TECHNICAL MEMORANDUM

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Subject: **Integration Assessment for North Davis Meadows Community**

1 – EXECUTIVE SUMMARY

Trussell Technologies, Inc. (Trussell) is working with West Yost Associates to assess the potential for water quality issues when switching the North Davis Meadows (NDM) community from groundwater with high levels of iron, aluminum, and nitrate to the City of Davis' water supply. The City of Davis' water is a blend of groundwater and treated surface water from the Woodland-Davis Clean Water Agency (WDCWA), which is softer and has lower levels of metals and dissolved salts. This new water is expected to be much higher quality compared to the NDM groundwater, but the change in water chemistry with a new source water has the potential to release accumulated contaminants from scale material lining the pipes of the distribution system. Under some circumstances DDW can require an integration study when new water is introduced into a system. Yolo County has been proactive in completing this study without a formal requirement by the Division of Drinking Water (DDW). While this study is not a guarantee that there will not be noticeable changes in water quality (e.g., colored water), the age of the NDM community and distribution system pipe materials suggest that problems are not expected.

Key findings from this assessment include the following:

- The probability of releasing metals from existing corrosion scale with the change in water supply is low. A key reason that noticeable release of metals is not expected is because the NDM community has mostly polyvinyl chloride (PVC) pipes with a low susceptibility for accumulation of scale material on the pipe walls.
- The presence of lead in the distribution system is expected to be minimal considering that the construction of the NDM community began in 1987,

after the federal government and California passed laws in 1986 severely restricting the use of lead in plumbing materials.

- The blend of treated surface water and groundwater supplied by the City of Davis is expected to have more seasonal variability than the NDM groundwater, although this new supply is softer and higher quality, with lower levels of metals and dissolved salts. In addition, the WDCWA provides corrosion control treatment for the softer surface water supply, which coats the pipes with orthophosphate to minimize the release of existing scale material. This treatment is expected to also be protective of the plumbing throughout the NDM community within days following the integration.
- In some cases, it can be beneficial to add orthophosphate and coat the water system pipes and consumer plumbing before making a change in water supply. Orthophosphate is a USEPA recommended corrosion inhibitor. However, the PVC pipes in the NDM community are not expected to accumulate the protective orthophosphate coating.
- Home water treatment devices (e.g., reverse osmosis, ion exchange) should have less of a burden after the water supply change.
- A water quality monitoring program will be implemented by the City of Davis to track the progress of the water system integration and identify any issues in a timely manner.
- Community members who observe any unusual water quality (e.g., cloudiness, color, particulates), are encouraged to notify the City of Davis.

This technical memorandum (TM) should be submitted to DDW for their review and approval prior to integration.

2 – INTRODUCTION

2.1 Project Background

Yolo County (County) is currently planning potable water improvements for the North Davis Meadows (NDM) community, including conversion of NDM's potable water supply from County groundwater wells to the City of Davis' existing water supply. These improvements will resolve ongoing maximum contaminant level (MCL) violations due to high concentrations of iron, aluminum, and nitrate in the County wells that serve NDM. The water supply from the City will be predominantly treated surface water with groundwater blended in as needed. This new water supply will therefore be different and generally of better quality than NDM's existing groundwater. It is expected the new water supply will be softer, and have lower concentrations of chloride, total dissolved solids (TDS), and alkalinity.

Some corrosion related issues can occur when changing the water chemistry with a new source water in an existing distribution system. These issues are primarily related to the potential release of metals from destabilization of scale accumulated on the inside surface of the pipes during previous service, which may lead to a decline in drinking water aesthetics and compliance concerns with the State and Federal Lead and Copper Rule (LCR). Since the Lead and Copper Rule Revisions (LCRR) were promulgated in 2021, any change in source water or drinking water treatment requires approval by the primacy agency (i.e., the State Water Resources Control Board Division of Drinking Water (DDW)).

When the NDM community switches from its current groundwater supply to the City's water supply, the City will absorb the NDM community into its service area and associated LCRR regulations for this larger system will apply. As such, the City requested an integration assessment as part of the water improvements project.

2.2 Objectives

The objective of this technical memorandum (TM) is to understand the potential for water quality issues when switching the NDM community from groundwater to the City's water supply, particularly corrosion related aesthetic and regulatory excursions. Assessment of corrosion potential will be based on the following considerations:

- Water quality reviews of the existing groundwater supply and the new water supply from the City;
- Assessment of the NDM community distribution system piping;
- Comparison of corrosion indices for the different water supplies; and
- An assessment of consumer plumbing based on regulations at the time of construction.

Following this assessment are recommendations for a "best practice" strategy for the NDM community and the City to minimize corrosion related issues in the NDM distribution system when the community switches to its new water source. It must be noted that this "best practice" strategy is based on a review of literature and the experiences of other utilities. No pilot- or bench-scale testing using harvested pipe from NDM's system was performed to evaluate corrosion control techniques to assess the potential for red water or other corrosion related effects. As such, the recommendations included in this TM are based on experience and best judgment, and are not a guarantee that red water and other corrosion related events will not occur.

Because the LCRR requires approval by the primacy agency prior to any change in source water, this TM should be submitted to DDW to aid in the approval process.

3 – WATER QUALITY CHANGES WITH CHANGING SOURCE WATERS

All metal piping in a distribution system that comes into contact with water is subject to corrosion. Most or all properly maintained distribution systems have some type of corrosion scale on the interior walls of the pipes (Rodriguez et al., 2001). Scale is a protective coating made up of deposits of carbonates with incorporated metals, radionuclides, and/or trace elements. The metallic components of this scale sometimes originate from corrosion of the local pipe surface (especially important with cast iron or galvanized pipe), from mobilization of metals by corrosion of pipe elsewhere in the system or from constituents in the water source, particularly iron, manganese, aluminum, or silica. With time these scales reach a metastable equilibrium with the water quality flowing through the distribution system. When the source water chemistry is changed, such as when switching water supplies, the scale inside the existing distribution system will go through a period of re-equilibration to this new water quality. Some corrosion related issues can occur during this transition to a new water source, including "red water" or "black water" associated with the release of iron and/or manganese from existing scale deposits.

Red water is characterized by a rust-colored or reddish tint to the water. Red water is often the result of direct exposure of water to ferrous (Fe(II)) materials in pipes made of galvanized iron, unlined steel, unlined cast iron (CI), ductile iron (DI), or older DI and CI pipe where the lining has failed. Although not a threat to public health, red water may lower consumer confidence and lead to customer complaints. Prevention of red water is contingent upon preventing the mobilization of legacy scale deposits within the distribution system and/or consumer-owned plumbing, maintaining stable water quality (e.g., pH and alkalinity), and reducing stagnation that can cause loss of chlorine residual and dissolved oxygen.

A similar phenomenon to red water is black water, which is characterized by a brownish-black color due to elevated levels of manganese. If a water source has high levels of manganese that are not removed during treatment, manganese may deposit on the pipe walls of the distribution system and be subject to displacement should the water quality suddenly change, potentially resulting in consumer complaints about aesthetics. Although manganese is an essential nutrient, elevated exposure to manganese well above DDW's notification level (NL) of 0.5 mg/L can present a neurotoxic risk with symptoms that include a decline in motor skills, difficulty balancing, and certain emotional disorders. Key objectives in the prevention of black water are protecting legacy scale deposits and minimizing rapid changes in water quality.

Other key corrosion related issues include lead and copper leaching from consumer plumbing, which are addressed in the LCR and, most recently, the LCRR as summarized in the following section.

The existing NDM water mains consist of 95.9% PVC pipe and 4.1% DI pipe by length, as is discussed further in Section 6.1. Although PVC is less susceptible than other pipe materials to releasing metals into the water or accumulating scale that may contain metals, DI pipe is at greater risk for these effects.

4 – SUMMARY OF THE LEAD AND COPPER RULE REVISION

In 1986, the U.S. Congress amended the Safe Drinking Water Act (SDWA) to prohibit the use of pipes, pipe fittings, and plumbing fixtures containing more than 8.0% lead and solder containing more than 0.2% lead. That same year, California enacted Proposition 65 which also led to more stringent limits on the leaching of lead from brass faucets. Later legislation eventually resulted in “lead free” faucets in California by the year 2000. These regulations greatly reduced the presence of lead in water systems, and by the early 1980s it was understood that the majority of the lead contributed by service lines and homes came from 50/50 lead/tin solder and lead service lines (LSLs) connecting water mains to the internal plumbing of a building.

To address these issues, the USEPA promulgated the Lead and Copper Rule (LCR) in 1991, establishing monitoring requirements at consumer taps as well as action levels (ALs) for lead and copper. While the original LCR minimized the installation of new lead pipes in water systems, lead pipes still exist in older systems and buildings. Accordingly, in 2021 the USEPA promulgated the first major update to the LCR in the rule’s history, with a focus on protecting children and communities where LSLs are still prevalent (USEPA, 2021). The revised rule is intended to increase testing and treatment for lead exposure in drinking water. The LCRR will officially be enforced beginning October 16, 2024, so it is prudent to comply with the new requirements as soon as possible.

