Finished Water Quality Audit

PREPARED FOR INDIAN RIVER COUNTY UTILITIES DEPARTMENT

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Abbreviations

ADF	Average Daily Flow
ANSI	American National Standards Intuition
CCL	Contaminant Candidate List
CT	Contact Time
DBP	Disinfection By-Products
EPA	Environmental Protection Agency
FAS	Floridan Aquifer Supply Wells
FDEP	Florida Department of Environmental Protection
gfd	gallons per square foot per day
gpd	Gallons Per Day
gph	Gallons Per Hour
gpm	Gallons Per Minute
H_2SO_4	Sulfuric Acid
H_2S	Hydrogen Sulfide
HAA	Haloacetic Acids
HDPE	High Density Polyethylene
HGL	Hydraulic Grade Line
HP	Horsepower
IDSE	Initial Distribution System Evaluation
IRCU	Indian River County Utilities
LCR	Lead And Copper Rule
LRAA	Location Running Annual Average
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MDF	Maximum Daily Flow
MG	Million Gallons
MGD	Million Gallons Per Day
MRDLS	Maximum Residual Disinfectant Levels
NaOCl	Sodium Hypochlorite
NaOH	Sodium Hydroxide (caustic)
NF	Nanofiltration
NPDWR	National Primary Drinking Water Regulations
NSDWR	National Secondary Drinking Water Regulation
NSF	National Sanitation Foundation
NTU	Nephelometric Turbidity Units
O&M	Operation and Maintenance
PLC	Programmable Logic Controller
PHF	Peak Hour Flow
ppd	Pounds Per Day
PQL	Practical Quantitation Limit
PVC	Polyvinyl Chloride
PWS	Public Water System
SCADA	Supervisory Control and Data Acquisition
SDWA	Safe Drinking Water Act
TDS	Total Dissolved Solids
TL	Trigger Level
TM	Technical Memorandum
TOC	Total Organic Carbon
TTHM	Total Trihalomethane
VFD	Variable Frequency Drive
WTP	Water Treatment Plant

Executive Summary

Indian River County Utilities (IRCU) owns and operates a consolidated water system, consisting of two regional Water Treatment Plants (WTPs) with a combined maximum rated capacity of 25.71 MGD. The water system has remote storage and repump facilities that provide treated water to their customers. To enhance and stabilize water quality sent to customers, IRCU implements raw water blend and chemical addition to permeate water to provide customers with a stable finished water quality. This treatment technique is employed to enhance IRCU's ability to protect their distribution system network, as well as their customer's household plumbing. Over time, IRCU has remained proactive towards optimizing operations to enhance quality of finished water provided to their customers. Proactive measures have included design studies, construction of improvements, finished water quality reports, corrosion testing studies and evaluations, flushing measures, and most recently, this Finished Water Quality Audit.

Recently, IRCU has received an increase in customer complaints pertaining to household plumbing leaks. Customer complaint locations have been variable throughout the County's water system. IRCU has been responsive to their consumers through listening and responding to customer complaints, making visits to homes, taking water quality samples, and informing their consumers of IRCU's state and federal regulatory compliance as it relates to providing safe and clean drinking water. As part of IRCU's ongoing efforts to be proactive and address customer concerns regarding finished water quality, IRCU retained the services of Kimley-Horn to review and evaluate water quality of its distribution system to confirm compliance with regulatory agencies with respect to the lead and copper testing regimes, confirm treatment protocols are working and determine, what, if any, protocol changes are needed.

As part of this investigation, the following elements pertaining to finished water corrosivity are noted:

- **IRCU has been and remains compliant with the provisions of the Safe Drinking Water Act (SDWA), including the Lead and Copper Rule (LCR), a federal law that intends to protect public health through minimizing lead (Pb) and copper (Cu) levels in drinking water, primarily by reducing water corrosivity.** Figures 10 and 12 within this report clearly illustrate IRCU is in full compliance with lead and copper rule and in similar compliance with several other local utilities located along the Treasure Coast.
- IRCU compliance sampling for lead is under the action level (AL), the upcoming trigger level (TL), and the Practical Quantitation Limit (PQL) for lead.
- IRCU compliance sampling for copper is well under the AL for copper.
- LCR sampling is consistent with previous years, and although 90th percentile values are slightly higher than previous cycle, finished water is characterized as "non-corrosive" based on regulatory compliance.
    - IRCU could consider more frequent lead and copper sampling to better understand trends, if any, that may exist.
    - Additional sampling is recommended to coincide with distribution system flushing to better understand impacts of hydraulic conditions and flushing affects with respect to lead and copper sampling and sample results.
- The pending Lead and Copper Rule Revision (LCRR) removes calcium hardness as a water quality parameter (WQP) for corrosion control treatment.
    - This change will allow IRCU to shift chemical feed to focus on enhanced alkalinity, thereby reducing potential of pH changes in the system.

Household plumbing failures are not uncommon and can be caused by a variety of causes, such as;

- stray current and/or associated lightning strikes that can cause these

- contact with dissimilar metals,
- thin wall copper plumbing typically installed during strong economy periods,
- workmanship,
- contact with defective drywall,
- plumbing techniques and inadequate flushing of lines after installation
- temperature changes,
- and quality of materials, to include just a few.

There are many factors that can initiate corrosion of residential plumbing that are NOT water quality related that can contribute to household plumbing failures. After corrosion is initiated, water can propagate, or advance corrosion. To mitigate these effects, IRCU has implemented measures, constructed capital improvement projects and dedicated resources towards enhancing their ability to protect water system infrastructure.

IRCU is not alone in their efforts to strengthen consumer confidence through addressing complaints related to plumbing failures. Many municipalities throughout the USA are responding to plumbing failure customer complaints and are having to explain this very concept to their customers, some of which are in the Treasure Coast and Southeast Florida. In summary, the following important factors relating to corrosion should be noted:

- Water purveyors and municipal/private water utilities are not responsible after the customers water meter for the integrity of homeowner and customer plumbing and fixtures other than that prescribed under the lead and copper rule (LCR).
- There are many causal factors of pitting corrosion
  - Workmanship and installation
  - Dissimilar pipe interaction
  - Elevated flow velocities
  - Microbiological interactions
  - Stray Electrical Currents
  - Lightning
- The key legal case Brynwood vs. Clearwater in 1980's relieved utility of responsibility of pitting in condo units serves as the base case for utility defenses in Florida.

This TM also reviewed IRCU's compliance with regulations pertaining to disinfection byproducts and overall aesthetic quality of the finished water. In summary, the following key observations and recommendations are provided:

- IRCU remains compliant and below the MCL for TTHMs and HAA5s
- The Cal~Flo (lime slurry) system contributes to finished water turbidity for both Oslo and Hobart. Fluctuations in turbidity impact the operational balance of maintaining consistent pH of 8.3.
  - Operational optimizations consisting of lime slurry feed reduction and caustic addition at both WTPs are recommended to maintain pH, reduce turbidity and achieve alkalinity of 70-80 mg/L as $CaCO_3$
  - Operational testing confirmed feasibility of operational optimization.
  - Minimum WQP value of calcium hardness (60 mg/L as CaCO3) must continue to be maintained until LCRR is promulgated
- Turbidity is variable throughout the distribution system.
  - Elevated turbidity may be exacerbated in areas of low demand or areas that require flushing, including dead-end mains.
  - IRCU is exploring system-wide flushing plan to help resolve these issues.

