Safe Drinking Water Program Corrosion Control Treatment Matrix (Adapted from Colorado Water Quality Division and Edited by Arizona Department of Environmental Quality)

Background

The Lead and Copper Rule Revisions (LCRR) requires community and non-transient non community public water systems to meet with the State[1] at a minimum 6 months before a public water system plans to implement a source water change and/or treatment change and to obtain approval of the new source or treatment change prior to its implementation. As referenced in 40 CFR 141.80 (d)(4):

"Any water system shall notify the State in writing pursuant to 141.90 (a)(3) of any upcoming long-term change(s) in treatment and/or the addition of a new source as described in 141.90 (a)(3). The State must review and approve the addition of a new source or long-term change in water treatment before it is implemented by the water system. The State may require any such water system to conduct additional monitoring or to take other action the State deems appropriate to ensure that such water system maintains minimal levels of corrosion control in its distribution system".

Additions and changes to drinking water sources and treatment may have the potential to change control of corrosion within the distribution system. Due to the potential changes, ADEQ may require the public water system to perform additional evaluations, based on the scope of source water or treatment changes. Additionally, ADEQ may require: corrosion modeling, corrosion testing, treatment to address corrosivity, standard lead and copper tap monitoring after the source/treatment change takes place, and/or additional information during the approval to construct process.

As a result of these changes, ADEQ has developed this guidance to assist public water systems in identifying any actions required for the system to complete prior to submitting the Approval to Construct (ATC) application.

Corrosion Classification framework

[1] Section R-18-111 (40 CFR 141, Subpart I by reference) requires the Arizona Department of Environmental Quality (ADEQ) or delegated county (e.g. Maricopa County Environmental Services or Pima Department of Environmental Quality) to review drinking water source and/or treatment changes, at a minimum 6 months before a public water system plans to implement those changes. The Lead and Copper Rule Revisions (LCRR) requires the public water system to obtain approval of the new source or treatment change prior to its implementation.

The '*Corrosion Control Treatment Matrix'* framework assists the public water system in determining the correct actions and approaches to specific source water or treatment changes. The Approval to Construct (ATC) submittal requirements and any required standard LCR monitoring (e.g., every 6 months at the standard number of sampling sites) will depend on the potential corrosivity impacts or risks of the proposed project. The Department has developed a four Class framework which is outlined in Table 1.1 below. The Department may require additional submittal items based on the specific circumstances of the project.

Impacts to Corrosivity Classification and Required Actions (Arizona Administrative Code R18-4-111)
Table 1.1: Corrosivity categories and required actions[2]

Project Classification	Required actions
Class 1 – No impacts to corrosivity or improved corrosion impacts	Description: The source/treatment project is not expected to have any impact on corrosivity or will have improved corrosivity impacts; however, the public water system must consider any unintended changes to pH, alkalinity, and other water quality parameters (WQPs) that may affect corrosion. ATC submittal requirements: No additional information is required with the ATC submittal. Standard Tap monitoring: No changes to LCR monitoring after implementation of source water or treatment change.
Class 2 – Possible impact to corrosivity	Description: The source water/treatment changes project may have a possible impact on corrosivity but the risk is expected to be minimal. ATC submittal requirements: No additional information required in the ATC submittal. Standard Tap Monitoring: The public water system will return to standard LCR monitoring (six month monitoring) for at least a year after the source/treatment change to demonstrate no significant corrosion impacts. At the discretion of the Department, a desktop study may be required to be completed prior to implementing the source water or treatment change(s).

[2] Including but not limited to items listed; and PWSs to meet with regulatory agency at a minimum of 6 months before anticipated changes, or ATC submittal

Class 3 – Probable impact to corrosivity	Description: The source water/treatment changes project has a probable impact on corrosivity and additional evaluation is required during the design phase. The Department may require a mitigation plan if corrosivity is expected to be adversely impacted. ATC submittal requirements: The ATC submittal must include an evaluation of the project's impact on corrosivity. The ATC submittal must summarize anticipated changes to water chemistry as a result of the project (e.g., pH, alkalinity, chloride to sulfate mass ratio, dissolved inorganic carbon, etc.) and describe the anticipated effect on corrosivity based on the results of the evaluation.

