requirements and public notification protocols, school and childcare facility testing, and stronger corrosion control requirements. The LCRI also requires a complete baseline inventory. Colorado is currently updating Regulation 11 with these changes; the compliance date for the LCRI is November 1, 2027.

STUDY/REPORT SCOPE

This study is not intended to address all provisions of the LCRI (Improvements); however, we recommend that the Operator target a lower lead action level consistent with the LCRI as the compliance date approaches. Following is a summary of RESPEC's evaluation of the WWWUA system, past and ongoing corrosion control efforts and their effectiveness, and potential future treatment adjustments.

REVIEW OF EXISTING INFORMATION

RESPEC reviewed the following data for this analysis:

- LCR results, 10+ years (2015-2026) *see Table 1*
- LCR individual sample trends, 5 years (2022-2026) *see Table 2*
- Water quality monitoring results, laboratory: entry point and distribution system (2nd and 3rd quarters 2026) *see Table 4*
- Additional water quality monitoring data, by ORC: Cl, PO4, pH, temp, TDS (2022-2026)
- *Proposal for Modifying Existing Corrosion Control Treatment to Achieve Optimal Corrosion Control*. Respec. March 17, 2017 *see Table 3 for history of CCT*
- *LCRR Service Line Inventory Form*

OTHER REFERENCES

- *Optimal Corrosion Control Treatment Evaluation Technical Recommendations for Primacy Agencies and Public Water Systems*. EPA. March 2016

PROJECT BACKGROUND

SYSTEM INFORMATION

The Woodland West Water Users Association (WWWUA) was created in 1976 to deliver water to homes on the system, which now number approximately 126. WWWUA initially operated as a consecutive system and water was purchased from the MCI Water Company until 2021, when WWWUA acquired MCI's treatment equipment and its three groundwater wells.

A pipeline delivers water from the wells to the system. Caustic soda (for pH adjustment,) Carus 8100 (low-poly phosphate blend for corrosion control,) and sodium hypochlorite are dosed in an underground vault near the well heads. Water enters the distribution system directly to satisfy system demand, with excess water filling the reservoir. The reservoir, on district-owned land, consists of nineteen (19) buried concrete water storage tanks plumbed in parallel. All but two of the concrete tanks are currently online.

A review of data provided by the Operator shows that homes at the current LCR monitoring sites were built between 1979 and 1987. Five of these sites have copper service lines while the other five have high density polyethelyne (HDPE) service lines. To the best of our knowledge, none of the monitoring sites utilize point-of-entry or point-of-use devices and all or most sites likely use copper plumbing with lead solder (installed prior to 1988) for premise plumbing. All system-owned materials are non-lead (never lead) and there are no lead service lines (LSLs) in the system.

SYSTEM LCR MONITORING AND COMPLIANCE HISTORY

A 2016 ALE for both lead and copper triggered a desktop study and the implementation of OCCT recommendations. No further exceedances were reported for nearly nine years until 2025, when a copper exceedance again triggered the optimization process. It should be noted, however, that copper levels remained only slightly below the action level from 2019 through 2024. Table 1 shows the LCR monitoring history for the system since 2015, three years after MCI began chlorination.

Table 1. LCR Monitoring History

WOODLAND WEST WATER USERS ASSOCIATION LCR MONITORING RESULTS 2015-2026								
YEAR	# REQUIRED/ RECEIVED	FREQUENCY	MONITORING PERIOD	MONITORING PERIOD	90th %ile COPPER	# ABOVE COPPER AL	90th %ile LEAD	# ABOVE LEAD AL
2015	5/5	12 mos	annual	Jun-Sep	0.94	0	0.0032	0
2016	5/12	12 mos	annual	Aug-Sep	1.66	2	0.0168	3
2017	10/10	6 mos	1st half	Mar-May	0.98	0	0.007	0
	10/10	6 mos	2nd half	Sep	0.98	0	0.005	0
2018	10/10	6 mos	1st half	May	1.02	0	0.004	0
	10/10	6 mos	2nd half	Nov-Dec	0.94	0	0.003	0
2019	10/10	6 mos	1st half	Jun	1.25	0	0.01	0
		6 mos	2nd half					
2020		6 mos	1st half					
	10/10	6 mos	2nd half	Nov	1.02	0	0.002	0
2021	10/10	6 mos	1st half	Apr-May	1.22	0	0.003	0
	10/10	6 mos	2nd half	Nov	1.2	0	0.0026	0
2022	10/10	6 mos	1st half	Mar-Apr	1.1	0	0.0032	1
	10/10	6 mos	2nd half	Sep	1.2	1	0.0014	0
2023		6 mos	1st half					
	10/10	6 mos	2nd half	Oct	1.2	0	0.0016	0
2024		6 mos	1st half					
	10/10	6 mos	2nd half	Sep	1.32	1	0.0015	0
2025	10/10	6 mos	1st half	Mar-Apr	1.73	3	0.0057	1
	10/11	6 mos	2nd half	Oct-Dec	1.32	1	0.0026	1
2026	10/10	6 mos	1st half	Jun	1.68	2	0.002	0