- The clearwell turbidity data at Hobart suggest operations has challenges maintaining target pH values and maximum turbidity than at Oslo. This was confirmed during operational testing.
- Elevated alkalinity in the distribution system has resulted in fewer pH excursions and
  - The elevated alkalinity has resulted in fewer pH excursions, but an overall reduction in system pH.
  - Increase in alkalinity and mitigating turbidity excursions through supplementing lime slurry pH adjustment with caustic will assist IRCU in maintaining target pH of ~8.3.

Introduction

In 2013, Indian River County Utilities Department (IRCU) implemented a finished water stabilization system to replace the zinc orthophosphate (ZO) feed system in order to improve finished water quality, enhance control of potential corrosion, and provide water with more buffering capacity within the distribution system. This project consisted of discontinuation of zinc orthophosphate corrosion inhibitor feed and implementation of carbonic acid solution with lime slurry feed at both water treatment plants in order to improve buffering capacity and stability of finished water.

In 2016, Kimley-Horn provided a distribution system water quality and corrosion investigation report which included gravimetric and linear polarization resistance (LPR) testing results, water quality data review, and operational adjustments at the WTPs in an effort to yield more favorable finished water quality conditions. In summary, several key observations from the previous evaluation include:

- Inconsistent water quality influences corrosion rates negatively. Variations in water quality may have been more tolerable in the past with the use of corrosion inhibitor (ZO), allowing wider fluctuations in these parameters without mattering.

- Lead corrosion rates were less than copper corrosion rates with the change in corrosion control treatment from ZO to CO_2/lime.
  - Supports the concept that copper corrosion is more susceptible to fluctuations in water quality.

- The quality and purity of lime slurry (Cal~Flo) directly affects the turbidity of the product water, and subsequent effectiveness at increasing pH and alkalinity. Suspected impurities in the Cal~Flo product may contribute to this issue.

- The Hobart water plant produced more inconsistent water quality from the post-treatment system, mostly during the SCADA system improvements. Operating the West/South and East/North clearwells separately may contribute to this inconsistency.

- Lack of consistent chlorine feed to the Hobart West/South clearwell was observed, which may interfere with lime dissolution in the mixing chamber.

- Flushing of areas within the water distribution system helped expedite flushing and removal of zinc and other turbidity formed during the transition from ZO discontinuation and CO_2/lime feed system implementation.

- Raw water blend was reduced at both facilities to reduce the disinfection byproduct formation, and the CO_2/lime feed system was implemented to restore alkalinity and hardness. Although the system was designed to operate at higher feed rates, operating costs will be higher with this change in operation.

Approximately five years have lapsed since this evaluation was prepared for IRCU. Accordingly, IRCU desires to continue to monitor and evaluate the water quality of its distribution system to confirm regulatory compliance with respect to the lead and copper testing regimes, confirm treatment operating protocols are working and determine, what, if any, protocol changes are needed.

System Background

Indian River County Utilities (IRCU) owns and operates a consolidated water system that treats and pumps potable water to customers from two regional membrane softening water treatment plants (WTPs). The southern portion of the County is served by the South Oslo Road WTP currently has a capacity rating of 8.57 MGD, consisting of 6 MGD nanofiltration (NF) permeate and 2.57 MGD of raw water bypass blend. There are four (4) NF trains that treat brackish groundwater from seven (7) Upper Floridan Aquifer (UFA) wells. Post-treatment stabilization is achieved through combination of raw water blend and chemical addition, utilizing carbonic acid solution and lime slurry addition. Caustic feed for pH and alkalinity adjustment is in place but not currently in service. Fluoride is also added to the finished water for consumer health benefits and free chlorine is utilized for disinfection.

Oslo has historically operated with a raw water blend of 30 percent of the plant's capacity; however, due to formation potential of disinfection by-products (DBPs), particularly of bromide species, this blend ratio has been reduced over time, further reducing the contribution of hardness and alkalinity from the raw water. This reduction in blend flow rate, although beneficial to finished water quality, results inadvertently in treatment capacity reduction. IRCU has an active project to increase WTP capacity to 9 MGD with 7.5 MGD of NF permeate and 1.5 MGD of raw water bypass, reducing the blend ratio to 17% blend. This project will include multiple improvements to the WTP, most notably to the membrane softening trains, process piping, high service pumps, and chemical systems. Project is anticipated to be completed by winter 2024.

The northern portion of the county is served by the North Hobart WTP which has a capacity rating of 17.14 MGD. Due to permitted limitations associated with concentrate disposal to Spoonbill Marsh, the WTP is truly limited to 11.44 MGD capacity. Hobart consists of eight (8) NF trains that treat brackish water from nine (9) Upper Floridan Aquifer (UFA) wells. Similar to Oslo, post-treatment stabilization consists of raw water blend, and chemical addition of carbonic acid, lime slurry and sodium hydroxide addition. The plant is configured such that there are two banks of NF trains (North and South) and two clearwells (East & West), where each bank is dedicated to a specific clearwell. This configuration has let to operational hurdles towards maintaining a finished water quality. Hobart has historically maintained a raw water blend of 30 percent of the plant's capacity but has reduced blend flow percentages to reduce DBP formation potential in the finished water. The existing post-treatment stabilization system serves to supplement the reduction in hardness and alkalinity otherwise gained through raw water blend.

The goal of the membrane softening water treatment process is to produce water that is free of salts, low in hardness and organics. In doing so, other more desirable constituents, such as hardness and alkalinity, are removed from the water, leading to a less stable finished water quality. These types of characteristics in membrane permeate water quality warrant post-treatment stabilization processes which add chemicals back into the water to produce a less corrosive, slightly scale-forming and aesthetically pleasing water to consumers. Post-treatment of nanofiltration (NF) permeate is especially necessary for compliance with the United States Environmental Protection Agency's (USEPA) Lead and Copper Rule (LCR). The LCR establishes action levels of 0.015 mg/L for lead and 1.3 mg/L for copper at consumer's taps and requires corrosion control measures be implemented if more than 10 percent of the tap water samples collected during any monitoring period exceed these levels. Post-treatment stabilization is therefore necessary to inhibit corrosion and preserve the distribution system.

For years, raw water blending and zinc orthophosphate (ZO) were the methods used to stabilize the membrane treated product water. Although this method was used to both inhibit corrosion and increase alkalinity and hardness in the finished water, the alkalinity was still low (less than 20 mg/l as $CaCO_3$). Finished water quality fluctuations would sometimes create turbid conditions in the finished water when the zinc orthophosphate would come out of solution, a phenomenon which only occurred when pH exceeded 8.3. Raw water blending also resulted in an increase in other constituents which were already removed through the membrane softening process, such as sodium, chlorides, and specifically organics which resulted in increased disinfection byproducts (DBPs) into the distribution system.

