

Technical Memorandum No. 6
Mint Farm Regional Water Treatment Plant Corrosion Control
Plan

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Subject: New Longview Mint Farm Regional Water Treatment Plant (MFRWTP) Corrosion
Control Plan
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Introduction and Purpose

The City of Longview will change its source of drinking water supply from the Cowlitz River to groundwater. Treatment facilities are being provided to remove iron and manganese from the groundwater. Arsenic will also be removed; although, it occurs in the ground water at a level below the City's finished water goal (<5 µg/L). This finished water arsenic concentration is also well below the Federal and State Maximum Contaminant Level of 10 µg/L. Design of the groundwater treatment facility, the Mint Farm Regional Water Treatment Plant (MFRWTP), was completed in 2010. Construction is anticipated to be complete in late 2012.

A Preliminary Design Report and the final plans and specifications for the new MFRWTP facilities have been previously submitted for review by the Washington State Department of Health (DOH). The purpose of this document is to present the corrosion control strategy for the new MFRWTP so that the City will remain in compliance with the Lead and Copper Rule (LCR) once the new plant is in operation. The City is also developing a separate document, termed a Distribution System Water Quality Plan, which includes recommendations for a new flushing plan.

Regulatory Summary

LCR Overview

The LCR was promulgated in 1991. The purpose of the LCR is to reduce lead and copper levels in water mainly by reducing the corrosivity of the water in the distribution system and reducing the corrosion of lead- and copper-containing plumbing materials. Lead can cause damage to the brain, red blood cells, and kidneys, especially in young children and pregnant women. Copper can cause stomach and internal distress, liver or kidney damage, and complications with Wilson's disease in genetically pre-disposed people.

The LCR set a maximum contaminant level goal (MCLG) of zero for lead in drinking water and requires a treatment technique to reduce corrosion within the distribution system. The rule established action levels (ALs) of 0.015 mg/l (15 µg/L) for lead and 1.3 mg/L for copper, based upon the 90th percentile level of targeted tap water samples. An AL exceedance is not an MCL violation but can trigger other requirements that include water quality parameter (WQP) monitoring, corrosion control treatment, source water monitoring and treatment, public education, and lead service line replacement.

The sampling requirements include collection of first-draw samples at cold-water taps in homes identified as potentially at higher risk for elevated levels of lead, and to a lesser extent, copper. Systems serving fewer than 50,000, like the City of Longview, can qualify for a reduced sampling frequency if specific conditions are met.

In 2000, EPA published revisions to the LCR to address implementation problems and issues arising from legal challenges to the 1991 rule. The revisions also streamlined and reduced the monitoring and reporting burden. In 2004, EPA published minor corrections to the LCR to reinstate text that was inadvertently dropped from the rule during previous revisions.

2007 LCR Short-Term Regulatory Revisions

In 2007 EPA finalized Short-Term Revisions to the rule that included targeted regulatory changes to strengthen the implementation of the LCR in the following areas: monitoring, treatment processes, public education, customer awareness, and lead service line replacement. This rule revision became effective on 10 December 2007.

The 2007 rule requires water systems to provide advanced notification and gain the approval of the primacy agency for intended changes in treatment or source water that could increase corrosion of lead. The primacy agency must approve the planned changes.

LCR Sampling Requirements

Lead and copper samples are to be first-draw and collected from consumers' kitchen or bathroom cold water tap following a six-hour period in which the tap had not been used. The 90th percentile values of the data collected are calculated for both lead and copper for compliance purposes. Table 1 presents the standard and reduced sampling requirements for the City of Longview, which is classified as a medium sized system, serving between 3,300 and 50,000 people. For the first year of operation of the new MFRWTP, DOH is requesting standard monitoring. Following the first two six-month sampling events, if the 90th percentile is greater than 0.005 mg/L for lead, or 0.65 mg/L for copper, but both are less than the ALs, then 30 distribution samples would be required every six months. If, following the first two six-month sampling events, the 90th percentile results are less than 0.005 mg/L for lead and 0.65 mg/L for copper, then one set of 30 distribution samples is required every three years.

Table 1: LCR Sampling Requirements

Monitoring Type	Number of Samples	
	Lead/Copper	WQP
Standard	60 per 6 months	10 per 6 months
Reduced ¹	30 per 6 months	7 per 6 months
Reduced ²	30 per 3 years	none

Notes: ¹ If, 90th percentile copper is greater than 0.65 mg/L but less than the AL (1.3 mg/L) and 90th percentile lead is greater than 0.005 mg/L but less than the AL (0.05 mg/L)

² If 90th percentiles for copper and lead are less than 0.65 mg/L and 0.005 mg/L, respectively.

Systems on reduced monitoring must perform the sampling over four consecutive months during the calendar year (usually June, July, August, and September, when drinking water consumption is anticipated to be highest). The WQP include pH, alkalinity, calcium, orthophosphate (if a phosphate-based inhibitor is used), and silica (if a silica-based inhibitor is used). Conductivity and temperature are included in the initial monitoring and will be requested by DOH during the initial LCR sampling after the City has begun operating its new MFRWTP.