Note: copper MCL 1.3 mg/L, lead MCL 0.015 mg/L; AL=action limit

The operator-in-responsible-charge (ORC) obtains 10 tap samples each monitoring period for LCR monitoring. The ages of the various fixtures from which samples are taken are unknown.

INDIVIDUAL MONITORING RESULTS

Individual LCCR sampling results from 2022-2026 are tabulated in Table 2 for an analysis of trends.

Table 2. LCR Monitoring History – Individual Results

WOODLAND WEST WATER USERS ASSOCIATION LCCR INDIVIDUAL RESULTS 2022-2026

COPPER (mg/L)

Address	Sample ID	Year Built*	Service Line Material*	May-22	Sep-22	Oct-23	Sep-24	Mar-25	Oct-25	Jun-26
737 Northwestern Pl	LCR002	1986	1993 new valve, Cu	1	0.25	0.022	0.0507	1.73	0.0633	
94 Harvard Pl	LCR004	1984	2012 new valve, 2000 poly	1	0.16	0.067	0.112	0.685	0.102	0.242
75 Pennsylvania Ave	LCR007	1983	2008 new valve, poly	1.2	0.094	1.2	1.1	1.24	0.983	1.16
201 Pennsylvania Ave	LCR009	1987	2013 new valve, poly			0.85	1.5	2.06	1.42	1.28
418 University Dr	LCR016	1987	2012 new valve, poly	0.98	1	1.1	1.06	1.06	0.0462	1.68
672 Woodland West Dr	LCR021	1985	orig. valve, likely Cu							1.13
427 Cornell Dr	LCR022	1979	orig. valve, likely Cu	0.26	0.16	0.15	0.211	0.195	0.171	0.177
751 Northwestern	LCR023	1985	orig. valve, Cu	0.098	1.2					
613 University Dr	LCR024	1999	orig. valve, poly							
65 Columbia Pl	LCR025	1985	2009 new valve, poly	0.33	0.62	0.54	1.32	1.24	0.873	0.164
236 Pennsylvania Ave	LCR027	1987	2013 new valve, line	0.36	0.31	0.65	0.539	0.466	0.48	0.343
697 Northwestern Pl	LCR028	1987	1997 new valve, poly	0.38	1.5	1.3	0.697	1.73	0.706	
215 Pennsylvania	LCR029	1981	2009 new valve, poly	1.1	1.1	0.039	0.984	1.34	1.33	
32 Dartmouth Pl	LCR030	1985	orig. valve, Cu						1.28	
180 Brown	LCR031	1984	2010 new valve, poly							0.912
105 Penn	LCR032	1986	1995 new valve, Cu							1.83

*** Per ORC records**

Key: ABOVE AL
ELEVATED

Table 2 (cont'd). LCR Monitoring History – Individual Results

RESPEC

WOODLAND WEST WATER USERS ASSOCIATION LCCR INDIVIDUAL RESULTS 2022-2026

LEAD (mg/L)