	Anticipated corrosivity effects[3] may be performed by a desktop evaluation, comparison of water quality from similar water systems, pilot study results, or other supporting information necessary to predict anticipated water quality changes to corrosivity. Requirements for desktop evaluations can be found in Appendix A. *Anticipated Results of Corrosivity Evaluation:* Public water systems must include, in the ATC submittal, a plan to control for corrosion if the corrosivity evaluation indicates that corrosion control is expected to be adversely impacted. The corrosion control plan must describe how the supplier will control corrosion and provide information outlined in Appendix A. For example: If a public water system submits for a project to install reverse osmosis treatment the public water system would discuss the anticipated impact to corrosivity and any modeling results as the RO permeate will likely be corrosive due to low TDS concentrations. The ATC submittal will then include a mitigation plan that describes the blending ratio, chemical addition, and/or other approach that will be used to minimize corrosion. Standard Tap monitoring: The public water system will resume standard LCR monitoring for a minimum of two years after the source/treatment change in order to demonstrate no significant corrosion impacts.

[3] Anticipated corrosivity changes may be at the discretion of the regulatory department

Class 4 – Adding or adjusting Optimal Corrosion Control Treatment (OCCT) AAC **R18-4-111**	Class 4 applies to public water systems implementing corrosion control treatment in response to an action level exceedance (ALE), population growth, or making modifications to an existing OCCT. At the discretion of the Department, a desktop study may be accepted in lieu of a corrosion control study. <u>Submittal requirements</u>: 1. Public water systems with a population less than or equal to 50,000 population typically must submit an OCCT recommendation in accordance with AAC R18-4-111 and USEPA Guidance Manual (2019). 2. Public water systems with a population over 50,000 or smaller water systems that have been required by the Department must submit a corrosion control study in accordance with AAC R18-4-111 (a.k.a. the Lead and Copper Rule). ● These submittals are typically done as part of the Optimal Corrosion Control Treatment (OCCT) evaluation designation step and not necessarily during the ATC submittal. <u>Standard LCR monitoring</u>: The public water system will resume standard LCR monitoring as required under AAC **R18-4-111** for water systems going through the OCCT steps.

Default project categories:

The default corrosivity Class for various projects are summarized in Table 1.2 below. If a project type is not included in Table 1.2, please contact the Department to discuss which Class would be appropriate for your water system's project. When an overall project includes multiple sub-projects then the highest corrosivity Class applies (i.e., an overall project adding RO (Class 3) and a replacement groundwater source (Class 1) will be considered a Class 3 project. The project Class applies to each source or treatment plant and not the overall water system (e.g., switching primary coagulant which impacts chloride to sulfate mass ratio (Class 3) is considered a Class 3 project even if that same coagulant is already used at other supplier's treatment facilities).

Table 1.2 outlines the default Class; submittals may demonstrate that a lower Class is appropriate by providing additional information. The Department will review these submittals on a case by case basis to determine if a lower Class is appropriate.

- *Demonstration immersion coupon corrosion evaluation:* Results from a demonstration corrosion control study (CCS) may be used for Class 2 and 3 projects to justify a project qualifies as a Class 1. Minimum CCS requirements are outlined below. Results must anticipate minimal or negligible adverse corrosion impacts to justify as a Class 1.
- *Water quality comparison:* Projects that do not impact water quality may submit a comparison for the Department's review to justify a Class 1. See Examples below:
    - Project Example A: A new groundwater well in the same aquifer as other sources in the supplier's portfolio (default Class 2), may submit additional water quality data to demonstrate that the new source is substantially similar to the other sources.
    - Project Example B: A project changing from conventional filtration to microfiltration (default Class 2) may provide a water quality comparison of pilot project membrane filtrate and existing filter effluent to justify that no change in corrosivity is anticipated.