4.1 Summary of Changes Associated with the LCRR

The LCRR retains many of the monitoring requirements and the ALs for lead and copper established under the 1991 LCR. The ALs for lead and copper remain unchanged at 15 µg/L and 1.3 mg/L, respectively, both based on the 90^{th} percentile monitoring values from select consumer taps. Like the previous rule, the LCRR requires that water systems practice corrosion control treatment (CCT), if needed, to mitigate corrosion in the distribution system and internal plumbing of buildings. Approved CCT options identified in the LCRR are alkalinity and pH adjustment and orthophosphate- or silicate-based corrosion inhibitors.

A detailed summary of the LCRR can be found in Appendix A. Key revisions in the 2021 LCRR include the following:

- **Tiered sampling site definitions:** changed to emphasize LSLs and use of consistent tap sampling sites to track changes over time.
- **Implications of 90^{th} percentile lead level:** the monitoring tiers have been updated to prioritize sampling from locations where LSLs have been identified. Implicated systems will need to update LCR monitoring sites. In

addition, there are changes to the required timing and notification of results where certain lead thresholds are observed.

- **Introduction of trigger level:** a trigger level (TL) of 10 µg/L was established for lead in addition to the existing AL of 15 µg/L.
- **Service line inventory:** the LCRR requires a service line inventory on both the utility and customer sides of the service line. Results of the inventory are used to identify sample sites and future service line replacement plans depending on the materials identified during the inventory.
- **Testing at schools and childcare facilities:** the LCRR requires that the water system complete lead testing at elementary schools and childcare facilities.
- **Public outreach:** requirements for public outreach have changed and include (1) updating the water quality consumer confidence report (CCR) and (2) providing customer notification depending on results from the service line inventory and water quality monitoring.

4.2 Monitoring Changes Under the LCRR

Once the City of Davis absorbs the NDM community into its drinking water system, NDM will be subject to the LCR monitoring requirements for the larger City system. According to the original LCR, systems on a reduced monitoring schedule must obtain prior approval from DDW before changing water sources but are not required to conduct additional monitoring. The LCRR modifies this rule by requiring *all* systems to obtain prior approval before changing water sources and to perform additional follow-up monitoring. This includes conducting a full round of LCR compliance monitoring every six months at the standard number of sites following the change until no AL exceedances for lead or copper are measured for two consecutive six-month monitoring periods. Once this condition is satisfied, LCR monitoring may be reduced as before.

The LCRR also introduces new requirements for tap sample collection, including new criteria for sample site selection. Tap samples must be collected from sites with LSLs, if available. For homes with LSLs, samplers must collect a fifth-liter sample following a minimum six-hour stagnation period. That is, samplers must draw four liters of water from the tap before collecting the test sample in order to collect a sample that is more representative of water that has been stagnant within the LSL for an extended period of time. In homes without LSLs, a first-liter sample will still be collected, as the fifth-liter sample rule does not apply. Samples must also be collected in wide-mouth bottles, and sampling instructions may not recommend cleaning or removing faucet aerators prior to sample collection.

5 WATER QUALITY ASSESSMENT

In order to evaluate the potential for scale destabilization and corrosion related issues for the NDM community, it is necessary to characterize and compare the water qualities of the historic and new water sources. An information request was submitted to the County and City on January 10, 2022, to obtain relevant historical water quality data for the NDM community and the City over a ten-year period. A follow-up information request was submitted on February 1, 2022, for additional data. Below is a comparison of the historic water quality received for both sources, including discussions on those parameters that might indicate the potential for destabilization of the existing scale or the contents of the scale should it be released upon integration of the two systems.

Data provided by the County and City included routine regulatory monitoring reports and annual consumer confidence reports. Additional data for the City wells was supplemented from other publicly available sources published by the City. Data was compiled spanning 2012 to 2021 for the following locations:

- NDM Community
    - NDM1 and NDM2 groundwater wells
    - Standby NDM groundwater well
    - Spanish Bay Place sample station (used for TCR compliance and general water quality monitoring)
    - LCR sample sites
- City of Davis
    - Woodland-Davis Clean Water Agency point of interconnection to the City
    - Active City groundwater wells expected to have the greatest influence on NDM water quality

5.1 Source Water Descriptions

5.1.1 NDM System

The current NDM community water supply is from two groundwater wells owned by the County and operated and maintained by the City. Well NDM1 is located on Fairway Drive and Well NDM2 is located on Blackhawk Place. A standby well is located just east of 24375 Fairway Drive. A 50,000 gallon storage tank is situated adjacent to Well NDM1. The existing NDM distribution system is shown in Figure 1. Groundwater from each in-service well is treated with sodium hypochlorite to maintain a detectable chlorine residual throughout the distribution system for disinfection. No other treatment is currently practiced at the NDM wells.

All three wells and the storage tank are to be demolished following integration with the City water system. Select water quality parameters are routinely analyzed at the three NDM wells as well as a sample station within the distribution system located on Spanish Bay Place.

5.1.2 City of Davis System

The City has a conjunctive use water system, meaning it relies on both surface water and groundwater sources, as depicted in Figure 2. The City receives a majority of its drinking water from the Woodland-Davis Clean Water Agency (WDCWA) regional surface water treatment plant (WTP), which began operation in mid-2016. The WTP treats surface water from the nearby Sacramento River and supplies treated drinking water for both the Cities of Davis and Woodland. The remainder of Davis' supply comes from City-owned groundwater wells. Five deep aquifer wells (namely Wells 31, 32, 33, and 34, with Well 30 maintained as a backup) supply the majority of the groundwater, which is generally only delivered to the distribution system during the summer months to meet peak demands. Four intermediate aquifer wells (Wells 23, 24, 26, and 27) are also available for use but are typically only operated to ensure they stay in working condition and to meet peak water demand.

The ratio of surface water to groundwater supplied to the system varies throughout the year based on demand and surface water availability. Figure 3 summarizes the annual average blend of treated surface water and groundwater in the City's municipal drinking water between 2017 and 2020. During this period, the City's water supply consisted on average of 82.5% surface water and 17.5% groundwater.

Following treatment at the WTP, the surface water is pumped into a transmission line and travels six miles before connecting to the City's distribution system at the point of interconnection (POI) in north central Davis. From the transmission line the water is dispersed throughout the distribution system via turnouts located in west, central, and south Davis. Depending on the well, groundwater from the City's wells is pumped directly into either the transmission line or the distribution system where it is blended with treated surface water. The four deep aquifer wells connect directly into the transmission line.