Address	Sample ID	Year Built*	Service Line Material*	May-22	Sep-22	Oct-23	Sep-24	Mar-25	Oct-25	Jun-26
737 Northwestern Pl	LCR002	1986	1993 new valve, Cu	0.0022	0.00073	0	0.0005	0.0057	0	
94 Harvard Pl	LCR004	1984	2012 new valve, 2000 poly	0.016	0.0009	0	0.00071	0.0012	0.00079	0.00099
75 Pennsylvania Ave	LCR007	1983	2008 new valve, poly	0.0027	0.00087	0.0026	0.0094	0.0177	0.0028	0.0022
201 Pennsylvania Ave	LCR009	1987	2013 new valve, poly			0	0.00055	0	0.00053	0.0006
418 University Dr	LCR016	1987	2012 new valve, poly	0.0018	0.0014	0.0016	0.0015	0.0014	0	0.0013
672 Woodland West Dr	LCR021	1985	orig. valve, likely Cu							< 0.0005
427 Cornell Dr	LCR022	1979	orig. valve, likely Cu	0.0029	0.0012	0.0011	0.0012	0.00097	0.00071	0.00077
751 Northwestern	LCR023	1985	orig. valve, Cu	0	0.0021					
613 University Dr	LCR024	1999	orig. valve, poly							
65 Columbia Pl	LCR025	1985	2009 new valve, poly	0.0032		0.00077	0.0015	0.00052	0.00055	< 0.0005
236 Pennsylvania Ave	LCR027	1987	2013 new valve, line	0.00068	0.00072	0.00078	0.00071	0.0011	0.00096	0.00054
697 Northwestern Pl	LCR028	1987	1997 new valve, poly	0.00063	0.00063	0.00059	0.0015	0.00061	0.00051	
215 Pennsylvania	LCR029	1981	2009 new valve, poly	0.00084	0.0012	0	0.00087	0.0014	0.00079	
32 Dartmouth Pl	LCR030	1985	orig. valve, Cu						0.0254	
180 Brown	LCR031	1984	2010 new valve, poly							0.002
105 Penn	LCR032	1986	1995 new valve, Cu							0.001

*** Per ORC records**

Key: ABOVE AL
ELEVATED

Though 90th percentile copper exceedances were only documented for the first half of 2025 and 2026 monitoring periods, a look at individual results over the past year is useful. In March of 2025, three samples tested above the action level (AL) for copper with three others slightly below the AL. Only one of these six sample sites is noted as having a copper service line. In October of 2025, one sample tested above the AL for copper (no 90th percentile exceedance) with two others slightly below. Only one of these three sample sites is noted as having a copper service line. Similarly, in June of 2026, two samples tested above the AL with one additional sample slightly below the AL. Only one of these locations has a copper service line. Premise piping is therefore likely contributing to copper leaching in many of the samples where copper has been near or above the action level.

The system has not had a 90th percentile lead exceedance since 2016.

CORROSION CONTROL TREATMENT HISTORY

Corrosion control treatment has been an ongoing process requiring continued evaluation and monitoring for compliance with the LCR. Initial corrosion control efforts for copper were approved in 1995 and continued to be the focus of the system until 2016, when both lead and copper exceedances occurred. While chlorine has been in use since 2012, the system has been adjusting for pH since 1995, with the most recent change from soda ash (sodium carbonate) to caustic soda (sodium hydroxide) occurring in 2007. Addition of a blended phosphate inhibitor (CalciQuest) began in 1998; this was changed to a specialized blended phosphate inhibitor (SeaQuest) beginning in 2002, with a more recent switch to Carus 8100, another blended phosphate inhibitor, occurring sometime around 2022. It is likely that Carus 8100 was chosen in an effort to product-match since SeaQuest and Carus 8100 have similar poly/ortho ratios. Table 3 summarizes the system's CCT history.

Corrosion control inhibitors such as these are utilized to control iron and manganese scale or corrosion. Previous chemical additives used for corrosion control had different mechanisms for controlling corrosion and different water chemistry requirements. The primary mechanism by which CalciQuest inhibits lead and copper leaching is the formation of a microscopic film (for example, formation of a copper-phosphate passivation barrier.) CalciQuest required more stable water chemistry, requiring a pH optimized to approximately 7.2-7.8. Because CalciQuest, leverages calcium naturally present in water to produce a barrier, it requires a neutral or slightly positive Langelier Saturation Index (LSI.) In contrast, SeaQuest is a blended orthophosphate and polyphosphate product designed to promote chemical equilibrium/stability and metal sequestration (generally reducing anodic oxidation reaction at the wall of copper pipe by altering the metal's ionic state.) SeaQuest (75% poly / 25% ortho blend), however, is purported to be effective in more variable water chemistries and within a wider pH range of 6.0-9.0. SeaQuest sequesters calcium and operates independently of LSI. Lastly, Carus 8100 (70% poly / 30% ortho blend) functions both as a corrosion inhibitor and sequestering agent. The polyphosphates in the 8100 bind to iron, manganese, and calcium to minimize stains, scale, or discolored water while the orthophosphates facilitate the formation of a protective film on pipe walls to minimize lead, copper, and iron leaching.