Ground Water Quality

The Longview MFRWTP raw ground water quality is presented in Table 2. These data were collected from the first production well (PW1) for the MFRWTP during well flushing in the fall of 2009 and in the spring of 2010 and from deep monitoring well No. 9 (DW9), which is adjacent to PW1, in the spring of 2010 during pilot-scale testing of greensand media. The water quality analyses were performed at a certified lab, with the exception of pH and temperature, which were measured on-site using calibrated probes. Water quality for the existing source of supply, the Cowlitz River, provided by the City, is also presented in Table 2.

Table 2: Raw Ground Water Quality

Parameter	Average Raw Ground Water Quality	Raw Cowlitz River Water Quality
pH	7.2	6.2 to 7.9
Alkalinity (mg/L as CaCO ₃)	110	18 to 34
Temperature (°C)	12	5 to 19
Total Hardness (mg/L as CaCO ₃)	90	NA ¹
Calcium (mg/L as CaCO ₃)	66	8 to 20
Dissolved Inorganic Carbon (mg/L)	254	40 to 60
Total Dissolved Solids (mg/L)	160	30 to 85
Conductivity (µMhos/cm)	280	50 to 150
Total Silica (mg/L)	51.5	23.9
Fluoride (mg/L)	< 0.2	< 0.2
Chloride (mg/L)	6.0	3.0 to 6.0
Sulfate (mg/L)	0.6	4.0 to 8.0
Phosphate (mg/L)	0.4	< 0.05

Notes: ¹ NA = not available.

Water Quality Calculations

Table 3 presents the indices used to assess the corrosivity of the ground water source of supply. No one index can adequately describe a water, so a range of indices are used to make judgments concerning the stability of the water and the likelihood of different types of corrosion.

Table 3: Water Quality Indices

Index	Desirable Range	Remarks
Langelier Index (12°C)	-0.5 to 0.5	Indicates tendency to either deposit (if positive) or dissolve (if negative) calcium carbonate scale
Langelier Index (60°C)	-0.5 to 0.5	Indicates tendency to scale hot water heaters
Calcium Carbonate Precipitation Potential (mg/L)	4 to 10	Slight scaling tendency is preferred
Aggressiveness Index	≥ 12	Identifies tendency for concrete and asbestos cement pipe corrosion, < 10 is highly aggressive, 10 to 11.9 is moderately aggressive
Ryznar Index	6 to 8	Indicates tendency for corrosion of steel
Alkalinity/(Cl ⁻ + SO ₄ ²⁻)	> 5.0	Suggests tendency for corrosion of mild steel
Larson's Ratio	< 0.3	Suggests tendency for corrosion of mild steel
Chloride/Hardness	< 0.5	Indicates tendency for brass dezincification

Table 4 presents the calculated values for the selected indices for the raw ground water without the addition of any corrosion control chemicals.

Table 4: Calculated Water Quality Indices for Raw Ground Water

Index	Calculated Values for Raw Ground Water
Langelier Index (12°C)	-0.8
Langelier Index (60°C)	-0.15
Calcium Carbonate Precipitation Potential (mg/L)	-24
Aggressiveness Index	11.06
Ryznar Index	8.8
Alkalinity/(Cl ⁻ + SO ₄ ²⁻)	16.7
Larson's Ratio	0.1
Chloride/Hardness	0.07

The Rothberg, Tamburini & Winsor (RTW) Model 4.0 is a spreadsheet-based tool designed to help users evaluate the effects of chemical addition on the stability of water and to predict changes in water quality parameters, such as pH and calcium carbonate precipitation potential. The RTW Model 4.0 is often used by water engineers to develop corrosion control strategies, optimize coagulation, determine pH impacts on precipitation of metals, and to evaluate chemical dosage options and their economics. The RTW Model 4.0 was run to assess corrosion control techniques to produce a stable finished water that would not promote corrosion in the distribution system or in household plumbing and also maintain compliance with the LCR. The ground water contains adequate alkalinity which will tend to buffer the pH and limit changes in pH as the water passes through the distribution system. pH adjustment would be beneficial to increase the Langelier Index and the calcium carbonate precipitation potential and make the water less aggressive. Alternative pH adjustment chemicals include sodium hydroxide, lime, sodium carbonate, and sodium bicarbonate. Sodium hydroxide was selected because it can be purchased as a liquid, and chemical feed systems to add it to the ground water are well known and widely available. The other alternative chemicals are typically delivered in solid form requiring additional handling and specialized equipment and were, therefore, not considered further.

In general, copper corrosion tends to be the major corrosion concern for Washington ground waters; whereas, surface water systems tend to have both lead and copper corrosion problems. Many ground water utilities in Washington have found that adjusting the pH to 7.5 or slightly greater provides adequate corrosion control. For the City of Longview, a target pH of 7.6 was selected in order to match the average existing condition in the distribution system.