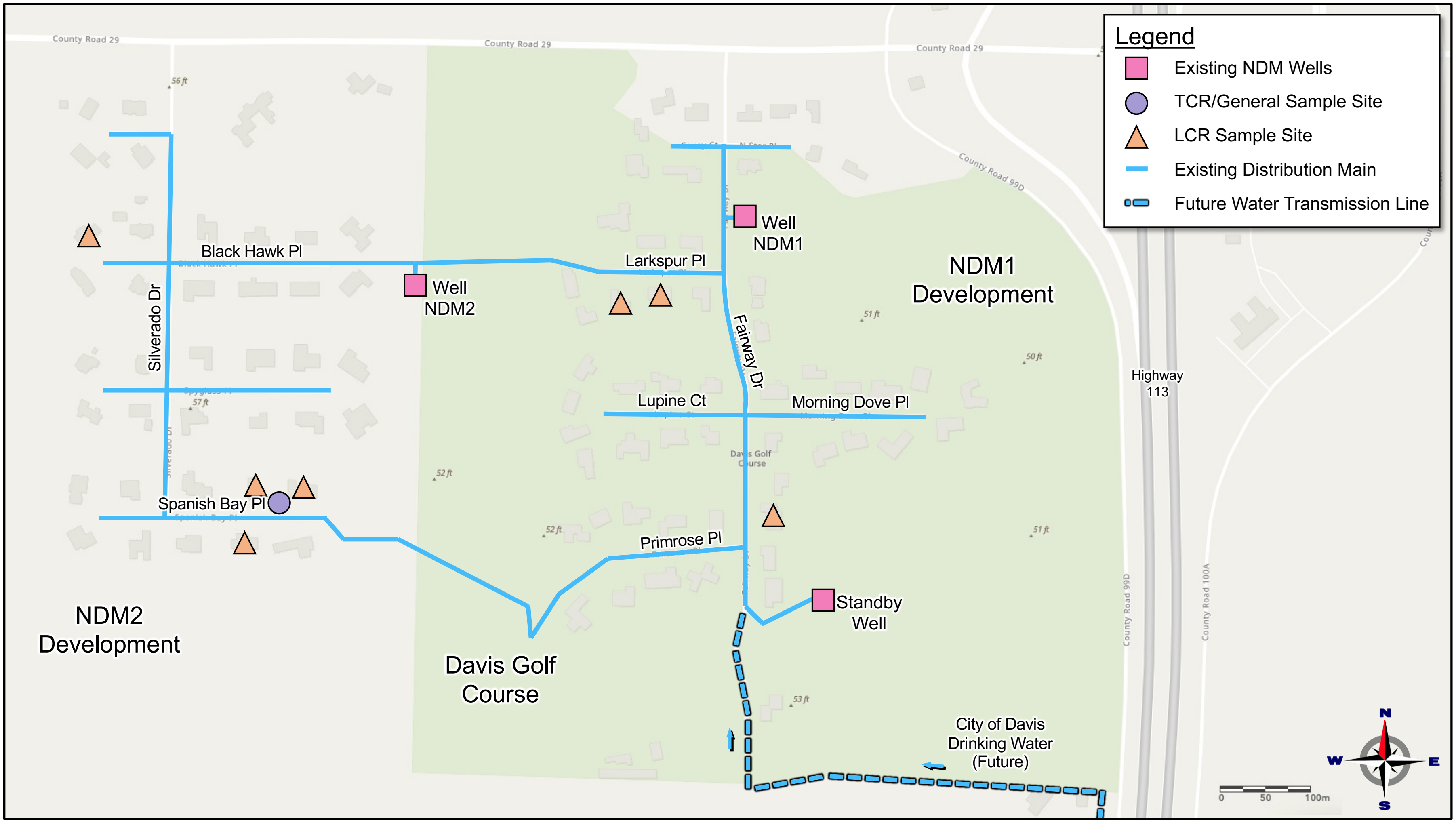

Figure 1. Existing NDM Drinking Water System and Sampling Sites

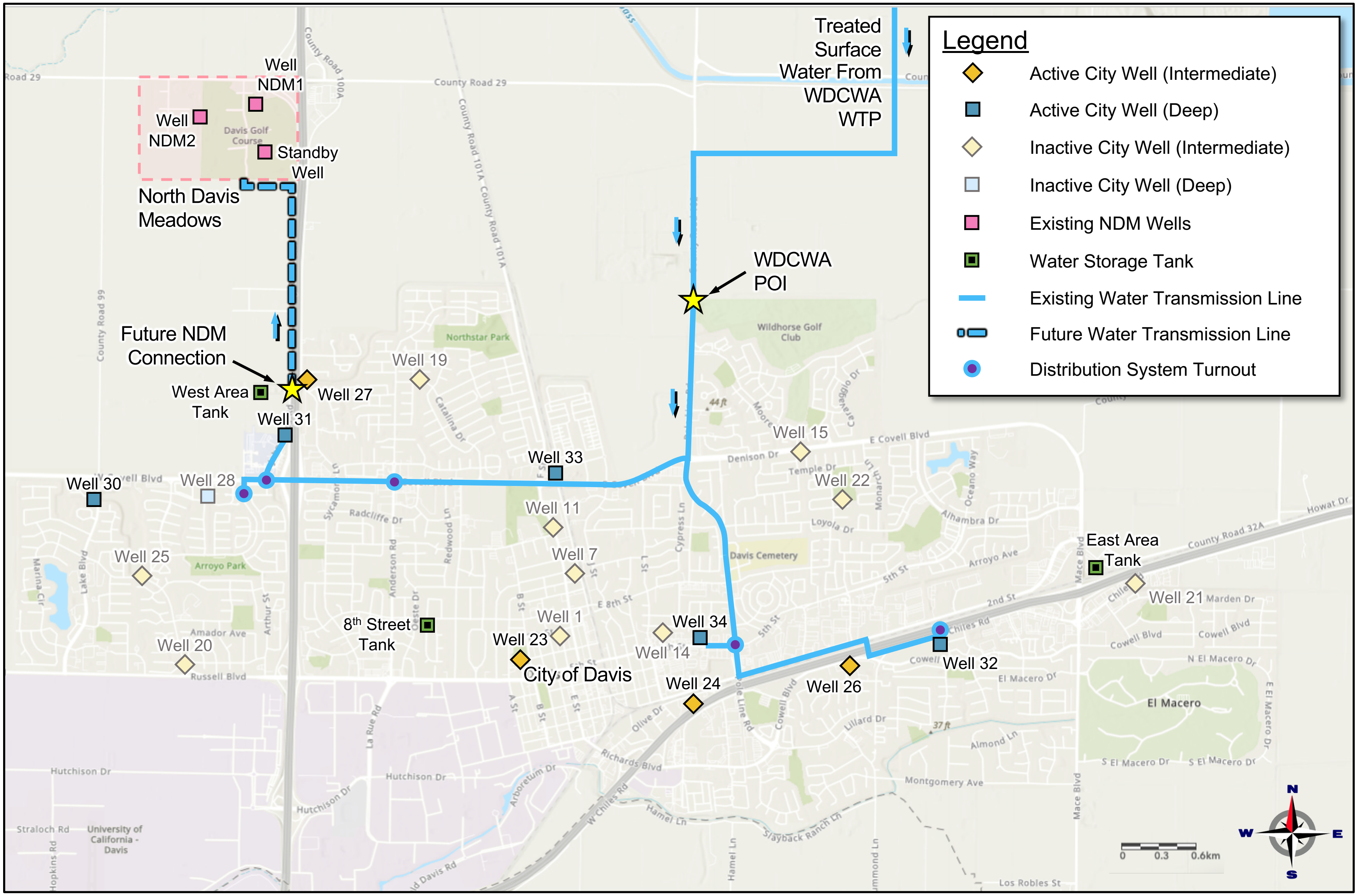

Figure 2. City of Davis Drinking Water System

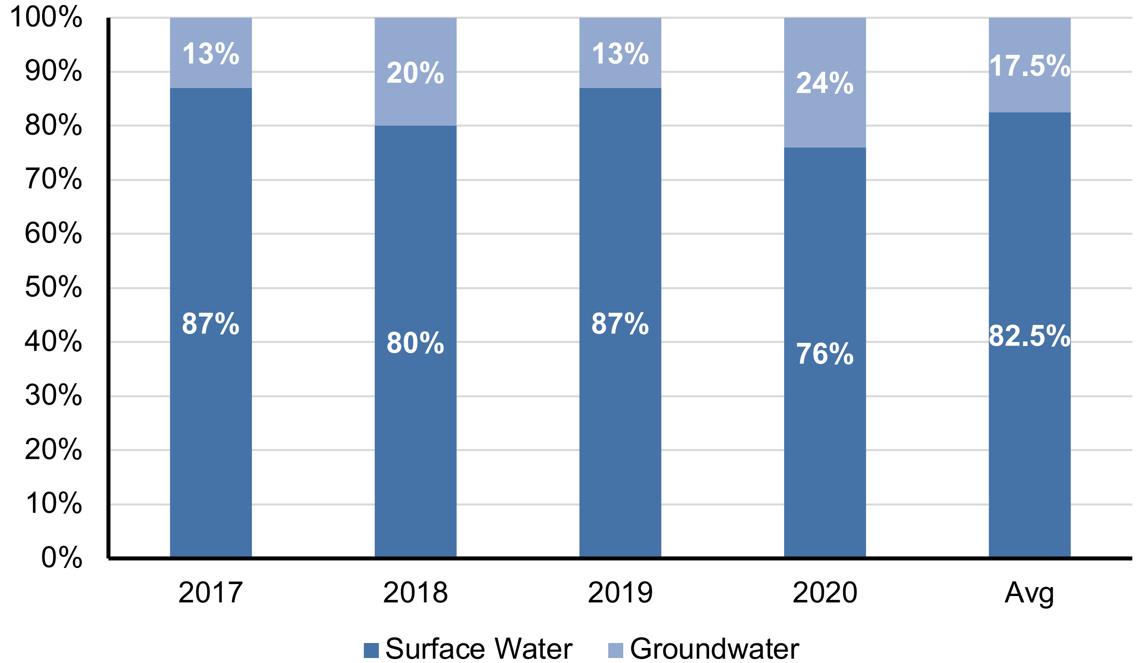

Figure 3. Historic Annual Average Blending Ratios for the City of Davis Drinking Water

5.2 Water Quality Assessment

Available water quality data for the NDM community were relatively limited, but reflect each of the wells and the distribution system LCR monitoring site (Spanish Bay Place). Water quality was also assessed for the City's primary source water, WDCWA treated surface water, as well as three of the City's active groundwater wells (Well 27, Well 31, and Well 33) selected to represent the wells that will likely have the greatest influence on NDM water quality post-integration because of their proximity to the future NDM connection and/or location on the main transmission line that will feed NDM. Using the available data, the water qualities of the NDM and City sources were compared for key water quality and corrosion related parameters as presented in Table 1.