Table 3. Corrosion Control Treatment History

Date Range	Target	Notes	Chlorine	pH/Alkalinity Adjustment	Corrosion Inhibitor	Results/ Effectiveness
Feb 1995-Jun 1998	copper	desktop evaluation submitted Feb 1995	none	installed limestone contactor at system point of entry to increase pH	none	ineffective
Jun 1998 – May 2000	copper	study approved Apr 1998	none	(limestone contactor removed)	CalciQuest (phosphate-based)	ineffective
May 2000 – Jan 2002	copper	study continued	none	soda ash (sodium carbonate)	CalciQuest	ineffective
Jan 2002 – Mar 2002	copper	study continued	none	soda ash	SeaQuest (ortho- and poly-phosphate blend)	
Apr 2002 – May 2005	copper	desktop evaluation approved Jun 2005	none	none	SeaQuest	
2005 - 2007	copper	study continued	none	soda ash	SeaQuest	
2007 - 2011	copper	study continued	none	caustic soda (sodium hydroxide)	SeaQuest	copper below action level Jan 2010
Jun 2012 – Jul 2016	copper	study continued	chlorination initiated Jun 2012, 4-log reduction; high free chlorine level maintained	caustic soda	SeaQuest	compliance through Jul 2016; lead and copper exceedances Aug 2016

Table 3. Corrosion Control Treatment History

Dec 2016	lead and copper	LSI -0.94 (negative)	began reduction of chlorine level to minimum required	caustic soda	SeaQuest (1.8 mg/L)	
Mar 2017	lead and copper	proposal for treatment modification submitted	phase 2: if necessary, reduce free chlorine; target 0.35 mg/L at system entry point	phase 1: Increase caustic soda dose in 10% increments; target pH TBD but not above 7.3	SeaQuest (1.8 mg/L)	
Current treatment (since 2022)	lead and copper		maintaining 0.5-0.6 mg/L at entry point and 0.3-0.5 mg/L at system endpoints	caustic soda (60-65 ppm with 25% solution)	Carus 8100 low-poly blend	copper exceedance first half of 2025; second half 2025 copper slightly under AL; copper exceedance first half of 2026

WATER SYSTEM

WATER SYSTEM DESCRIPTION

Three wells at nearly the same depth and within approximately 40 feet of each other provide a redundant means of withdrawal but essentially no water source redundancy. A below-grade vault at the well site houses pumps and chemical feed equipment but provides only minimal space for chemical storage. Caustic soda (25% solution), Carus 8100, and sodium hypochlorite are currently mixed and added at the well site. None of the chemical feed pumps utilize flow-pacing. Treated water is piped from the well site to the entry point to the distribution system to meet demand; the system's reservoir floats on the system and is filled when demand allows. According to the 2017 OCCT recommendations by RESPEC, it was determined through extensive study that the system requires approximately 45-60 days to achieve a uniform concentration of chlorine, corrosion inhibitors, and other chemicals due to the reservoir's location and the daily refill cycle, which contribute to a relatively slow mixing of new water in the reservoir.

Currently, all three chemicals are injected within approximately 12 inches of pipe (sodium hypochlorite, then Carus 8100, then caustic soda) with essentially no opportunity for mixing or retention in between injection ports. This configuration is problematic as all three chemicals are interacting at higher concentrations, with the Carus 8100, in particular, still likely at a near-neat concentration, potentially causing chemical interference and reduced effectiveness. This configuration can reduce the effectiveness of disinfectant due to localized pH increase (see later discussion on free chlorine under *Optimal pH for Other Processes*.) It can also reduce the effectiveness of the corrosion control product as it exposes the phosphate blend to a powerful oxidizer (sodium hypochlorite) and a strong base (caustic soda) before any dispersion has occurred, potentially altering its chemistry and capabilities before it enters the distribution system.

Best practice for multiple chemical injections is to install an inline static mixer immediately after each injection port and to provide 6 to 10 pipe diameters of length before a subsequent injection port to allow for mixing. Utilization of center-of-pipe injection quills to reduce the potential for higher concentration boundary layers at the pipe wall at the injection site.

WATER QUALITY DATA

Relevant raw water parameters were sampled by the ORC in August of 2026 (see Table 5.) Entry point and distribution system water quality monitoring data was provided by the ORC for the second and third quarters of 2026 (see Tables 6 and 7.) In addition, the ORC has been tracking chlorine, phosphate, pH, temperature, and TDS on an approximately weekly basis since late 2022. See Attachment - Operator Data.

See below for discussions on phosphate concentration, calcium carbonate balance, and chloride-to-sulfate mass ratio in the finished water as these relate to corrosion control.