Table 1.2: Classification by Project Type

Project Type		**Default** Class
New Public Water Systems or new treatment plants with sources		
	Replacement treatment plant with same source and treatment processes	Class 1
	Groundwater system/treatment plant with chlorination only	Class 3
	Surface water or GWUDI system/treatment with chlorination and filtration process without coagulant addition (e.g., bag filtration)	Class 3
	Surface water or GWUDI system/treatment with chlorination and filtration process with coagulant addition (e.g., direct, conventional or membrane with coagulant)	Class 3
	Direct Potable Reuse system/treatment	Class 3

Source Projects assuming chlorination treatment		
	Replacement/Redrilled GW source	Class 1
	Relocating a surface water source within the same segment (similar water quality excluding GWUDI)	Class 1
	Addition of copper sulfate in the source water	Class 1
	New emergency GW or SW/GWUDI source	Class 1
	New aquifer storage and recovery source water	Class 2
	New GW source, not emergency or replacement	Class 2
	New SW/GWUDI source, not emergency	Class 2
	New purchased water source	Class 2
	Switching from water supplier with treatment to fully purchasing water from other public water supplier (e.g., becoming a consecutive system)	Class 3
Treatment Projects – Chemical addition		
	Addition/removal of powder activated carbon	Class 1
	Relocation of existing approved chemical (e.g. Permanganate, Chlorine or ClO2)	Class 1
	Changes of primary coagulant with the same chemical formula (e.g. two different brands of PACl or Alum)	Class 1
	Addition/removal of coagulant aid, floc aid, or filter aid (polymers)	Class 1
	Addition/removal to fluoridation	Class 1
	Switching primary coagulant that will not impact chloride to sulfate mass ratio	Class 2
	Addition/removal of oxidant (chlorine dioxide, permanganate, etc.)	Class 2
	Advanced oxidation processes (O3/UV, O_3/H2O2, UV/H_2O_2, UV/TiO2)	Class 2
	Switching from gas chlorine to sodium hypochlorite or from sodium hypochlorite to chlorine gas	Class 2

	Switching primary disinfectant (e.g., from free chlorine residual to total chlorine residual, from chlorine to ozone)	Class 3
	Pre-sedimentation basin/flow equalization with chemical additional	Class 3
	Switching primary coagulant that will impact chloride to sulfate mass ratio (e.g. Ferric sulfate to ferric chloride)	Class 3
	Switching from ammonium hydroxide (aqua ammonia) to liquid ammonium sulfate or liquid ammonium sulfate to ammonium hydroxide (aqua ammonia)	Class 3
	Addition/removal of polyphosphate	Class 3
	Biological Denitrification	Class 3
	Addition/removal of chemical softening	Class 3
	Addition/removal of orthophosphate or blended phosphate for purpose of stabilization (not optimal corrosion control treatment)	Class 3
	Addition/removal of pH and/or alkalinity adjustment (e.g., soda ash, caustic soda) for purpose of stabilization (not optimal corrosion control treatment)	Class 3
	Addition/removal of orthophosphate or blended phosphate as optimal corrosion control treatment	Class 4

	Additions/removal of pH and/or alkalinity adjustment (e.g., soda ash, caustic soda) as optimal corrosion control treatment	Class 4
Treatment Projects – Filtration		
	Physical modifications to flocculation or sedimentation	Class 1
	Screening	Class 1
	Addition/removal of granular activated carbon	Class 1
	Pre-sedimentation/flow equalization without chemical addition	Class 1
	Changes/modifications to filtration within the same family of filters (e.g. conventional media change out, microfiltration module replacement)	Class 1
	Biofiltration	Class 1
	Sediment removal for groundwater (no coagulant added)	Class 1
	Existing GW system reclassification to GWUDI – only adding bag or cartridge or micro (ultra) filtration with no coagulant addition	Class 1
	Changes/modifications to filtration between different families of filters (e.g. from conventional to microfiltration). See chemical above for potential impact of coagulation.	Class 1
	Existing GW system reclassification to GWUDI – adding filtration process with coagulant addition (e.g., direct, conventional or membrane with coagulant)	Class 2
	Oxidation media for iron and manganese removal	Class 2
	Clarification processes with coagulation/flocculation	Class 3
	Addition/removal of RO or nanofiltration	Class 3
Other Treatment Projects		
	Disinfection with UV	Class 1
	Addition/removal of iron and manganese treatment except oxidation and phosphate addition	Class 2
	Aeration including DAF	Class 2
	Ion Exchange	Class 3

	Distillation	Class 3
	Other Inorganics Removal (e.g. activated alumina)	Class 3
	Air stripper (not optimal corrosion control treatment)	Class 3
	Air stripper if goal is corrosion control OCCT	Class 4
Distribution system projects		
	Storage tanks - Physical changes to storage tanks, addition of distribution system storage tanks	Class 1
	Booster chlorination treatment	Class 1
	Distribution system aeration	Class 2
	Distribution tank mixing systems*	Class 2

* Note: Passive tank mixing systems without aeration (e.g., spray above water level, diffusers, bubblers) may be considered Class 1.