As suggested previously, the City's drinking water quality is seasonally variable, as it relies on changing blends of surface water and groundwater throughout the year. The City's water quality is also highly dependent on the influence of individual groundwater wells. For example, intermediate Well 27 is characterized by higher alkalinity, calcium, chloride, conductivity, magnesium, sulfate, TDS, and hardness than deep Wells 31 and 33. This variable water quality will be a change for the NDM community, as their water quality has historically been more consistent using only groundwater. Despite the variability, the City's drinking water is generally higher quality than the existing NDM water. The City's water has lower alkalinity, hardness, chloride, conductivity, sulfate, and TDS than the current NDM water.

Table 1. Water Quality Comparison for Select Parameters at NDM Wells, NDM Distribution System, and City Water Sources. Median Values Shown with Range in Parentheses.

Parameter	Units	Regulatory List	MCL/ sMCL	NDM Existing System[1]				City System			
				Well NDM1	Well NDM2	NDM Standby Well	Spanish Bay Place	WDCWA Treated Surface Water[2]	Well 27[3]	Well 31[3]	Well 33[3]
Alkalinity	mg/L as $CaCO_3$	--	--	375 (360 - 390)	445 (420 - 470)	410 (400 - 420)	450	69 (25 - 111)	510	220	220
Calcium	mg/L	--	--	45 (38 - 52)	54 (53 - 54)	55	54	13 (6.3 - 18)	36	19	17
Chloride	mg/L	sMCL	250	66 (58 - 74)	68 (64 - 72)	76 (73 - 79)	--	--	49	34	23
Color	ACU	sMCL	15	<5	<5	<5	--	--	<3	<3	<3
Conductivity	µS/cm	sMCL	900	950 (890 - 980)	1100 (1000 - 1200)	1100 (1000 - 1100)	1200	--	1200	580	530
Iron	mg/L	sMCL	0.3	0.29 (<0.01 - 3.7)	<0.03	<0.03	--	<0.03 (<0.03 - 0.09)	<0.1	<0.1	<0.1
Magnesium	mg/L	--	--	62.5 (56 - 69)	76 (75 - 77)	74 (73 - 74)	--	--	91	22	8.5
Manganese	mg/L	sMCL	0.05	0.02 (<0.01 - 0.02)	<0.01	<0.01	--	<0.01 (0.01 - 0.18)	<0.02	<0.02	0.03
Odor	units	--	3	1	<1	<1	--	--	<1	<1	<1
Ortho-phosphate	mg/L	--	--	--	--	--	0.099	2.5 (1.9 - 2.6)	--	--	--
pH	--	--	--	8.1	8.1	8.1	7.8	8.1	7.9	8.2	8.4

Parameter	Units	Regulatory List	MCL/ sMCL	NDM Existing System[1]				City System			
				Well NDM1	Well NDM2	NDM Standby Well	Spanish Bay Place	WDCWA Treated Surface Water[2]	Well 27[3]	Well 31[3]	Well 33[3]
				(8 - 8.2)	(8 - 8.2)	(8 - 8.2)		(8.0 - 8.2)			
Sulfate	mg/L	sMCL	250	70 (64 - 76)	60 (58 - 61)	58 (57 - 58)	--	--	110	48	38
TDS	mg/L	sMCL	500	575 (510 - 640)	695 (670 - 720)	630	--	125 (66 - 190)	770	350	330
Temperature[4]	ºC	--	--	24.9	25.1	25.3	--	18.8 (10.0 - 26.7)	--	--	--
TOC	mg/L	--	--	--	--	--	--	0.94 (0.34 - 2.1)	--	--	--
Total Hardness	mg/L as $CaCO_3$	--	--	365 (320 - 410)	445 (440 - 450)	440	--	69 (25 - 111)	460	140	77
Aluminum	mg/L	sMCL	0.2	0.13 (<0.2 - 1.1)	--	--	--	<0.05	<0.05	<0.05	<0.05
LSI[5]	--	--	--	0.91	1.04	1.00	--	-0.33	0.63	0.36	0.52
CCPP[5]	mg/L as $CaCO_3$	--	--	41.59	58.69	53.54	--	-2.11	36.02	7.14	9.16

1. NDM water quality compiled from regulatory monitoring performed from 2012 through 2020.
2. WDCWA treated surface water quality compiled from monthly compliance reports prepared from 2016 through 2021. Water quality is monitored at the City of Davis finished water pump station/point of interconnection (POI).
3. City well water quality from City records for an August 2020 sampling event.
4. WDCWA temperature data shown for January 2021 through December 2021.
5. LSI and CCPP calculated using median values. In the absence of temperature data for the City wells, LSI and CCPP were calculated for the City wells assuming a temperature of 18.8 °C based on the median WDCWA treated surface water temperature.

Because the water quality in the City's distribution system varies significantly depending on (among other factors) time of year, proximity to groundwater wells, and well operations, various blending scenarios of treated surface water to City groundwater were evaluated using the source water quality (Table 1) to better characterize the potential range of water quality that NDM may receive following integration. These scenarios were then compared to the historic water quality observed at the NDM wells. A summary of this comparison for key parameters is given in Table 2. The three scenarios evaluated were:

- Scenario A: 100% of supply from WDCWA treated surface water
- Scenario B: 100% of supply from Well 27 groundwater
- Scenario C: 82.5% of supply from WDCWA treated surface water and 17.5% from City groundwater, which was the annual average breakdown for the City's supply from 2017 to 2020.

Table 2. Estimated Median and Worst-Case Future NDM Water Quality

Parameter	Units	Regulatory List	MCL/ sMCL	NDM Wells Historic Range[1]	Blending Scenarios[2]		
					A (100% SW)	B (100% GW)	C (82.5% SW 17.5% GW)
Alkalinity	mg/L as $CaCO_3$	--	--	360 - 470	69 (111)	220 (510)	95 (181)
Calcium	mg/L	--	--	38 - 55	13 (18)	19 (36)	14 (21)
Iron	mg/L	sMCL	0.3	<0.03 - 3.7	<0.03 (0.09)	<0.1 (<0.1)	0.04 (0.09)
Manganese	mg/L	sMCL	0.05	<0.01 - 0.02	<0.01 (0.18)	<0.02 (<0.02)	0.01 (0.15)
pH	--	--	--	8 - 8.2	8.1 (8.2)	8.2 (7.9)	8.0 (8.1)
TDS	mg/L	sMCL	500	510 - 720	125 (190)	350 (770)	164 (292)
Total Hardness	mg/L as $CaCO_3$	--	--	320 - 450	69 (111)	140 (460)	81 (172)

1. NDM water quality compiled from regulatory monitoring performed from 2012 through 2020.
2. Median blended values shown with maximum values in parentheses. Blended values calculated using median and maximum values measured in the WDCWA treated surface water (i.e., SW) and City groundwater (i.e., GW). Worst-case groundwater quality data came from Well 27 to represent potential worst-case conditions. It should be noted, however, that in practice Well 27 will only be used intermittently to meet peak demands and in conjunction with other (higher quality) City wells.

5.2.1 Alkalinity

Under Scenario B (Table 2), in which NDM receives only Well 27 water, the worst-case alkalinity is only slightly higher than the historic maximum measured at the NDM wells and the median alkalinity is below the historic range for NDM. Scenario C, which represents a more realistic blend of surface water to groundwater, has a maximum alkalinity almost half the lowest alkalinity measured at the NDM wells and a median alkalinity almost one-quarter the lowest NDM alkalinity. Alkalinity is therefore expected to be significantly lower in the new water supply compared to NDM's existing supply. This reduction in alkalinity could potentially contribute to destabilization of existing scale, particularly in consumer plumbing, following integration. Recommendations for mitigating corrosion related effects are addressed in Section 7.

5.2.2 Iron

Well NDM1 is known to have historically high concentrations of iron, which is one of the key drivers for this integration. The median concentration of iron recorded for NDM1 during the summarized period was 0.29 mg/L and the highest concentration was 3.7 mg/L. Exceedances of the 0.3 mg/L sMCL for iron are common at Well NDM1. However, iron is not known to have a tendency to accumulate inside PVC piping, which accounts for the majority of NDM's water mains (see Section 6). Moreover, the County has reported no customer complaints regarding NDM water which indicates this community has no prior history of red water. It is therefore unlikely that red water will be a serious concern for the NDM community during integration. Following integration, the NDM community will receive water with significantly lower levels of iron, making the potential for red water less of a concern. The City's water is especially low in iron in the WDCWA treated surface water and Wells 27, 31, and 33, which are the source waters most likely to be supplied to the NDM community.

5.2.3 Manganese

Based on the limited data available for the NDM system, manganese has not historically been present in the NDM groundwater and is unlikely to be present in any existing scale material within the NDM distribution system or consumer plumbing. Black water is therefore unlikely to occur when the system switches water supplies. Scenario A (Table 2) indicates that WDCWA treated surface water typically has concentrations below detection, but did have a maximum reported concentration of 0.18 mg/L right after the WTP came online. During the first few months of operation, while treatment was being optimized, the manganese levels declined. Manganese levels have been below the detection limit since February 2017. One characteristic of manganese dioxide–the typical oxidized state of manganese–is that it is "sticky" and adheres to PVC pipe walls. However, because manganese levels in the NDM wells have historically been very low, and because treated water from the WDCWA WTP has been non-detectable since February 2017, manganese is not expected to be a recurring problem for the NDM community following integration.