CONSULTATION WITH CARUS

RESPEC consulted with water treatment experts from Carus on this system. The consensus from Carus' representatives is as follows:

- Maintaining the higher/adjusted pH will be better for controlling copper corrosion
- Avoid a pH range of 8.0-8.5 due to lead corrosion concerns
- Initial thoughts are that this system should not be using Carus 8100 (70% poly / 30% ortho blend) and that a lower polyphosphate to orthophosphate ratio may be beneficial
- Carus 8100 is generally for high hardness, iron, and manganese. Woodland West's hardness and iron are not high enough to justify this higher polyphosphate blend
- Carus would like to eventually get the orthophosphates up to address the copper exceedances but it will also be necessary to reduce polyphosphate levels
- Carus will consider a switch to their 8500 (50% poly / 50% ortho blend) after review of additional water quality results to be conducted in the 3rd and 4th quarters of 2026
- In the interim, Carus recommended a reduction in 8100 dose to minimize introduction of polyphosphates into the system; target 0.5 mg/L to 0.6 mg/L as PO_4 throughout the distribution system
- Chloride (and CSMR) is high; this can lead to lead issues
- Carus will require entry point and distribution system water quality results, to include manganese, orthophosphate, and total phosphorus, both before the dose reduction and approximately 60 days after the reduction; these will be evaluated to determine the correct product and dose

Table 5. Raw Water - Water Quality Monitoring Data August, 2026

PARAMETER	RAW WATER (08-26)
pH	7.0
temp (C)	11.1
TDS (mg/L)	<100

Table 6. Entry Point and Distribution System - Water Quality Monitoring Data 2026

PARAMETER	ENTRY POINT (06-28-26)	ENTRY POINT (07-06-26)	DIST SYSTEM (06-28-26)	DIST SYSTEM (07-06-26)
pH	7.20	7.78	8.19	7.78
temp (C)	14.1	14.1	17.1	17.5
alkalinity (mg/L as CaCO3)	79.9	81.1	80.8	80.2
hardness (mg/L as calcium)	103	101	101	102
TDS (mg/L)	229	224	226	205
calcium (mg/L)	41.1	40.6	40.6	40.8
chloride (mg/L)	59.1	38.4	38.0	38.0
sulfate (mg/L)	12.9	12.9	12.9	13.1
iron (ug/L)	313	317	320	310

Table 7. Entry Point and Distribution System - Water Quality Monitoring Data 2026 - AVERAGES

PARAMETER	ENTRY POINT - AVG.	DIST SYSTEM - AVG.
pH	7.49	7.99
temp (C)	14.1	17.3
alkalinity (mg/L as CaCO3)	80.5	80.5
hardness (mg/L Ca as CaCO3)*	102	102
TDS (mg/L)	227	216
calcium, elemental (mg/L)	40.9	40.7
chloride (mg/L)	48.8	38.0
sulfate (mg/L)	12.9	13.0
iron (ug/L)	315	315

PIPELINE AND PLUMBING MATERIALS

Distribution system piping varies from 2-inch to 4-inch PVC mains with glued joints. Service line materials vary from original copper to poly where lines have been replaced. There are no lead service lines.

SUMMARY OF WATER QUALITY COMPLAINTS

According to the ORC, the District has not been receiving water quality complaints. This desktop study is in response to the notice of Action Level Exceedance for copper issued in May of 2025.

ANALAGOUS SYSTEM INFORMATION

RESPEC has not studied an analogous system as part of this evaluation.

TAPS (MONITORING LOCATIONS)

Information on LCRR monitoring locations has been obtained from the *LCRR Service Line Inventory Form* (on file with CDPHE) and from ORC records.

POTENTIAL CAUSES OF ELEVATED LEAD AND/OR COPPER LEVELS IN THE SYSTEM

PHOSPHATE

While a certain amount of polyphosphate is needed to sequester iron and manganese, excess polyphosphate could also be binding copper ions and keeping them in solution, with copper service lines or copper premise (household) piping a logical source. Polyphosphates can also hinder or dissolve carbonite scale on the wall of copper pipe.

According to ORC data, phosphate (PO_4) levels at the entry point began increasing from approximately 0.5 mg/L in late 2022, to 0.7 mg/L in late 2023, to over 1 mg/L by mid-2024, to around 1.5 mg/L in September of 2025. Limited phosphate levels were recorded in late 2025 and the first half of 2026; however, two higher values (2.42 mg/L in November of 2025 and 1.79 mg/L in June of 2026) indicate further increasing levels. Prior levels near 0.5 mg/L were more appropriate for this system.