In order to address these issues, a finish water stabilization study was prepared for Indian River County which outlined alternatives for post-treatment stabilization. The results of the study recommended pilot testing and subsequent construction of a carbonic acid solution and lime slurry addition to the degasified permeate at both water treatment facilities (RO Plants Lime Slurry Addition, completed in spring 2014). The intent of the project was to primarily increase finish water alkalinity and improve overall stability through remineralization without the use of zinc orthophosphate corrosion inhibitor. This project was successfully implemented and both WTPs have been operating with a combination of lime slurry and carbonic acid solution for approximately seven (7) years. Design water quality goals for alkalinity and hardness have been achieved and maintained since this project was completed, with values ranging from 60-70 mg/L as $CaCO_3$ and 80-100 mg/L as $CaCO_3$, respectively. The following table presents the current finished water quality values for Hobart and Oslo, as well as the goals that were established during the previous investigation and PDR for the finished water stabilization system:

Table 1 - Finished Water Quality Goals

Water Quality Parameter	Goal	Current Water Quality		State Designated Optimal Water Quality Parameters @ POE***
		Hobart	Oslo	
pH	**8.3**	8.15	8.2	7.9 - 8.5
Calcium Hardness (mg/L as CaCO3)	**70**	90	85	60 - 100
Total Hardness (mg/L as CaCO3)	**120**	115	110	N/A
Alkalinity (mg/L as CaCO3)	**70**	66	62	40 - 80
LSI*	**0.1 – 0.2**	0.07	0.07	N/A
CCPP*	**0.5 – 10.0**	0.43	0.38	N/A
TDS (mg/L)	**300-350**	275-315	275-315	N/A
Dissolved Inorganic Carbonate (mg C/L)	**17**	16	16	N/A

* Calculated using RTW Model

** Predicted utilizing EPA Guidance Manual for Selecting Lead and Copper Control Strategies

*** From IRC reporting Format 62-550.730(4)©

POST-TREATMENT STABILIZATION DESCRIPTION

Carbonic acid solution (H_2CO_3) is used for re-carbonation and to assist the calcium addition increase alkalinity of the product water. This system reduces pH of the product water stream and converts hydroxide to bicarbonate and carbonate species to enhance lime and/or caustic addition. The H_2CO_3 feed system provides buffering capacity for the product stream but does not add alkalinity by itself. The combination of this system with lime helps increase alkalinity and hardness of the finished water. H_2CO_3 lowers pH of the degasified permeate to make it possible for the water to dissolve or uptake more lime without the dramatic pH increase that would otherwise occur through lime addition by itself.

This system includes a refrigerated storage and receiver tank and utilizes a Pressure Solution Feed (PSF) system manufactured by $TomCO_2$ Systems® (Loganville, GA) to add carbonic acid solution to the clearwell. The PSF system injects pressurized CO_2 gas into a side stream of pressurized degasified permeate to dissolve the CO_2 into solution. This reaction generates H_2CO_3 that is added into the degasified RO product water. Hobart and Oslo contain two PSF panels, each intended to be dedicated to a clearwell (Hobart) or clearwell bay (Oslo), two carrier water pumps to elevate the pressure of the water stream, and diffuser injection assemblies installed at the end of the degasifier down comer pipe. There is not a redundant PSF cabinet at either WTP. The PSF system, in conjunction with the pre-treated and acidified raw water blend, has demonstrated the ability to provide adequate buffering capacity with pH ranges of 5-5.5, pre lime addition.

The lime slurry feed system is a proprietary system provided by Burnett, Inc. (Campobello, SC). The system includes a bulk storage tank, make-up water supply, mixer, and diaphragm pumps, and a patented lime slurry chemical. The system includes dedicated chemical feed lines to each degasifier bay and variable speed mixers to enhance the mixing and dissolution of lime slurry. The lime slurry system operates at a dosage setpoint with pH trim control via submersible probes installed at the end of the clearwell structure. Lime slurry is added to increase pH, add hardness, and form alkalinity with the buffering capacity provided by the TomCO2® system. The addition of calcium hydroxide, or lime, is a cost-effective finished water stabilization method. It provides enhanced stability in the water by increasing alkalinity and provides a more consistent method of forming a protective film on the interior surface of distribution system piping and components. Lime slurry has been used extensively in the water treatment industry for many years. It has been typically used for lime softening of hard waters and more recently as a finished water stabilization method of very soft waters, such as RO & NF permeate waters. Several installations in Florida are in operation at water treatment plants for stabilization of product waters. It is a relatively simple system and its operation is familiar to most water plant operators. The process generally consists of H_2CO_3 addition followed by lime slurry addition and mixing. H_2CO_3 is added to lower pH and enhance dissolution of the lime which increases the alkalinity of the blended stream. The lime slurry raises the pH, adds calcium hardness to the stream, and increases the alkalinity all at the same time.

Photo 1 - Oslo Post-Treatment Facilities

Photo 2 - Clearwell Weir

To date, the post-treatment system has yielded favorable water quality results which has enhanced the County's control of corrosion within the system. One adverse effect of the carbonic acid and lime slurry process has been the inability to dissolve all of the solids that are present in the lime slurry solution, mainly due to the trace impurities that exist in the lime slurry. Since implementation, IRCU has noted difficulties in maintaining turbidity less than 1 ntu prior to transfer pumping product water to ground storage. This issue is not unique as other Southeastern Florida membrane facilities with this post-treatment stabilization process have experienced the same, or similar impact, of additional turbidity from the lime slurry system.

In 2016, IRCU noted sedimentation at the bottom of the ground storage tanks that was not present prior to the lime slurry system. Samples were taken and sent to a lab and appear to be consistent with the lime slurry product sheets. This effort was duplicated by another nearby municipality and the findings were similar in that much of the insoluble matter was primarily calcium, with lower amounts of aluminum, iron, silica and zinc. The following photo illustrates the sediment found at the WTP and re-pump ground storage tank (North Beach).

Photo 3 - Ground Storage Tank Sediment

Water Quality

PARAMETERS AT POE

Hobart and Oslo provide finished water that is characteristically higher in hardness and alkalinity concentrations for a Floridan membrane plant, this is primarily due to the quality of source water and IRCU's ability to blend. Alkalinity in the finished water provides resistance to pH changes in the system, whether it be from age, temperature, loss of residual, etc. Historically, both WTPs have shown to exhibit a degree of pH fluctuation at POE which operations has primarily attributed to the added turbidity from lime slurry feed or the SCADA's system ability to respond to set point ratios and pH trim functions.

IRCU desires to maintain finished water turbidity of approximately 1 ntu and pH of 8.3. Operations has noted difficulty in achieving this target with the lime slurry system, as the pH adjustment after carbonic acid solution system results in variable turbidity values in the finished water. Furthermore, based on differing qualities of the lime slurry that is delivered, operations has had a difficult time "dialing in" a specific flow setpoint and achieving consistent pH and turbidity. Based on operational data, these values can vary from 1 – 4 ntu, all while the system is working to achieve the same pH setpoint value. This problem is exacerbated at Hobart, where operations has to essentially run two separate WTP processes with each bank of four NF trains tied to a specific clearwell. To counteract the water quality variation at Hobart, IRCU had implemented caustic feed to supplement the pH and alkalinity increase exhibited by the Cal~flo system, without the added turbidity. This process change was completed in 2016 (during Phase C of the corrosion investigation). Figures 1 and 2 demonstrate a tighter window of pH ranges at Hobart primarily due to the consistent results of caustic feed. Conversely, these figures show that Oslo is able to sustain tighter window for alkalinity and hardness, primarily because the lime slurry system is the sole source of pH adjustment.