5.2.4 pH

For all scenarios considered, the pH of the City's blended water (8.0 - 8.2) closely matches that historically measured in the NDM community. Especially during integration, it is important to maintain a stable pH throughout the distribution system in order to preserve the existing protective scale in the NDM distribution system. Given the similarity in the pH of both water qualities, the pH for NDM is not expected to change significantly during the integration.

5.2.5 TDS

The TDS of the new water supply is expected to be much lower than the NDM wells. Historically the TDS of the NDM wells ranged between 510 and 720 mg/L. Although the highest estimated TDS (770 mg/L for Scenario B) is slightly higher than the historic maximum at NDM, the median TDS for this scenario (350 mg/L) was lower than the historic range for NDM. Moreover, it is not expected that the City will operate with only groundwater for extended periods of time. Scenario C is the more likely operational scenario where blended water is provided during dry weather periods, and a lower TDS of 164 mg/L is expected.

5.3 Lead and Copper Rule Data

NDM is on a reduced monitoring schedule for the LCR and is required to collect samples from the distribution system only once every three years. Results from two rounds of LCR monitoring (completed in 2016 and 2019) at consumer taps within the NDM community were reviewed and are summarized in Table 3. During these two monitoring rounds, all individual lead and copper concentrations measured well below the ALs of 15 µg/L and 1,300 µg/L for lead and copper, respectively. All lead concentrations also measured below the lead TL of 10 µg/L (which went into effect with the 2021 LCRR and will be enforced in 2024). The 90th percentile compliance value was 1.6 µg/L for lead and 690 µg/L for copper. Additionally, NDM sampled eight consumer taps during the 2013 LCR monitoring effort and reported no AL exceedances for either lead or copper. Lead concentrations from this effort were all non-detects and copper concentrations ranged between non-detect and 610 µg/L.

Based on historical data, the age of the NDM development, and information from the City indicating that there is no known lead plumbing within the NDM community (see discussion in Section 6.1), maintaining compliance with the LCRR lead requirements is not anticipated to be an issue following integration. Similarly, the copper data does not indicate any reason for concern that the copper requirements will be exceeded following integration.

Table 3. NDM LCR Monitoring Results for 2016-2019

	Monitoring Period: Jul 13, 2016 – Jul 28, 2016		Monitoring Period: Aug 13, 2019 – Sep 10, 2019	
Location	**Lead, µg/L**	**Copper, µg/L**	**Lead, µg/L**	**Copper, µg/L**
39629 Larkspur Pl	<5	700	3.6	690
39432 Spanish Bay Pl	<5	220	0.58	190
39655 Larkspur Place	<5	340	<0.5	360
39304 Blackhawk Pl	<5	960	0.7	700
39400 Spanish Bay Pl	<5	180	1.6	200
39397 Spanish Bay Pl	--	--	<0.5	120
24319 Fairway Dr	<5	<50	0.55	160
90th Percentile	<5	700	1.6	690
Median	<5	280	0.58	200
Max	<5	960	3.6	700

5.4 Total Coliform Rule Data

Chlorine in the form of sodium hypochlorite is continuously added at the NDM wellheads to maintain a target chlorine residual between 0.8 and 1.0 mg/L in the distribution system. Residual chlorine is monitored on a monthly basis at the Spanish Bay Place sample station in the distribution system for compliance with the California and federal revised Total Coliform Rule (rTCR). These chlorine measurements and trends in residual concentrations across the distribution system are also useful indicators of the potential for red water from iron release. An absence of chlorine residual in the distribution system correlates positively with red water because chlorine keeps iron oxides in their less soluble form. A consistent chlorine residual also reduces corrosion issues related to microbial activity.

TCR monitoring data for the NDM community were provided for January 2019 through November 2021. NDM is required to monitor at a minimum of one sample site, on a monthly basis. During the observed period, all *E. coli* and total coliform values at this sampling station measured less than 1 most probable number (MPN) per 100 mL (i.e., non-detect), indicating that there was no history of bacteriological contamination. Chlorine residual data for the sampling station is summarized in Table 4. The median chlorine residual at the sampling station during this monitoring period was 0.70 mg/L as Cl_2 and the minimum was 0.30 mg/L as Cl_2. Based on this data, the NDM system was able to reliably maintain a detectable chlorine residual in the distribution system, which is important for the integrity of the protective pipe scale.

Table 4. Statistical Analysis of Free Chlorine Residual (mg/L as Cl_2) at NDM Sampling Station

	Spanish Bay Place
Average	0.71
Median	0.70
Max	1.32
Min	0.30
N	34

5.5 Corrosion Control Treatment

As previously discussed in Section 4, the LCRR requires water systems to practice CCT, if needed to mitigate the potential for corrosion within the distribution system. Acceptable CCT methods include pH and alkalinity adjustment and the addition of orthophosphate- or silicate-based corrosion inhibitors.

The NDM community has historically complied with the LCR without the use of a CCT. As such, no CCT is currently practiced at the NDM wellheads.

The WDCWA WTP adds phosphoric acid to the finished water to produce a measurable orthophosphate concentration which helps maintain integrity of pipe scale material in the distribution system. WDCWA targets a phosphate concentration of 2.5 mg/L as PO_4 (±0.2) at the Davis POI for proper corrosion control. WDCWA also adjusts the pH to 8.1 (±0.2) by injecting sodium hydroxide to closely match the City's groundwater. Between July 2016 and January 2021 the monthly average phosphate concentration at the Davis POI ranged between 1.9 and 2.6 mg/L as PO_4, with a median of 2.5 mg/L as PO_4. During this period, the pH at the POI ranged between 8.0 and 8.2, with a median of 8.1.

Orthophosphate was injected at the City's active wells for approximately 6 months prior to the WDCWA WTP coming online in order to help stabilize the existing corrosion scale in the older distribution piping. However, since start-up of the WTP, the City has stopped orthophosphate addition at its wells. Considering that the NDM community water mains are primarily PVC (see Section 6), which is not thought to accumulate scale material or labile orthophosphate coatings, it is not recommended to dose orthophosphate at the NDM wells ahead of integration with the City water supply. The orthophosphate present in the City's water supply that includes treated surface water from the WDCWA WTP (Table 2 Scenarios A and C) should be sufficient for coating consumer premise plumbing, which most likely consists of copper pipes with brass fittings based on the development dates for the NDM community. In the less likely event that 100% groundwater is supplied to the NDM community (Scenario B), the water quality is more consistent with the historical supply from the NDM wells and less corrosive (see Section 5.6).

As can be seen in Table 1, Well NDM1 has had concentrations of aluminum above the sMCL of 0.2 mg/L. Orthophosphate can precipitate with aluminum, forming aluminum phosphate. To mitigate the potential for this precipitation, it is recommended to turn off Well NDM1 one month in advance of integration to allow for flushing of excess aluminum from the distribution system. Community members who observe cloudy water during and/or following integration are encouraged to notify the City of Davis.

5.6 Corrosion Indices

Two common corrosion indices were evaluated for the NDM wells and the City's water sources. The Langelier Saturation Index (LSI) characterizes the thermodynamic likelihood that calcium carbonate will precipitate or dissolve in water and is considered an indication of water aggressiveness. The Calcium Carbonate Precipitation Potential (CCPP) is another common corrosion index that quantifies how much calcium carbonate could precipitate or dissolve in a distribution system. A positive LSI or CCPP indicates a tendency to precipitate calcium carbonate while a negative LSI or CCPP indicates a tendency to dissolve calcium carbonate. Generally speaking, maintaining a positive LSI and CCPP is favorable for corrosion control. Both corrosion indices are calculated as a function of pH, temperature, TDS, calcium hardness, and alkalinity.

Table 1 presented LSI and CCPP values for each source based on median historic water quality. NDM wells have a high, positive LSI ranging between 0.91 and 1.04 and a high, positive CCPP ranging between 41.59 and 58.69 mg/L as $CaCO_3$. Conversely, the WDCWA treated surface water has an LSI and CCPP of -0.33 and -2.11 mg/L as $CaCO_3$, respectively. The Cities of Davis and Woodland each have the option to specify a finished water target for either pH or LSI (but not both) from the WDCWA WTP. At this time both cities request a target for pH but not for LSI. The City of Davis adds phosphoric acid to the treated surface water as a CCT to maintain a detectable orthophosphate corrosion inhibitor concentration in the distribution system.