Appendix A:

Desktop Corrosion Evaluation Requirements (source and treatment changes):

Desktop evaluations must include an evaluation of existing water quality and the modeling of water quality as it relates to the new source water or treatment change's potential corrosion impacts. The desktop evaluation must evaluate the following water quality parameters at or representative at the entry point. Public water systems must also take into consideration seasonal changes, water quality source changes, blending, etc. as part of the evaluation:

- pH
- Temperature
- Alkalinity
- Calcium
- Chloride
- Sulfate
- Ammonia
- Conductivity
- Total Dissolved Solids (TDS)
- Hardness
- Iron
- Manganese
- Dissolved Oxygen
- Total Organic Carbon
- Total and Free Chlorine Residual
- Corrosion Control Inhibitors (Orthophosphate, Silica)
    - Ortho Phosphate, if orthophosphate or blended inhibitor used[4]
    - Total Phosphate, if blended inhibitor used
    - Silicate, if silicate used

The report must anticipate minimal or negligible adverse corrosion impacts from the project or if adverse impacts identified then a mitigation strategy, discuss water quality sampling and modeling methods, summary of all water quality parameter monitoring and modeling results, and all testing data.

Demonstration Corrosion Study Requirement(s):

Public water systems, not designated by the state to conduct a demonstration study, may elect to do a demonstration corrosion evaluation (CCS). Demonstration studies may utilize a predictive model to determine corrosion impacts of a source or treatment change. Additionally, demonstration evaluations should follow the EPA's Guidance Manual (1992) using flow through testing using either coupons or pipe loops, or static testing method. PWSs may elect to do a demonstration testing such as using immersion coupon corrosion evaluation as a predictive model of corrosion impacts of a source or treatment change. The testing determines corrosion related changes due to source water changes and/or treatment changes

[4] Evaluating for orthophosphate is referenced in Appendix A

but does not determine optimal treatment to reduce corrosion related impacts. A PWS will submit a detailed testing protocol to the Division prior to testing for approval. Upon approval, the PWS serving 50,000 persons will conduct the testing and submit a report with any corrosion control treatment recommendations, if necessary, as part of a report. PWSs serving less than submit form appendix D and E from OCCT Guidance Manual and submit to Regulatory Agency to determine if the information is complete or additional information is required. Otherwise, a report with data and recommendations can be submitted to regulatory agency.

Alternatively, in discussions with the Division, EPA Guidance Manual (2003) may be used to develop a corrosion control strategy. ADEQ recommends referencing additional material such as the American Water Works Association (AWWA) M58 "Internal Corrosion Control in Water Distribution Systems, Second Edition". As well as the EPA's "Optimal Corrosion Control Treatment Evaluation Technical Guidance, 2019".
If the test results indicate that the current conditions and proposed conditions have similar corrosion impacts then the project will be categorized as Class 1 and no standard monitoring will be required after project completion.

The general Department requirements for a corrosion control study are summarized below:

- Pipe loops - Lead service line systems (may be informed by immersion coupons) Source water:
    - If the supplier has multiple sources (e.g., groundwater, surface water, etc.) then the evaluation must include multiple scenarios that reflect each source water. Each individual source water does not necessarily need to be tested but the test plan must address all sources (e.g., a single GW source may be representative of a well field).
- Treatment scenarios:
    - Control - baseline conditions
    - Proposed conditions (e.g., new source, new treatment)
- Duration:
    - Tests must be of sufficient duration for coupons or pipes to stabilize. The test duration must be a minimum of 6 weeks of testing conditions however longer may be necessary if results have not stabilized.
    - The Department recommends a pre-soak of at least 6-weeks with control condition water prior to test conditions.
- Materials:
    - Materials tested must reflect materials present in the distribution system. At a minimum, copper with lead solder must be tested. If lead service lines are present, then lead coupons must be included.
    - For immersion coupons, new materials are acceptable. For lead pipe loop studies, harvested materials are required.
- Water change outs / soak period:
    - Water must be changed out to model customer usage (i.e., a 12 week soak period is not acceptable). At a minimum, water must be changed out two times per week.
- Water quality testing:
    - Lead and copper results must be sent to an Arizona Department of Health Services (ADHS) certified environmental laboratory.
    - pH results must be tested onsite with calibrated instrument
    - Alkalinity and inhibitor residual may be tested onsite or sent to a laboratory. If tested on-site then alkalinity and inhibitor residual testing should be performed by a 40 CFR 136 approved method