LANGELIER SATURATION INDEX AND CALCIUM CARBONATE BALANCE

While calcium carbonate precipitation has been shown to be ineffective as a means of corrosion control and thus was removed from the list of acceptable methods with the 2016 edition of EPA's OCCT Manual, carbonate and bicarbonate along with pH play a role in carbonate balance, which in turn affects water's pH buffering capacity and dissolved inorganic carbon (DIC) concentration.

Water tries to reach a state of balance or equilibrium with respect to $CaCO_3$ concentration. The Langelier Saturation Index (LSI) is a metric or calculated value used to predict whether water will precipitate carbonate (and form scale at the pipe wall) or dissolve carbonate (corrode the pipe wall.) The LSI value is found by subtracting the pH_{SAT} from the actual water pH. When the actual water pH is equal to pH_{SAT}, water is balanced. Simply put, a negative LSI

value would predict corrosion while a positive LSI value would predict scaling. However, slightly negative or slightly positive values (-0.2 to +0.2) indicate generally stable water. At a pH of 7.99, water at the periphery of Woodland West's distribution system has a calculated LSI of -0.14, which indicates a very slight scale-dissolving tendency. It should be noted that LSI is only one parameter by which action at the pipe wall can be predicted. Some corrosion inhibitors are more dependent on LSI range for effectiveness.

The source water's negative LSI makes it potentially aggressive at the pipe wall. A saturation pH of 7.96 (calcium carbonate or $CaCO_3$) was calculated using the most recent water quality data. Raw water pH measured 7.0 in August of 2026. The entry point pH has averaged 7.49 (adjusted), while distribution system pH has averaged 7.99, which puts the water in a near balanced condition with respect to calcium carbonate and does not suggest high potential for corrosion.

CHLORIDE-TO-SULFATE MASS RATIO

Lastly, the potential effects of chloride and sulfate should be discussed. Chloride ions in water are aggressive (forming soluble complexes with lead) while sulfate ions are protective (precipitating low-solubility lead sulfate solids.)

Woodland West's water is relatively high in chloride. The distribution system's chloride-to-sulfate mass ratio (CSMR) is approximately 2.9. While alkalinity above 50 mg/L can buffer lower levels of chloride, this system will not see this benefit. A CSMR above 0.77 poses a risk for galvanic corrosion which, for this system, would be limited to the interface of lead solder and copper pipe for any remaining copper service lines or for copper premise piping. The CSMR ratio would be a much more important factor in the presence of lead service lines.

IDENTIFICATION AND ASSESSMENT OF CORROSION CONTROL ALTERNATIVES

EPA's *Optimal Corrosion Control Treatment Evaluation Technical Recommendations for Primacy Agencies and Public Water Systems (EPA's OCCT Manual),* in conjunction with CDPHE's *Appendix K- Application Form Lead and Copper Rule Source Water Treatment Recommendation and Optimal Corrosion Control Treatment Recommendation* (see Appendix K) provide the basis for this analysis.

CONSTRAINTS

It is important to evaluate not only system constraints, but the potential for unintended consequences because of any change in water treatment. Adjustments to water chemistry aimed at reducing lead and/or copper release must be done in such a way that enables the ORC to document the effect of each. As such, adjustments should generally be made to a single variable at a time and in small increments. The system should be allowed to stabilize after each adjustment and prior to a subsequent water quality analysis. For the purposes of this study, this stabilization period is assumed to be approximately 60 days.

Since WWWUA does not have a treatment building and the ORC operates in a below-grade vault (confined space,) the system is limited in terms of the types of chemicals it can use and space available for chemical storage. Treatment complexity and cost should also be considered with any recommendations.

Potential unintended consequences of changes to OCCT can vary depending upon source water chemistry, the type and stability of existing scale, and variation in chlorine residual and oxidation-reduction potential. Even a chemically stable scale can be impacted by physical/flow events. Operators and consultants should evaluate the effects of any chemicals used for corrosion control treatment on other drinking water quality treatment processes including disinfection/chlorine residual, formation of disinfection byproducts (DBPs), etc.