The new water supply will have a much lower LSI and CCPP compared to the NDM wells. Considering the NDM system has been subject to high LSI/CCPP water for so long, a gradual release of scale from the internal plumbing of NDM homes may be expected following integration. Scale release should not be a major concern, however, because NDM has no history of red water complaints and manganese is unlikely to be present in any existing scale. In fact, the water quality will only continue to improve as the system re-equilibrates to a negative LSI and CCPP. Moreover, given the age of the NDM homes, it is very unlikely that they contain any lead solder in their plumbing (see discussion in Section 6). Lead leaching is therefore very unlikely when the LSI and CCPP transition into the negative.

Worst-case historic water quality data was used to estimate the corrosion indices for blends of City water that could represent the water supply delivered to NDM after integration. The same three blends of treated surface water to City groundwater that were evaluated above (Table 2) were used for this assessment, substituting Well 31 data instead of Well 27 data because Well 31 has a lower corrosion index. Estimated orthophosphate concentrations were also evaluated, as summarized in

Table 5.

Table 5. Estimated Worst-Case Future NDM Corrosion Indices[1]

	Source	Blend	Ortho-phosphate (mg/L as PO_4)	pH	Temp (°C)	TDS (mg/L)	Ca-Hardness (mg/L as $CaCO_3$)	Alkalinity (mg/L as $CaCO_3$)	LSI	CCPP (mg/L as $CaCO_3$)
A	WDCWA	100%	1.9	8.0	10	190	15.75	25	-1.34	-4.88
	Well 31	0%	0	8.2	10[2]	350	47.5	220	0.23	4.57
	Blend		1.9	8.0	10	190	15.75	25	-1.34	-4.88
B	WDCWA	0%	1.9	8.0	10	190	15.75	25	-1.34	-4.88
	Well 31	100%	0	8.2	10[2]	350	47.5	220	0.23	4.57
	Blend		0	8.2	10	350	47.5	220	0.23	4.57
C	WDCWA	82.5%	1.9	8.0	10	190	15.75	25	-1.34	-4.88
	Well 31	17.5%	0	8.2	10[2]	350	47.5	220	0.23	4.57
	Blend		1.6	8.0	10	218	21.3	59	-0.85	-4.95

1. NDM water quality compiled from regulatory monitoring performed from 2012 through 2020.
2. In the absence of temperature data for the City wells, the worst-case temperature was assumed to be 10 °C based on the worst-case temperature in the WDCWA treated surface water.

Scenarios A and C, in which surface water dominates, both have negative corrosion indices yet maintain orthophosphate concentrations of 1.9 and 1.6 mg/L as PO_4, respectively. Conversely, under Scenario B in which only well water is used, there is no orthophosphate residual but there is a positive LSI (+0.23) and a positive CCPP (+4.57 mg/L as $CaCO_3$). The presence of a measurable orthophosphate concentration in those scenarios in which the LSI and CCPP become negative should help reinforce any pipe scale.

6 – DISTRIBUTION SYSTEM ASSESSMENT

This section summarizes the age, materials, and condition of the pipelines within the NDM distribution system followed by a discussion on the potential effects that changing water chemistry may have on the distribution system.

6.1 Main System Attributes

The relatively small NDM community services 94 homes and the Davis Golf Course. The community consists primarily of newer homes. The plans for Phase I of the development were approved in 1987 and Phase II in 1996, with construction of the homes taking place in subsequent years.

A review of the original NDM community design documents found that the distribution system is comprised of 2.1 miles of water mains, the vast majority (95.9% by length) of which is C900 PVC. The remaining water main pipes consist of two DI segments beneath the Davis Golf Course totaling 0.09 miles in length. This breakdown is summarized in Table 6. While DI pipe is somewhat susceptible to the formation of red water, neither PVC nor DI are associated with the presence of lead. The NDM distribution system was depicted in Figure 1.

Table 6. Summary of NDM Distribution System Pipelines

Approx. Year Installed	Material	Pipeline Length (mi)			
		6"	8"	Total (mi)	Percent (%)
1987	PVC	0.47	0.44	0.91	43.6
1996	PVC	0.64	0.45	1.18	52.2
1996	DI	0.09	0.00	0.09	4.1
Total (mi)		1.20	0.90	2.10	
Percent (%)		57.1	42.9		

6.2 User Service Lines

Under California Senate Bill (SB) 1398 in 2016 and SB 427 in 2017, water systems were required to compile a comprehensive inventory of utility-owned user service lines by July 2018 and to develop a schedule for replacement of all known lead and unknown material service lines by July 2020. The 2021 LCRR extended these inventory requirements to the consumer side as well (USEPA, 2021).

The 2019 LSL inventory for the NDM community determined that there are no lead or unknown material service lines and no lead fittings present in the distribution system on the utility side. Based on the City's records, the NDM service lines on the utility side are copper. Pipe material on the homeowners' side of the water meter is unknown. However, given the age of the NDM development, it is likely the plumbing of these homes is copper piping with brass fittings. As part of this project, the NDM water meters will be brought up to the City's standards for lead-free material, although this is not required per the LCRR. During construction, if the private service line after the water meter does not appear to be copper with brass fittings, as assumed, the City may elect to inspect the material and possibly harvest some pipe for lab analysis to verify the materials for the LCRR inventory.

As discussed in Section 5.3, LCR monitoring in the NDM distribution system does not indicate signs of active lead or copper corrosion. This is again likely due to the age of the NDM development and restrictions on lead plumbing beginning in the mid-1980s. In 1986 California and the federal government effectively banned the use of leaded materials in drinking water pipes, fittings, and fixtures. At the same time, 50/50 lead solder was prohibited and more stringent definitions of "lead free" were imposed on brass faucets. In 1997, legislation set national requirements on leaching of lead from brass. Then in 2006, California passed the Assembly Bill 1953 Lead Law which redefined "lead free" as ≤0.25% lead. As a result, faucets in California have been truly "lead free" for most of the 2000s.

The plans for the first phase of development at NDM were approved in 1987 and the second phase in 1996. The NDM homes were constructed in the years that followed and around the same time that stricter restrictions were being place on leaded materials in plumbing. Given these developments, the absence of LSLs in the community, and recent LCR monitoring data, lead corrosion does not appear to be a concern for the NDM community once the water supply is switched.

6.3 Future Distribution System Changes

Approximately 2 miles of new potable water main piping is to be installed as part of the NDM integration into the City's drinking water distribution system. Several water main segments of 6" PVC will be abandoned in place and replaced with 8" PVC pipe to accommodate higher flows. New copper water service piping will be installed at 13 locations within the community. A new transmission main connecting NDM with the City's distribution system will run parallel to County Road 99D and connect to the City's distribution system near 3003 John Jones Road near an existing water storage tank and pump station. This main will consist of approximately 1.31 miles of 14" PVC pipe and 0.01 miles of 14" DI pipe with cement mortar lining. As with the existing distribution system, the addition of these pipe segments does not cause concern over future corrosion related issues.

6.4 Flow Reversal

Based on the future location of the water main that will connect NDM to the Davis distribution system, it is clear from Figure 1 that a portion of the NDM distribution system will experience flow reversal when the new water supply is introduced. Hydraulic modeling and identification of which pipelines will experience flow reversal were not performed for this TM. Reverse flow is known to exacerbate disruption of scale and potentially corrosion issues due to the loss of scale. This is not expected to be an issue for the majority of the NDM system, which is PVC pipe. However, scale loss could occur in the DI pipe segments if the flow is reversed. During the initial flush following integration, flow reversal may also suspend loose sediments that have deposited in the pipelines over many years of operation which may be visible to homeowners. Community members who observe cloudiness or particulates in their water are encouraged to notify the City of Davis.

6.5 Consumer Complaints

The County is not aware of any customer complaints regarding the existing drinking water in the NDM community.

6.6 Effects on Home Water Treatment

Because of the improved water quality, home water treatment devices such as reverse osmosis and ion exchange units should have less of a burden after the water supply change. So, homeowners may not observe any change in operation or performance. After time, the homeowners may elect to remove their home treatment devices because of the improved and softer water quality from the WDCWA's WTP.

7 – RECOMMENDATIONS FOR INTEGRATION

This section provides recommendations for a "best practice" strategy for NDM and the City to minimize the potential for corrosion related issues in the NDM distribution system when the community switches to the City's drinking water supply. The recommendations presented here are based on a review of available literature and the experiences of other utilities. No pilot- or bench-scale testing using harvested pipe from NDM's system was performed to assess the potential for corrosion related issues or to evaluate corrosion control techniques.

Key practices for minimizing corrosion related issues are to (a) maintain as stable a water chemistry as possible in the distribution system, (b) stabilize existing corrosion scale, and (c) keep changes in water quality to a minimum. Vigilant water quality monitoring leading up to and after integration are also advised to identify potential issues in a timely manner.