The following graphs display calcium, alkalinity, and pH values from both facilities at POE:

Figure 1: Oslo Water Quality Parameters at POE

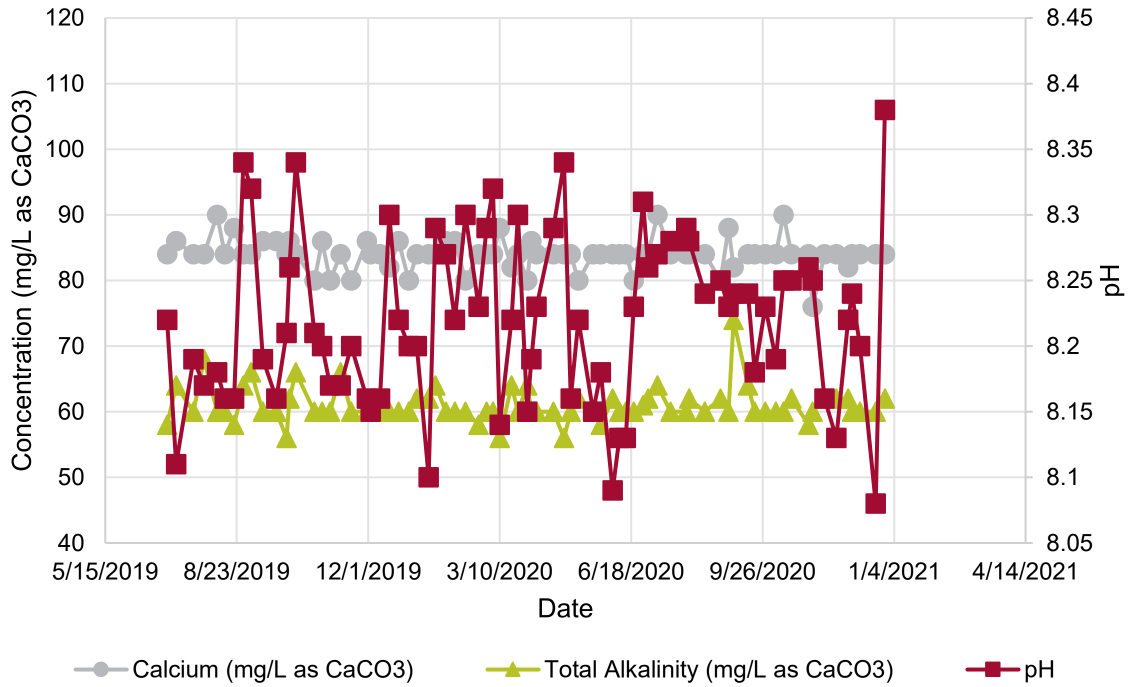
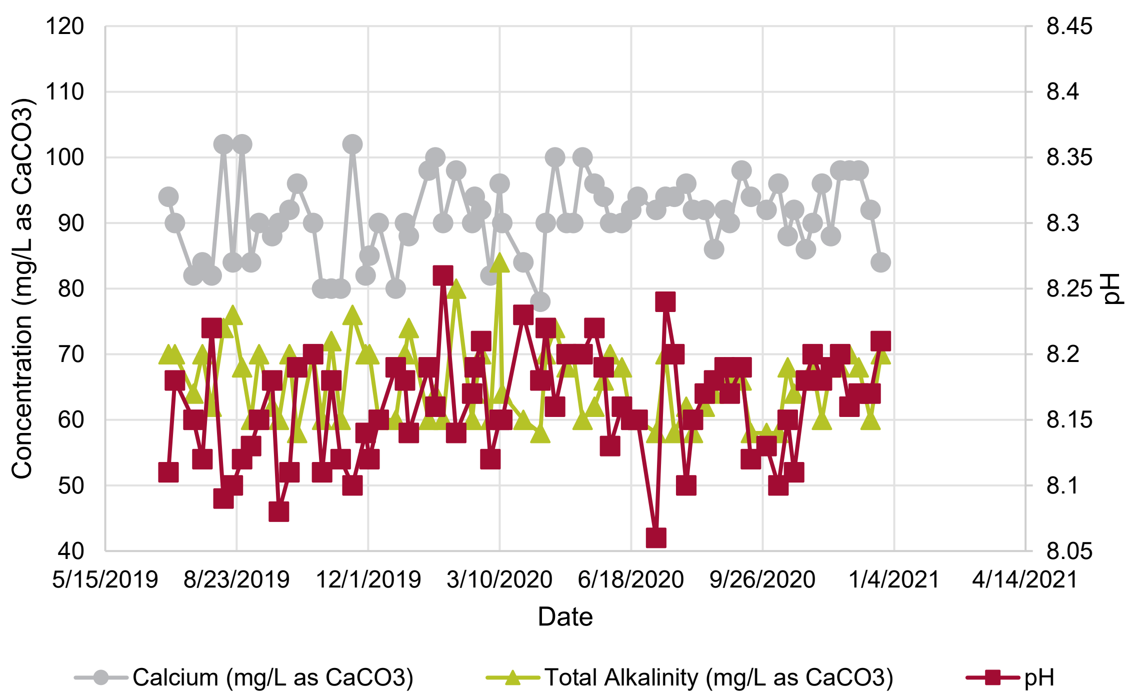


Figure 2: Hobart Water Quality Parameters at POE



Recently, the EPA issued the proposed revisions to the LCR (Lead and Copper Rule Revision) that proposed removal of calcium as a water quality parameter for corrosion control. This development deviates from corrosion indices, such as LSI and CCPP as being indicators of corrosion control, due to their reliance on calcium hardness to yield scale-forming water. In its place, parameters like alkalinity, dissolved inorganic carbonate (DIC), and orthophosphate residual are considered for enhancing corrosion control. Orthophosphate inhibitors are used to generate a protective film on the inside of distribution and customer plumbing, while also providing alkalinity to resist pH changes.

DISTRIBUTION SYSTEM

From January through March 2021, IRCU has received customer complaints regarding water quality aesthetics. These complaints are variable in description of color, smell, and taste. The complaints were reviewed throughout the system and incorporated in the water system model to understand if there was a direct relationship with water age. This exercise was inconclusive, as the complaints were random in location and inconsistent with regards to description and water age. However, one common theme from some of the customer complaints is the presence of turbidity (cloudiness, haziness) in the finished water and the ability to reduce this turbidity through flushing of the distribution mains nearby and the customer's plumbing. In one instance, IRCU sampled the water that was flushed from the hydrant and discovered elevated concentrations of calcium, magnesium, iron, and aluminum. Each of these constituents listed is present in the lime slurry statement of content and may have attributed to the water quality discovered. It appears that some areas within the system, in addition to dead end runs, turbidity appears to concentrate until it reaches the customer's residence, where the complaint will ensue, and subsequent flushing will restore water quality in the area. This appears to be a consistent theme for complaints through the system. In effort to address these complaints, IRCU is in the process of evaluating system flushing program.

Since 2014, IRCU has conducted water quality sampling (approximately once every 3 months) from the six (6) DBP sampling locations in the distribution system. These sampling locations vary in terms of water age, and locations range from Gifford to the Roseland areas. The water quality parameters tested for consist of calcium, alkalinity, pH, temperature, chlorine residual, and pH. Noteworthy trends include the following:

1. IRCU's ability to increase alkalinity concentrations at each of the six locations. This has translated to less variable pH values measured during the respective sampling events.
2. Decreasing pH throughout the system. The data indicates finished water is trending from the goal of ~8.3 towards 8.0. This pH reduction may have attributed to the increase in Lead and copper 90th percentile values discussed herein.