APPENDIX K SUMMARY

OCCT OPTIONS

According to the EPA's OCCT Manual, the applicable flowchart for OCCT evaluation for the WWWUA system is flowchart 3b due to the current distribution system pH above 7.2 and the presence of iron or manganese (at 0.315 mg/L, the entry point iron concentration is slightly above the secondary MCL; manganese concentration is unknown and will be obtained with upcoming samples). With a dissolved inorganic carbon (DIC) greater than 15 mg/L (17.5 mg/L DIC per Exhibit 3.2 in EPA's OCCT Manual for calcium of 40.7 mg/L and pH of 7.99,) CCT options listed on the flowchart include:

1. add blended phosphate (WWWUA has been using a blended phosphate) *or*
2. remove source water iron/manganese; add orthophosphate with pH adjustment to 7.2-7.8 (it is not practical at this time for WWWUA to remove source water iron and manganese prior to corrosion control treatment)

WWWUA plans to continue to use caustic soda to adjust for pH and to utilize a blended phosphate by Carus for sequestration and corrosion control. This approach and the need for further analysis is outlined below.

POSSIBLE LIMITATIONS OF PH/ALKALINITY/DIC ADJUSTMENT

Three things that typically limit pH, alkalinity, and DIC adjustment are: the requirement for optimal pH for other processes (such as disinfection), the potential for calcium carbonate precipitation, and oxidation of iron and manganese.

OPTIMAL PH FOR OTHER PROCESSES

Water treatment is usually accomplished through simultaneous processes, each of which has an optimal pH range. Though the target pH for orthophosphate use is often cited as 7.2-7.8, use of blended phosphate is less restricted by pH. Using caustic soda, the ORC is increasing the raw water pH of 7.0 to an average of 7.49 at the entry point. Water pH at the periphery of the distribution system is averaging 7.99, which according to Carus is suitable for copper control. Caustic soda can increase pH without increasing DIC or decreasing the water's

saturation pH. Buffer intensity dips (is lowest) in a pH range of 8.0-8.5 where water has decreased chemical stability and can increase lead and copper release; as such, this pH range is typically avoided. At lower pH (below 7.8) alkalinity and DIC can be the limiting factors in copper corrosion control.

Increasing pH prior to chlorine contact can reduce disinfection performance. The EPA OCCT Manual recommends adjusting (increasing) pH for corrosion control after chlorine contact but this is not feasible for many systems, including for Woodland West.

Alkalinity serves as a buffer for the H+ ions released when chlorine reacts with contaminants and pH remains relatively stable as the H+ ions are neutralized by abundant bicarbonate ions (HCO_3-) which are the hallmark of alkalinity. Buffering and associated pH stability continues until the bicarbonate is used up, at which point pH will decrease. In Woodland West's system, pH continues to increase within the distribution system. This is most likely caused by carbon dioxide (CO_2) outgassing, which increases pH through the removal of carbonic acid.

Free chlorine exists as two species: HOCl and OCl-. As pH increases and less H+ ions are available in the water, the reversible acid-base equilibrium reaction that governs the formation of either species shifts toward the formation of OCl-, which is a more powerful disinfectant than HOCl since the OCl- species, with its negative charge, is electrically resisted by bacteria and virus cell walls, which are also negatively charged. While free chlorine can be split nearly 50% HOCl and 50% OCl- at a pH of 7.5, a non-linear relationship means that at a pH of 8.0, HOCl will comprise only about 23% of free chlorine with OCl- making up the other 77%. This shift to predominantly OCl- ions can reduce free chlorine effectiveness.

The ORC's target free chlorine concentration of 0.4 mg/L seems prudent in this light. The ORC maintains free chlorine at the entry point of 0.4 to 0.6 mg/L (ppm) and typically sees chlorine residual at the periphery of the distribution system between 0.3 and 0.5 mg/L. With the location, configuration, and condition of the storage tanks and slow fill rate as well as the potential for OCl- ion dominance, a target of 0.4 mg/L of free chlorine at the periphery of the system is prudent.

WWWUA has not reported issues with disinfection byproducts (DBPs.)

CALCIUM CARBONATE PRECIPITATION

At 7.99, adjusted/distribution system pH is near a balanced or saturation pH (pH_{SAT}) of 7.96, meaning the water is essentially saturated with $CaCO_3$ and not scale-forming. $CaCO_3$ precipitation can interfere with phosphate effectiveness; hence, maintaining pH at or below pH_{SAT} should be a goal.

The ORC has not reported complaints of calcium carbonate precipitation.