Corrosion Control Plan Recommended Elements (Applicable to PWSs serving greater than 3,300 persons)[5]:

1. Introduction and System Description
2. Identification of Internal Corrosion Problems and Sources of Contaminants
3. Assessment of Significance of Contaminants and Sources
4. Identification of Alternative Corrosion Control Measures and Their Impacts
5. Identification of Preferred Measure for Corrosion Control
6. Monitoring Corrosion Control Effectiveness
7. Corrosion Control Plan Implementation

Appendices

1. Material Survey
2. Lead Service Line Information
3. Supporting Solubility Diagram Evaluations
4. Supporting Treatment Flow Chart Evaluation

List of Tables

1. Water Quality Parameter Monitoring Data Summaries
2. Source Summary Table

List of Figures

1. Treatment Facility Schematic
2. Distribution System Map - materials/ages of water mains
3. Distribution System Map - lead service line locations (if applicable)
4. Distribution System Map - areas served by each treatment plant/supply
5. Implementation Plan Schedule Schematic
6. Appropriate Schematics for preferred corrosion control measure (as needed)

Additional information that may be requested from ADEQ:

- Target water quality data ranges (e.g. pH, alkalinity, phosphate concentration)
- Explanation of selected corrosion control inhibitor:
    - Inhibitor concentration

Testing and Reporting Requirements for Orthophosphate

[5] MOE. 2009. Guidance Document for Preparing Corrosion Control Plans for Drinking Water Systems. Ontario Ministry of Environment. https://ia802301.us.archive.org/18/items/guidancedocument00snsn21738/guidancedocument00snsn21738.pdf.

- Reactive phosphate (PO_4): the sample is analyzed directly without digestion (refer to EPA – Lead and Copper Rule, Monitoring and Reporting Guidance for Public Water Systems, March 2010, Exhibit II-8). Total Phosphorus can be analyzed using EPA Method 365.3.
- Total phosphate (t-PO_4): This will give us the poly-portion of the chemical addition. To test for total phosphate the sample must be digested. Total phosphate includes p-PO_4 and o-PO_4. Total Phosphorus can be analyzed using EPA Method 365.3
- Reactive phosphate - total phosphate = polyphosphate portion.
    - Please note, measured reactive phosphate might increase with time. Utilities using a p-PO_4 or blend should measure both the p-PO_4 and o-PO_4 portions of the phosphate in the distribution system. Measuring both of these parameters will ensure adequate mass balance of your total and orthophosphate portions.
- Any PWS serving more than 50,000 persons using orthophosphate, must monitor at the point of entry of distribution system and at representative taps.
- Any PWS serving greater than 3,300 person and under 50,000 must monitor for orthophosphate only if tap water lead and/or copper exceed action levels

Public Water System's Previously Approved for Blended Phosphates (polyphosphate):

1) The public water system must provide information on the following items:
    a) Is there any PO_4 in the polyphosphate product used for corrosion control?
    b) What is the concentration of PO_4 in the polyphosphate product or reactive phosphate?
    c) The products polyphosphate concentration
    d) The products polyphosphate to orthophosphate ratio
    e) The products type of polyphosphate species
    f) What is the fed rate as either P or PO_4
        i) Fed rate as either P or PO_4
            (1) Example:
                (a) 1.2 mg/L of product fed
                (b) Utility purchased 36% orthophosphate reported as PO_4
                (c) 1.2 mg/L product X 0.36 orthophosphate concentration in the product
                (d) Or they feed .44 mg/L as PO4 which is the same as .15 mg/L as P
                    (i) Note: 3 times P is equal to P