The following graphs are provided for each of the six (6) sample locations to demonstrate the trends described herein:

Figure 3: 13180 Highway A1A

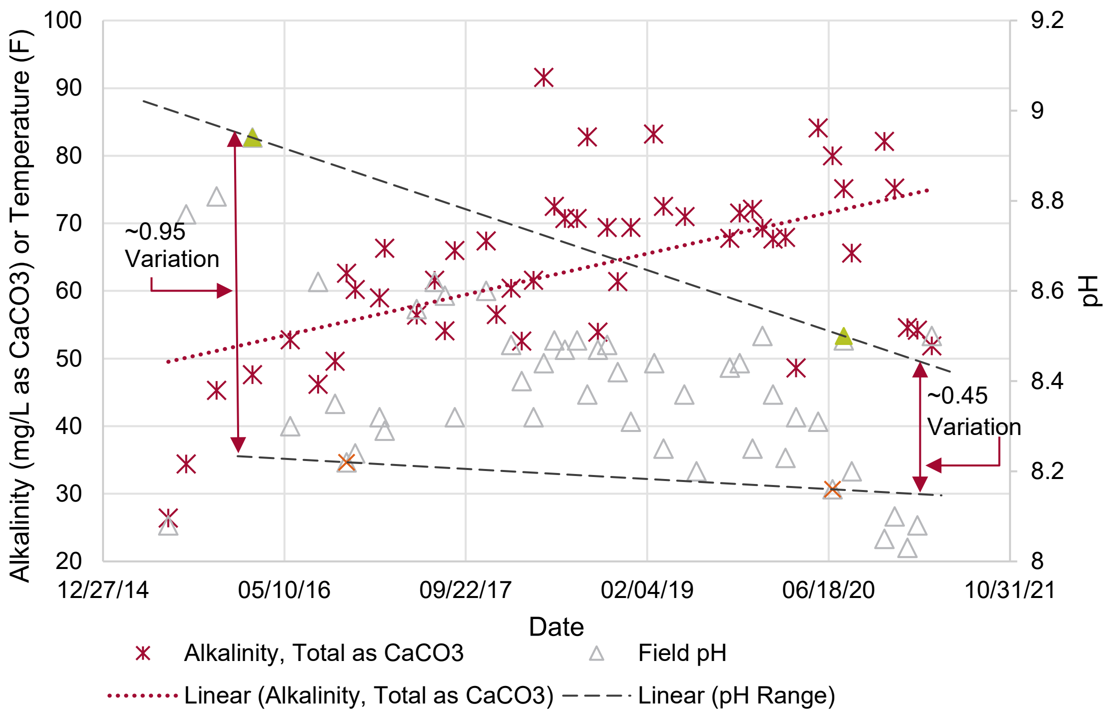


Figure 4: 5110 Indian River Drive

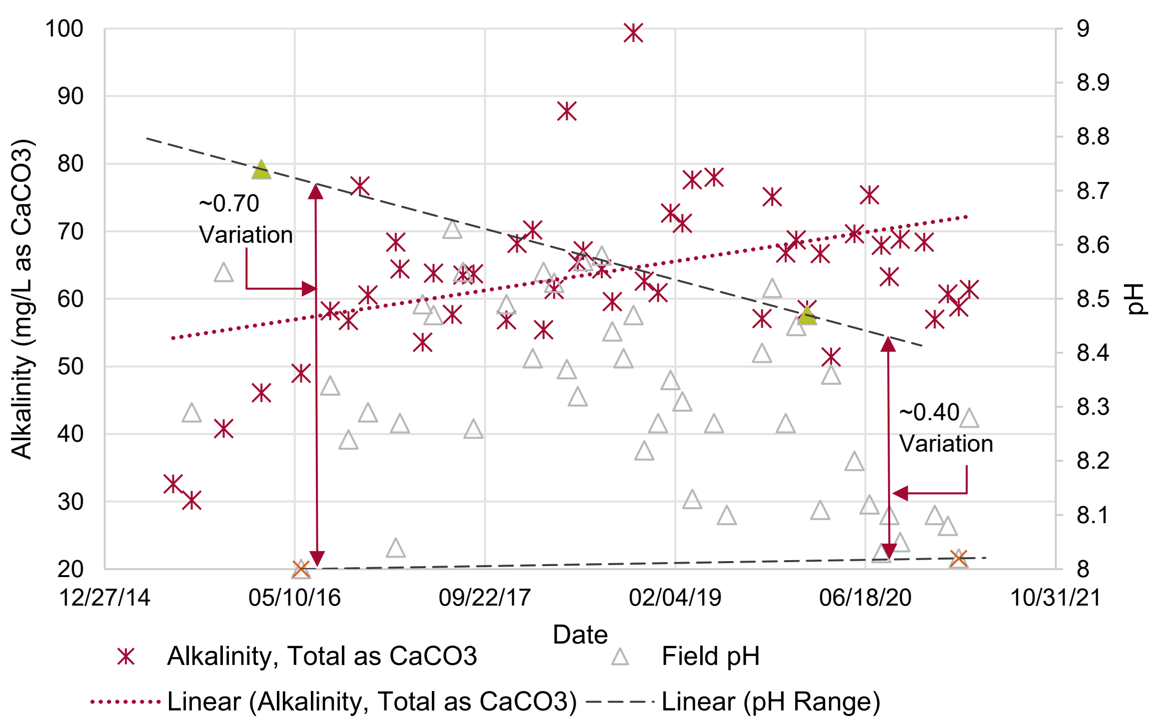