OXIDATION OF IRON AND MANGANESE

Increasing pH along with higher levels of free chlorine can cause oxidation of iron and manganese. Iron concentration appears relatively constant in the source water and distribution system and is slightly above the SMCL. Further adjustment (increase) in pH would not be recommended due to the risk of additional oxidation of iron within the distribution system. When oxidized, iron and manganese can result in black or red (respectively) water or staining complaints. If iron and manganese are not otherwise removed from the source water, polyphosphates can sequester iron and manganese to reduce the potential for issues.

The ORC has not reported complaints related to iron or manganese.

POSSIBLE LIMITATIONS OF PHOSPHATE-BASED INHIBITORS

1. Reactions with aluminum – The system does not use aluminum-based chemicals.
2. Impacts on wastewater - Homes in this district utilize On Site Wastewater Treatment Systems (OWTS.) Phosphorus from corrosion control chemicals will enter the soil through septic systems and/or directly with irrigation use. Removal of phosphorus by septic systems generally varies from 60%-90% depending upon the soil's phosphorus affinity; calcium-rich soils on the eastern plains tend toward lower adsorption (chemical precipitation) of phosphorus. The goal is to utilize the minimum amount of phosphates required for corrosion control.

EVALUATION OF FEASIBILITY AND COST

WWWUA currently utilizes caustic soda for pH adjustment and Carus 8100 for sequestration and corrosion control. Continuing use of these chemicals products aligns with the District's current budget.

RECOMMENDED PLAN FOR OCCT

While there are several changes that can be implemented immediately to optimize corrosion control treatment, there are other steps that could be taken with more significant investment and over time. WWWUA is in the process of developing a Long-Term Plan (CIP) for the water system. The short-term and long-term items listed below are not a complete list and further evaluation is needed to complete the long-term plan. In addition, the District will need to evaluate the feasibility of any short-term improvements, whether these will be sunken costs in the long-term, and the potential benefit to the system in the interim.

RESPEC

IMMEDIATE

1. Obtain one raw water sample and additional water quality samples at both the entry point and distribution system, to include all parameters noted below, immediately/prior to any dosage adjustments.

pH
temp (C)
alkalinity (mg/L as CaCO3)
hardness (mg/L Ca as CaCO3)
TDS (mg/L)
calcium, elemental (mg/L)
chloride (mg/L)
sulfate (mg/L)
iron (ug/L)
Manganese (ug/L)
Orthophosphate (mg/L as P)
total phosphorus (mg/L as P)

2. Reduce the dose of Carus 8100 to target PO_4 of 0.5 mg/L to 0.6 mg/L throughout the distribution system. Maintain current pH adjustment/caustic soda dose.
3. Allow 60 days for system stabilization, then obtain additional water quality samples at the entry point and distribution system for the parameters listed in number 1 above.
4. Carus will review all water quality results and will recommend the appropriate product and dose as well as confirm target pH. Following a consultation with Carus to discuss the suitability of their 8100 product versus other products for Woodland West, we anticipate that the system will switch to Carus' 8500 blend (50% poly / 50% ortho) after this evaluation period to reduce polyphosphate addition. Once received, the ORC shall implement Carus' recommendations in a timely manner with incremental adjustments as necessary.

Other considerations:

1. Continue to monitor free chlorine in the distribution system following each inhibitor dose adjustment and throughout the stabilization period. Minimize the concentration needed at the entry point to reduce the potential for the oxidation of iron or the formation of DBPs in the distribution system. Sodium hypochlorite demand within the distribution system may change as sequestering is optimized. Continue to target 0.4 mg/L chlorine residual at the periphery of the distribution system.
2. It will be necessary to conduct additional water quality monitoring after changing the blend of the phosphate inhibitor and after any subsequent dose changes. After the initial 8100 dose reduction, any adjustments to inhibitor dose should be incremental and should be made about 60 days apart. Any changes to inhibitor should be accomplished per Carus' recommendation.
3. Continue with LCR monitoring two monitoring periods per year.

SHORT-TERM / INTERIM IMPROVEMENTS

Short-term improvements that may provide benefits while the system is space-limited in its current below-grade vault:

1. New piping and inline static mixers, allowing for recommended pipe lengths between injection ports – evaluate the option for pipe loops within the vault or below grade outside
2. Flow pacing, if possible

LONG-TERM IMROVEMENTS

Long-term water system improvements may include but not be limited to:

1. WTP building to move the facility above ground
2. Aeration for pH adjustment in lieu of chemical addition – this will require a break in pressure and additional pumps
3. Flow pacing
4. Reservoir maintenance, improvements, or replacement