Liquid sodium hydroxide was evaluated using the RTW Model 4.0. A dose of 8 mg/L was found to achieve the target pH of 7.6 and resulted in a more stable water with respect to calcium carbonate and better matched the existing water in the distribution system. The anticipated

finished water quality using sodium hydroxide to adjust the finished water pH, is presented in Table 5. The existing finished surface water quality is presented for comparison purposes. Typical values for the existing fall/winter and also the spring/summer are provided to illustrate the seasonal variability in the existing treated surface water.

Table 5: Finished Water Quality Comparison

Parameter	Estimated MFRWTP Finished Water¹	Existing RWTP Finished Water (Fall/Winter)	Existing RWTP Finished Water (Spring/Summer)
pH	7.6	7.6	7.6
Alkalinity (mg/L as CaCO ₃)	120	24	24
Temperature (°C)	12	6	15
Total Hardness (mg/L as CaCO ₃)	90	NA	NA
Calcium (mg/L as CaCO ₃)	66	32	32
Dissolved Inorganic Carbon (mg/L)	254	51	51
Total Dissolved Solids (mg/L)	160	110	110
Conductivity (µMhos/cm)	280	160	160
Total Silica (mg/L)	51.5	NA	NA
Fluoride (mg/L)	1.0	~1	~1
Chloride (mg/L)	6.0	5.4	8.2
Sulfate (mg/L)	0.6	14.9	20.1
Phosphate (mg/L)	0.4	NA	NA

Notes: ¹ Estimated New MFRWTP finished water quality reflects following chemical dosages: 3 mg/L hypochlorite, 0.8 mg/L hydrofluosilicic acid, 8 mg/L caustic soda.

The RTW Model 4.0 results for several calculated indices are presented in Table 6. The calculated values for the City's existing finished water are presented for comparison purposes.

Table 6: Calculated Corrosivity/Scaling Indices

Index	Desired Range	Estimated MFRWTP Finished Water	Existing RWTP Finished Water (Fall/Winter)	Existing RWTP Finished Water (Spring/Summer)
Langelier Index (12°C)	-0.5 to 0.5	-0.32	-1.5	-1.3
Langelier Index (60°C)	-0.5 to 0.5	0.61	-0.7	-0.7
Calcium Carbonate	4 to 10	-6.3	-5.07	-4.4
Precipitation Potential (mg/L)				
Aggressiveness Index	≥ 12	11.5	10.5	10.5
Ryznar Index	6 to 8	8.3	10.5*	10.2*
Alkalinity/(Cl ⁻ + SO ₄ ²⁻)	> 5.0	18.2	1.2*	0.8*
Larson's Ratio	< 0.3	0.1	1.6*	2.2*
Chloride/Hardness	< 0.5	0.07	0.17**	0.26**

Notes: * Suggests high tendency for steel corrosion

** Calculated using calcium hardness

The following findings are based upon an analysis of the calculated index values:

- Sodium hydroxide addition is anticipated to result in a water quality within the preferred range for most of the calculated water quality indices. One exception is the calcium carbonate precipitation potential which is lower than preferred. This is not expected to be problematic because it remains in a similar range as the existing water in the distribution system and an existing calcium carbonate scale is not anticipated.
- The anticipated finished water quality for the new MFRWTP is less aggressive with respect to calcium carbonate scale than the existing finished water.
- The finished water from the new MFRWTP is not expected to cause excessive scale formation in hot water heaters.
- The finished water from the new MFRWTP is less aggressive to concrete and asbestos cement pipe compared to the existing finished water.
- The finished water from the new MFRWTP exhibits much less tendency for steel corrosion and dezincification of brass compared to the existing finished water.

Conclusions and Recommendations for Corrosion Control Strategy

Based upon the water quality data analysis and the calculated indices, pH adjustment is recommended to reduce the corrosivity of the ground water and to better match the existing

water quality in the distribution system. An initial target finished water pH of 7.6 is recommended. The extent of existing corrosion and scale development will be validated by qualitatively examining available pipe coupons from the distribution system.

Sodium hydroxide has been selected as the pH adjustment chemical and is sufficient as the sole corrosion control chemical. The new MFRWTP includes facilities to feed liquid sodium hydroxide, delivered as a 25% bulk solution. The sodium hydroxide feed pumps are designed to deliver up to 1266 pounds per day of sodium hydroxide.

The new MFRWTP will be operated at a range of flow rates. To illustrate the capacity of the sodium hydroxide feed system, Table 7 presents the range of potential dosages for the maximum day demand (MDD) at plant start up near the end of 2012 (10 mgd) and the anticipated MDD 20 years after start up (15 mgd). The minimum design dose is 3.5 mg/L.

Table 7: Design Sodium Hydroxide Dose Ranges

Plant Production Scenario	Design Caustic Dose Range
10 mgd (approximate 2012 MDD)	3.5 to 15 mg/L
15 mgd (approximate 2032 MDD)	3.5 to 10 mg/L