Figure 5: 1824 94th Drive

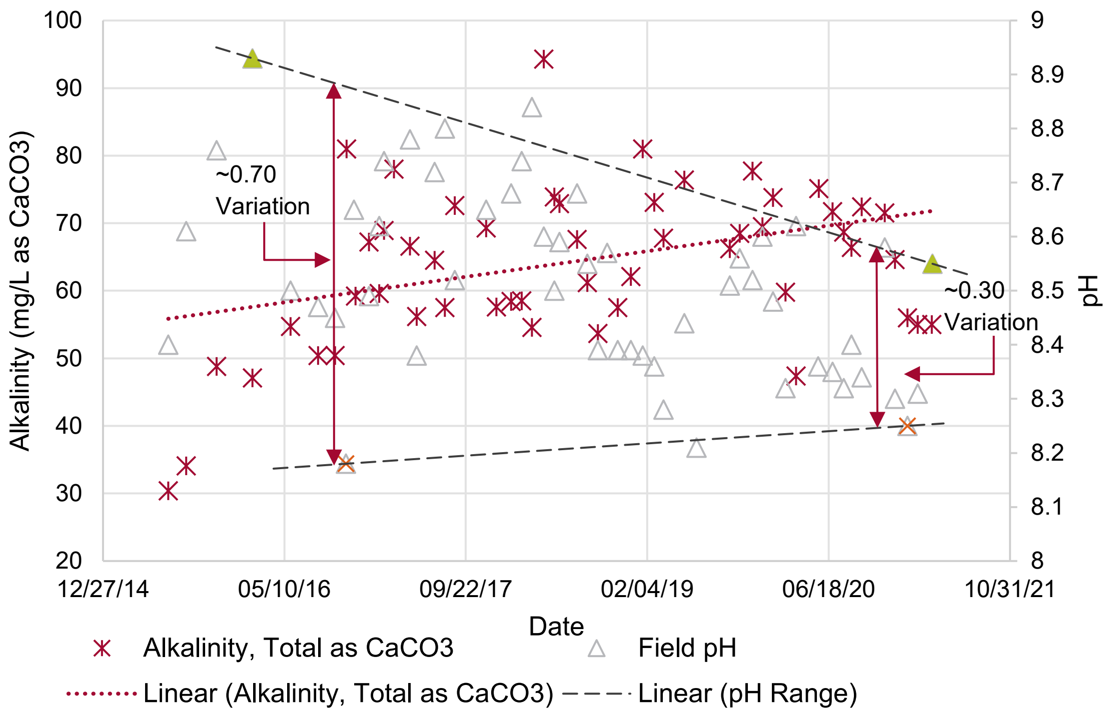


Figure 6: 5920 Old Dixie Hwy

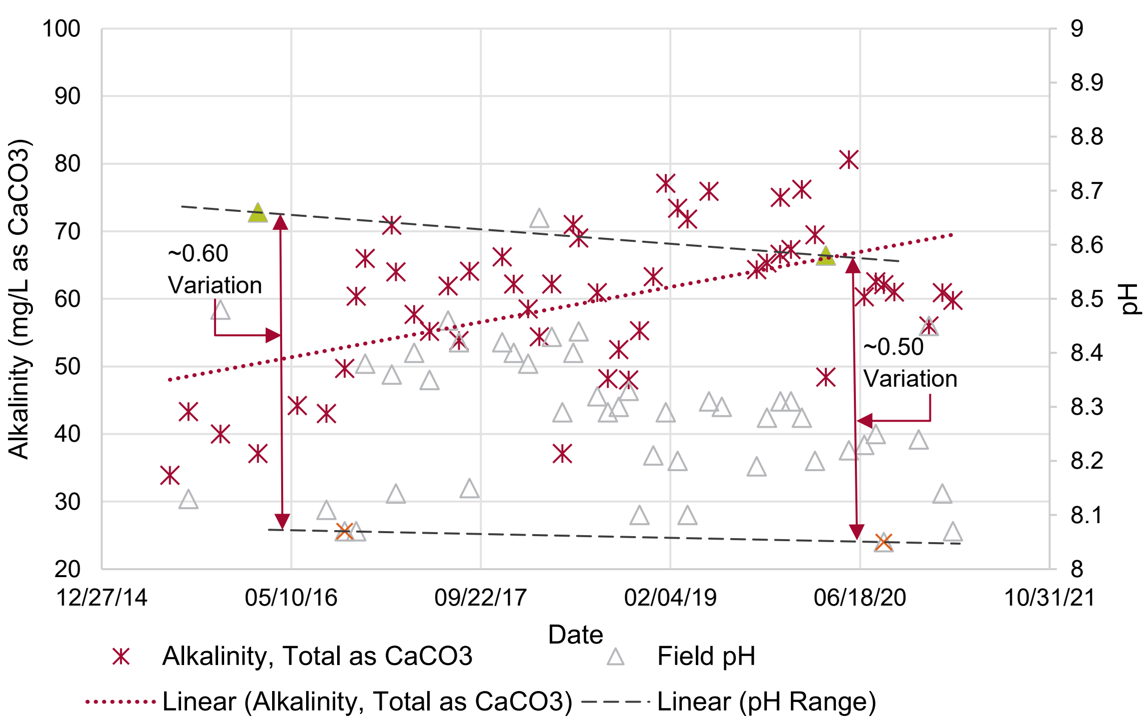


Figure 7: 830 Schumann Drive

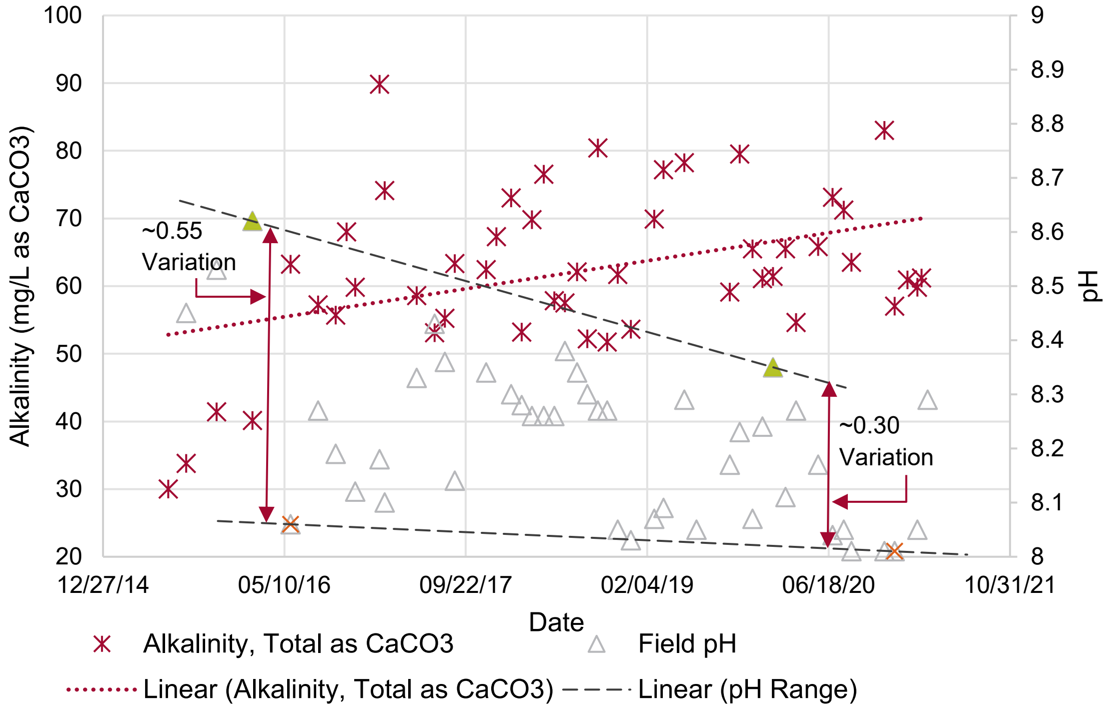
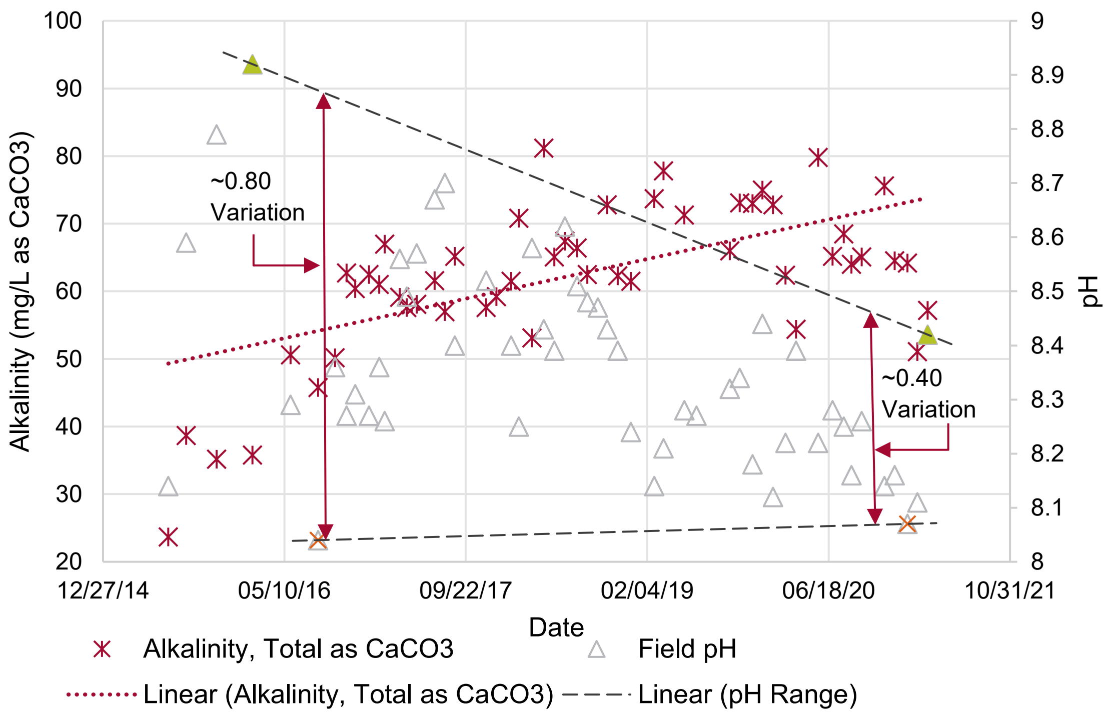