7.1 Ramp-Up Schedule for System Integration

Typically, introduction of a new water source into an existing distribution system is achieved following a carefully planned ramp-up schedule designed to slowly introduce the new water quality and minimize corrosion related effects. For example, the City followed a planned ramp-up schedule when treated surface water from the WDCWA WTP was first introduced into the distribution system. Unlike the City's distribution system, however, the NDM system is far less complicated, smaller, and dominated by pipe materials that are not prone to accumulating scale material. A slow ramp-up is therefore not required for a successful integration. Moreover, there are other water quality factors for this project that will dictate whether or not a slow ramp-up is even feasible.

The main objective of integrating NDM into the City's water supply is to resolve recurring MCL violations within the NDM community. Well NDM1 has concentrations of iron and aluminum above their respective MCLs, and Well NDM2 has concentrations of nitrate above its MCL. Table 7 summarizes estimated water quality for these constituents of concern under various blending scenarios for the NDM wells and the City water sources based on historic worst-case water quality data. Of the five scenarios considered, compliance with all three MCLs for iron, aluminum, and nitrate is only achieved once NDM has completely transitioned to the City's water supply. Given the criticality of meeting all MCLs, controlled ramp-up of the different source water is not considered a viable option for this project.

Table 7. Estimated Water Quality Under Various Ramp-Up Scenarios[1]

NDM Wells	City Sources[2]	Iron (mg/L)	Aluminum (mg/L)	Nitrate (mg/L as N)
		sMCL: 0.3 mg/L	sMCL: 0.2 mg/L	MCL: 10 mg/L as N
100%	0%	3.7	1.1	14
75%	25%	2.8	0.8	12

NDM Wells	City Sources[2]	Iron (mg/L)	Aluminum (mg/L)	Nitrate (mg/L as N)
		sMCL: 0.3 mg/L	sMCL: 0.2 mg/L	MCL: 10 mg/L as N
50%	50%	1.9	0.6	10
25%	75%	1.0	0.3	8
0%	100%	0.09	<0.05	6

1. Estimates based on maximum observed values in available data.
2. City water sources considered include WDCWA treated surface water, Well 31, Well 33, and Well 27. Estimates shown were calculated using the maximum value from any one of these sources for each parameter.

7.2 Water Quality Monitoring Recommendations

It is recommended for the City to adopt a water quality monitoring plan in the NDM community to track the progress of the integration and identify any water quality issues in a timely manner. The monitoring program is divided into three phases:

Phase 1 – *Baseline monitoring:* to be conducted between now and the introduction of the new water quality into the NDM system.

Phase 2 – *Start-up monitoring:* to be conducted for the first 6 weeks after the new water quality is introduced into the NDM system.

Phase 3 – *Stabilization monitoring:* to be conducted between week 6 and the first 12 months following integration while the NDM system is becoming acclimated to its new water quality.

Water quality collected during the baseline monitoring phase will help fill in data gaps for the NDM water quality prior to integration. Data collected during the start-up and stabilizations monitoring phases will be used to monitor the expected stability of any existing scale within the system as well as to identify any corrosion related issues resulting after integration. All proposed monitoring would be conducted at existing sampling sites within the NDM community. These include the TCR sample station located on Spanish Bay Place (which is also used for additional distribution system monitoring) and consumer taps located within six homes currently used for LCR compliance monitoring. Relying on existing sample sites should help minimize the hurdle for educating consumers on proper sample collection.

The following monitoring recommendations were made with consideration of regulatory requirements, the need to adequately monitor system changes, and additional operational and financial burdens on the City.

Baseline monitoring should consist of three sampling events between now and the start of integration for those parameters in Table 8. Each event should be spaced to capture any variation in water quality over time. Baseline monitoring should be conducted at the existing TCR sample station located on Spanish Bay Place.

Start-up monitoring should commence once integration begins and last a total of 6 weeks. Start-up monitoring should include weekly or monthly monitoring for those parameters in Table 8 at the Spanish Bay Place TCR sample station and LCR monitoring in select NDM homes, as discussed below.

Stabilization monitoring should begin on week 7 following the integration and last until 12 months have elapsed since integration. Stabilization monitoring includes monthly monitoring for those parameters in Table 8 at the Spanish Bay Place TCR sample station and a continuation of the LCR monitoring started during the start-up monitoring phase.

Once the City absorbs the NDM community into its drinking water system, NDM will be subject to the LCR monitoring requirements for the larger City system, which is also on a triennial monitoring schedule. Under the LCRR, all systems are required to obtain prior approval before changing water sources and to perform additional follow-up monitoring. Although the LCRR will not officially be enforced until October 16, 2024, it is recommended that the City be consistent with the additional monitoring required under the LCRR following a source water change. As previously described in Section 4.2, follow-up monitoring includes conducting a full round of LCR compliance monitoring every six months at the standard number of sites following the change until no AL exceedances for lead or copper are measured for two consecutive six-month monitoring periods. Once this condition is satisfied, LCR monitoring may be reduced as before. Lead and copper samples collected as part of this integration follow-up monitoring shall be labeled as “special” and are not required to be reported as part of the City’s LCR three-year compliance monitoring program.

This follow-up LCR monitoring should be performed at five homes in the NDM community that have previously participated in LCR monitoring. As part of its community outreach regarding the integration, it is recommended that the City notify these homes of the additional sampling related to the water supply change and communicate the importance of routine water sampling to ensure the public safety. Sample collection should conform to the additional sampling requirements introduced under the LCRR (see Section 4.2).

Table 8. Recommended Integration Monitoring Schedule

Parameter	Units	Baseline Monitoring	Start-up Monitoring	Stabilization Monitoring
		Present - Start-up	Start-up – Week 6	Week 7 - 12 mos.
Orthophosphate	mg/L as PO4	--	Monthly at Spanish Bay Place TCR sample site	Monthly at Spanish Bay Place TCR sample site
pH	--	3 sample events at Spanish Bay Place TCR sample site		
Temperature	°C			
Conductivity	μS/cm			
Apparent Color	ACU			
ORP	mV			

Parameter	Units	Baseline Monitoring	Start-up Monitoring	Stabilization Monitoring
		Present - Start-up	Start-up – Week 6	Week 7 - 12 mos.
Alkalinity	mg/L as $CaCO_3$			
TOC	mg/L			
TDS	mg/L			
LSI (by calculation)	--			
Iron, total	mg/L		Weekly at Spanish Bay Place TCR sample site	
Manganese, total	mg/L			
Aluminum, total	mg/L			
Calcium Hardness	mg/L as $CaCO_3$			
Turbidity	NTU			
Total Chlorine	mg/L as Cl_2			
Lead	mg/L	--	Once every 6 months for 12 months (per LCRR) at five LCR sample taps	
Copper	mg/L			

8 – REFERENCES

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APPENDIX A

DETAILED SUMMARY OF THE LEAD AND COPPER RULE REVISIONS

In 1986, the U.S. Congress amended the Safe Drinking Water Act (SDWA) to prohibit the use of pipes, pipe fittings, and plumbing fixtures containing more than 8.0% lead and solder containing more than 0.2% lead. That same year, California enacted Proposition 65 which also led to more stringent limits on the leaching of lead from brass faucets. Later legislation eventually resulted in "lead free" faucets in California by the year 2000. These regulations greatly reduced the presence of lead in water systems, and by the early 1980s it was understood that the majority of the lead contributed by service lines and homes came from 50/50 lead/tin solder and lead service lines (LSLs) connecting water mains to the internal plumbing of a building.

To address these issues, the USEPA promulgated the Lead and Copper Rule (LCR) in 1991, establishing monitoring requirements at consumer taps as well as action levels (ALs) for lead and copper. While the original LCR minimized the installation of new lead pipes in water systems, lead pipes still exist in older systems and buildings. Accordingly, in 2021 the USEPA promulgated the first major update to the LCR in the rule's history, with a focus on protecting children and communities where LSLs are still prevalent (USEPA, 2021). The LCRR will officially be enforced beginning October 16, 2024, so it is prudent to comply with the new requirements as soon as possible. The revised rule identifies six key areas of focus, including:

1. Strengthening treatment requirements;
2. Increasing sampling reliability;
3. Identifying areas most impacted;
4. Systematically replacing LSLs;
5. Improving risk communication; and
6. Protecting children in schools.

8.1 Limits and Treatment Requirements

The LCRR retains many of the monitoring requirements and the ALs for lead and copper established under the 1991 LCR. The ALs for lead and copper remain unchanged at 15 µg/L and 1.3 mg/L, respectively, both based on the 90^{th} percentile monitoring values from select consumer taps. Like the previous rule, the LCRR requires that water systems practice corrosion control treatment (CCT), if needed, to mitigate corrosion in the distribution system and internal plumbing of individual buildings. Approved CCT options are alkalinity and pH adjustment and orthophosphate- or silicate-based corrosion inhibitors.