Figure 8: 14499 US Hwy 1



Lead and Copper Review

United States Environmental Protection Agency's (USEPA) LCR component of the SDWA establishes action levels for lead and copper at consumers taps. Typically, sampling in a representative number of customer's taps is required every three years. The LCR establishes action levels of 0.015 mg/L for lead and 1.3 mg/L for copper, respectively at consumer's taps, and requires corrosion control measures be implemented if more than 10 percent (90th percentile) of the tap water samples collected during any monitoring period exceed these levels.

Lead sources in drinking water include lead service lines (LSLs), soldered joints, and brass (many of which are found on the customer's side of the meter). Copper plumbing and fixtures are primary contributors to its presence in the drinking water. Elevated lead and copper concentrations in drinking water can be correlated to the water chemistry's ability to propagate corrosion. Water is the universal solvent and there are many factors that contribute to corrosion, such as stray current (lightning), plumbing workmanship, defects in materials, velocity, contact with dissimilar metals, etc. Regardless of the water system, corrosion can and will occur. The LCR is in place to help guide utilities in controlling the rate of corrosion through setting action levels for lead and copper. Exceedance of these action levels described herein will result in regulatory enforcement of Optimal Corrosion Control Technique (OCCT), which requires utilities to investigate and implement corrosion control measures to mitigate lead and copper corrosion.

Indian River County Utilities remains compliant with the provisions of the Safe Drinking Water Act (SDWA), including the Lead and Copper Rule (LCR), a federal law that intends to protect public health through minimizing lead (Pb) and copper (Cu) levels in drinking water, primarily by reducing water corrosivity. The following sections discuss IRCU's historical LCR sampling data.

LEAD SAMPLING DISCUSSION

Lead enters drinking water primarily from the lead-containing solder and flux material used to join copper pipes in home plumbing and new cast-brass faucets (Cardels and Sorg 1990). The most important water quality parameters related to lead solubility are pH, alkalinity, dissolved inorganic carbonate, and ortho-phosphate levels (AWWARF 1990). A recent survey of lead at the consumer tap concluded that the highest lead levels were found in the newest plumbing systems onto which household electrical systems were grounded (Lee et. al. 1989). It was also demonstrated that controlling the pH values in water in the distribution system to greater than 8.0 and the addition of blended phosphate inhibitor reduced the home tap lead concentrations. Corrosion control methods that rely on adjusting the pH have been shown to be a cost-effective, reliable and the more common methods of treatment currently in practice today (Taylor, et.al., 1992; Vinci 1991; Maas 1991; McNally, et. al., 1993). IRCU utilizes pH, alkalinity and calcium carbonate adjustment techniques for finished water stabilization.

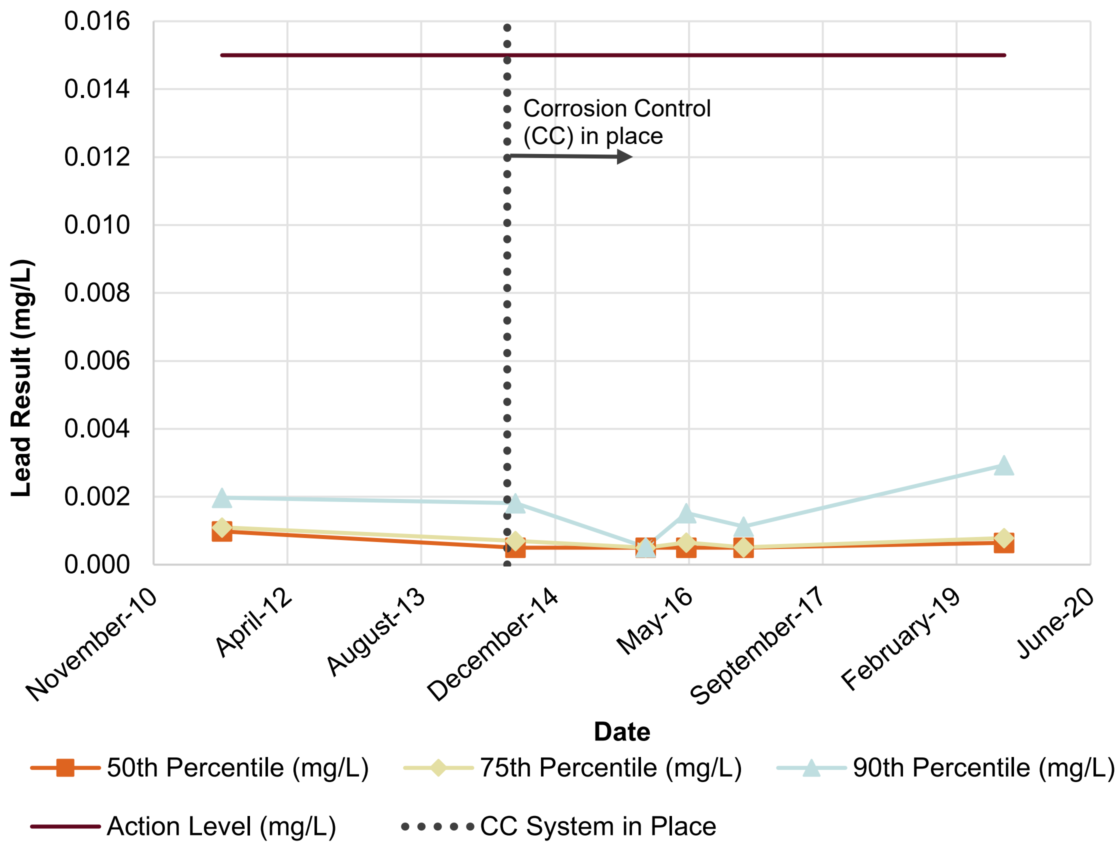
IRCU has maintained compliance with lead samples below the 90^{th} percentile action level of 0.015 mg/L. From 2011 through December 2015, 90^{th} percentile data displayed a downward trend. Since this sampling event, lead 90^{th} percentile data has trended upwards with 90^{th} percentile data increasing to 0.003 mg/L. Although 90% of the samples were at this value or lower, the average concentration of lead in the samples has maintained relatively consistent, with exception of the May 2016 LCR sampling event. In this instance, there was one outlier sample that was approximately 17 times greater than the next highest ranked lead sample, which contributed to the overall average increase but no impact to the 90^{th} percentile value.