The LCRR also establishes a new trigger level (TL) for lead at 10 µg/L. The ALs and TL under the LCRR are presented in Table A - 1. When the TL is exceeded for any given sample, systems that already practice CCT must re-optimize their treatment. At the TL, water systems that do not already practice CCT are required to conduct a CCT study to identify the best treatment approach for their system. If the system exceeds the lead AL in the future, the system will be required to implement the identified treatment approach immediately. For all water systems, an exceedance of the lead TL also requires the system to start planning for replacement of LSLs.

Small systems serving 10,000 people or fewer may select an alternative to CCT, including point-of-use treatment, replacement of lead-bearing plumbing materials, and LSL replacement.

All systems must obtain prior approval from the primacy agency before changing their water source or treatment.

Table A - 1. Action Levels and Trigger Levels Under the LCRR

Parameter	Action Level	Trigger Level	Comments
Lead	15 µg/L	10 µg/L	Based on 90th percentile
Copper	1.3 mg/L	--	Based on 90th percentile

8.2 CCT Monitoring

Like the original LCR, the LCRR specifies monitoring requirements to assess the efficacy of existing CCT practices and prompt action in the event of an exceedance. Compliance monitoring must be conducted following a minimum stagnation period of six hours at consumer taps from sites served by LSLs, if available. When an AL exceedance has occurred, the water system is required to take follow-up action but will not incur a violation. These actions include public notification of the exceedance, educating the public on the health risks of lead in drinking water, and, potentially, LSL replacement. LCR violations can be incurred if samples are not collected or reported properly.

The LCRR introduces new requirements for tap sample collection, including new criteria for sample site selection. Tap samples must be collected from sites with LSLs, if available. For homes with LSLs, samplers must collect a fifth-liter sample following a minimum six-hour stagnation period. That is, samplers must draw four liters of water from the tap before collecting the test sample in order to collect a sample that is more representative of water that has been stagnant within the LSL for an extended period of time. In homes without LSLs, a first-liter sample will still be collected, as the fifth-liter sample rule does not apply. Samples must also be collected in wide-mouth bottles, and sampling instructions may not recommend cleaning or removing faucet aerators prior to sample collection.

The monitoring frequency and number of sample locations is determined by the size of the population served by a water system and historic compliance with the LCRR. The number of sample taps to be monitored is summarized in Table A - 2.

The standard monitoring frequency for both lead and copper is semi-annual (i.e., two consecutive six-month periods). However, systems may qualify for reduced monitoring if any of the following criteria are met:

- Lead
  - If 90th percentile lead ≤ 15 μg/L and > 10 μg/L, may perform annual monitoring at standard number of sample taps
  - If 90th percentile lead ≤ 10 μg/L for two consecutive periods, may perform annual monitoring at standard number of sample taps
  - If 90th percentile lead ≤ 5 μg/L for two consecutive periods, may perform triennial monitoring at reduced number of sample taps
  - If the population served ≤ 3,300 with 90th percentile lead ≤ 10 μg/L for two consecutive periods, may apply for 9-year monitoring waiver
- Copper
  - If the population served ≤ 50,000 people and copper ≤ AL for two consecutive periods, may perform annual monitoring at reduced number of sample taps
  - If 90th percentile copper ≤ 0.65 mg/L for two consecutive periods, may perform triennial monitoring at reduced number of sample taps
  - If the population served ≤ 3,300, may apply for 9-year monitoring waiver

In addition to lead and copper monitoring, water systems must conduct water quality parameter (WQP) monitoring at consumer taps and at entry points to the distribution system. WQPs for monitoring are pH, alkalinity, and either orthophosphate or silica, depending on the applicable corrosion inhibitor used. For water systems serving a population of 50,000 or greater, tap monitoring is performed every six months and monitoring at the entry points to the distribution system are performed every six months prior to implementation of CCT, and every 2 weeks thereafter. Systems serving fewer than 50,000 people must perform WQP monitoring until they no longer exceed the lead and/or copper AL for two consecutive 6-month monitoring periods. A system may qualify for reduced WQP monitoring at consumer taps if it is below the TL for lead and the system meets the optimal water quality parameters (OWQPs) set by the primacy agency.

Lead, copper, and WQP data will be reviewed during sanitary surveys against the most recent CCT guidance issued by the USEPA.

Table A - 2. LCRR Tap Monitoring Requirements

Population Served	Pb/Cu Tap Sample Sites		WQP Tap Sample Sites[1]	
	Standard	Reduced	Standard	Reduced
> 100,000	100	50	25	10
10,001-100,000	60	30	10	7
3,301-10,000	40	20	3	3
501-3,300	20	10	2	2

Population Served	Pb/Cu Tap Sample Sites		WQP Tap Sample Sites[1]	
	Standard	Reduced	Standard	Reduced
101-500	10	5	1	1
≤ 100	5	5	1	1

1. Two WQP tap samples are collected at each sampling site.

Under the original LCR, water systems were required to perform periodic source water monitoring if they treated their source water for lead or copper, or if they did not treat their source water for lead or copper and exceeded an AL. Under the LCRR, the primacy agency can waive continued source water monitoring if the water system has already conducted source water monitoring for a previous AL exceedance, the system has not added any new water sources, and the primacy agency feels that source water treatment is not required.

8.3 Find-and-Fix Requirements

All compliance samples must be collected from homes with LSLs or galvanized service lines that have ever been downstream of an LSL (considered to be high risk for leaching lead), if available. If no LSLs are present in the distribution system, samples must be collected from homes with copper pipes installed before California's 1985 lead ban. Barring none of these higher risk connections, samples are to be collected from 'representative plumbing.' If any individual tap sample exceeds 15 µg/L, the water system must implement a find-and-fix assessment to identify the sources of lead and actions to reduce lead in the drinking water. This process begins with WQP sampling within five days at another tap in the same pressure zone, on the same size main, and within 0.5 mile. If no existing WQP sample site meets these criteria, the water system must add additional sites until the system has twice the standard number of WQP sites listed in Table A - 2.

The next step in the find-and-fix assessment is to perform follow-up lead/copper sampling at the tap where the lead AL was exceeded within 30 days. Samples collected for this reason must be submitted to the primacy agency, but do not count toward the 90th percentile calculation for regular compliance monitoring.

Water systems shall evaluate the results of the find-and-fix monitoring to determine if localized or centralized adjustment of the CCT or some other action is necessary to correct the exceedance. The system shall submit its findings and recommendations to the primacy agency within six months of the original AL exceedance.

8.4 LSL Inventory and Replacement

To better inform the public of the potential presence of lead in a community's drinking water, water systems must identify and publicize the locations of all LSLs, including those on the customer side of the water meter, or demonstrate that no LSLs are present in the distribution system. This inventory must be updated annually or triennially based on the tap sampling frequency. Customers with a known or suspected LSL will be notified and given information on how they can reduce their exposure to lead in drinking water.

All systems with known or possible LSLs must develop an LSL replacement plan. Water systems that exceed the lead AL are required to fully replace at least 3% percent of LSLs annually. Systems that are above the TL but at or below the lead AL shall perform LSL replacement at a goal rate approved by the primacy agency. It should be noted that the federal definition of LSL does not include lead goosenecks, pigtails, or connectors in order to avoid water systems replacing only lead connectors to meet goal rates and LSLR requirements. Partial LSL replacements are also not counted toward these goals under the LCRR. Water systems are required to replace the water system-owned portion of an LSL when a customer voluntarily replaces their privately owned portion of the line. The LCRR also requires replacement of galvanized service lines that are or ever were downstream of an LSL.

Following a LSL replacement, the water system must collect lead tap samples at locations served by the replacement line within 3 to 6 months following the replacement. The water system must also provide pitcher filters and/or cartridges to each customer affected by a LSL replacement within 24 hours for a period of 6 months following replacement.

8.5 Public Education and Outreach

The LCRR increases the number and variety of public education materials on lead in drinking water that a water system must provide to the public. Systems must publicize their inventory of customers with LSLs in the annual consumer confidence report and notify customers with LSLs annually to remind them about the risk of lead exposure through drinking water and their options to mitigate this exposure, up to and including LSL replacement.

Water systems must notify customers within three days if a sample taken from their tap exceeds 15 μg/L of lead. If the sample is under 15 μg/L, the customers must be notified within 30 days. If a lead AL exceedance is systemwide, all customers must be notified within 24 hours and provided with educational materials within 60 days on how to reduce their exposure to lead in drinking water. Water systems must also notify homeowners and building owners about opportunities to replace LSLs.

8.6 Lead in Schools and Child Care Facilities

The LCRR introduces a new requirement to test for lead in drinking water at elementary schools and child care facilities. Water systems must test all elementary schools and child care facilities they serve at a rate of 20% per year. Along with this new monitoring requirement is an obligation to provide timely monitoring results to these facilities as well as information on how these facilities can minimize the amount of lead in their drinking water. Community water systems are required to provide lead testing to secondary schools upon request during the initial 5 years of mandatory testing, and also to elementary schools and child care facilities upon request after the initial round of mandatory testing. Facilities that were built or had their entire plumbing replaced after January 1, 2014, are exempt from these requirements.