Table 2: IRCU Lead Sample Tap Results

Sampling Date	Average (mg/L)	Maximum (mg/L)	50th Percentile (mg/L)	75th Percentile (mg/L)	90th Percentile (mg/L)	Action Level (mg/L)	Sample Size
Aug-11	0.002	0.014	0.001	0.001	0.002	0.015	50
Aug-14	0.001	0.004	0.001	0.001	0.002	0.015	50
Dec-15	0.001	0.001	0.001	0.001	0.001	0.015	50
May-16	0.008	0.360	0.001	0.001	0.002	0.015	50
Dec-16	0.0007	0.0029	0.001	0.001	0.001	0.015	50
Aug-19	0.001	0.0057	0.00064	0.0007875	0.003	0.015	52

Overall, lead levels in the drinking water are well below the action level of 0.015 mg/L, or 15 parts per billion. The slight variation of 1 part per billion from the previous sampling event 3 years prior should be monitored but is not cause for concern. Since this testing is conducted on a triennial basis, there is insufficient data to support the notion that lead corrosion rates have increased. In order to more accurately track lead corrosion, IRCU may consider conducting their own lead and copper sampling (separate from LCR sampling) on a more frequent basis (bi-annually or annually) to have a better understanding of the lead concentration trends.

Figure 9: Lead Sample Tap Results



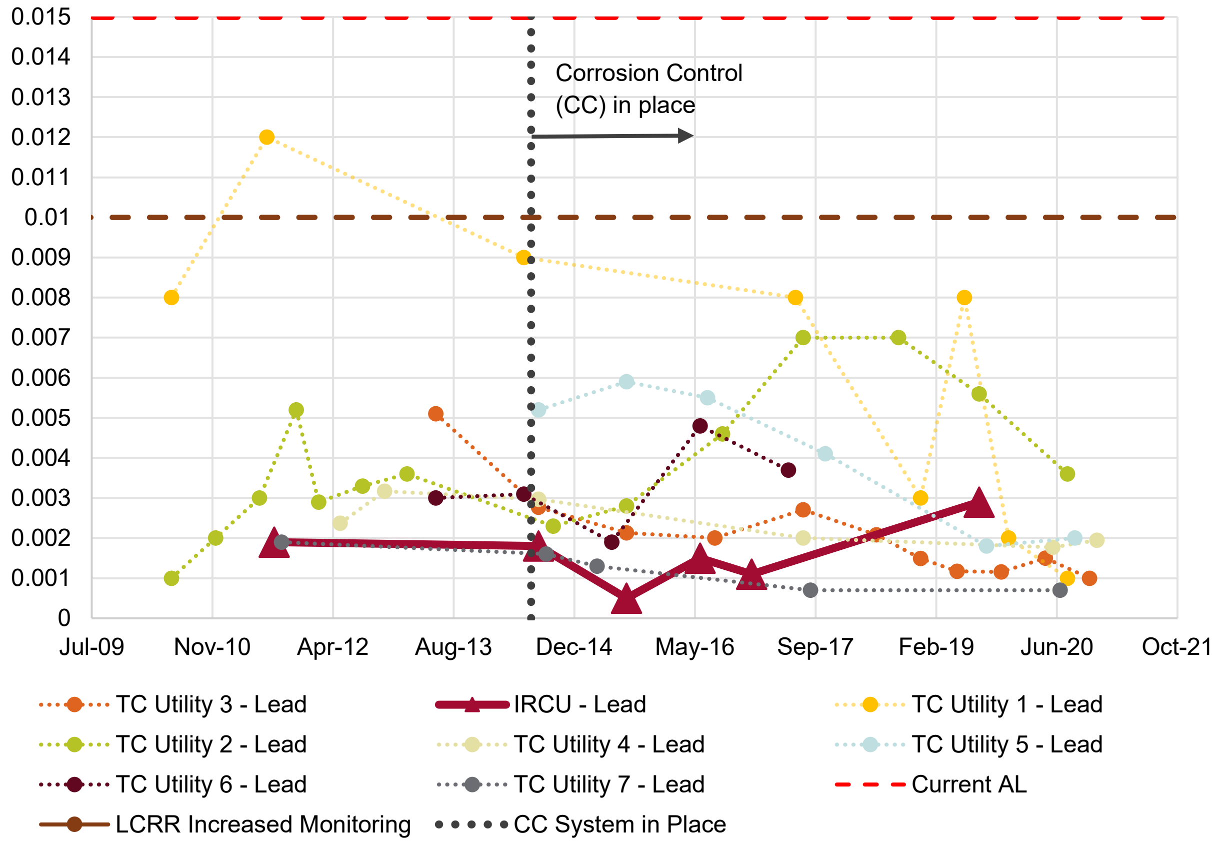
The following table presents the sites that exhibited the highest ranking with respect to lead sample results:

Table 3: Lead Rankings by Location and WTP

Location	Year	Lead Rank	# of Samples	WTP
1850 6th St	Aug-11	50	50	OSLO
681 23rd Place SW	Aug-11	47	50	OSLO
856 10th Court	Aug-11	49	50	OSLO
24 Highland Drive SW	Aug-11	48	50	OSLO
1021 2nd Street	Aug-11	42	50	OSLO
1050 31st Ave	Aug-11	40	50	OSLO
2206 16th Ave	Aug-14	50	50	OSLO
8345 Chinaberry Road	Aug-14	49	50	HOBART
2075 7th Drive SW	Aug-14	48	50	OSLO
9612 Riverside Drive	Aug-14	47	50	HOBART
675 4th Street	Dec-15	50	50	OSLO
2465 17th Ave SW	Dec-15	49	50	OSLO
1405 82nd Ave	Dec-15	48	50	OSLO
1175 Winding Oaks	Dec-15	47	50	HOBART
1980 Coco Plum Lane	Jun-16	49	50	HOBART
1235 Palmetto Court	Jun-16	48	50	HOBART
8388 Calamandren Way	Jun-16	50	50	HOBART
2046 8th Ave SW	Jun-16	47	50	OSLO
5 Sunset Drive	Aug-19	52	52	HOBART
302 Citrus Ave	Aug-19	51	52	HOBART
869 Robin Lane	Aug-19	50	52	HOBART
449 Alamonda Ave	Aug-19	49	52	HOBART

As shown, over time, the highest-ranking sites appear to have shifted from areas served by Oslo WTP to areas in the system primarily served by Hobart. The following graph presents IRCU's lead sample data with respect to other nearby treasure coast utilities that utilize similar source water and treatment techniques. The figure also displays the lead trigger level (TL) that is proposed under the Lead and Copper Revision Rule (not promulgated at the time of this report). Amongst other proposed requirements, such as LSL replacement and public outreach, the TL requires utilities with 90th percentile values between 10-15 ppb to initiate planning, additional monitoring (annually) and implement treatment requirements in effort to mitigate lead corrosion rates. IRCU has maintained 90th percentile values below 5 ppb, which EPA defines as the Practical Quantitation Level (PQL) for lead. This presents a lesser degree of confidence that lead is present in the finished water at the reported concentration.

Figure 10: Treasure Coast Utilities Lead 90th Percentile Data



Utility	Treatment	Stabilization Method
TC Utility 1	RO & NF	Caustic, Corrosion Inhibitor
TC Utility 2	RO & Blend	Raw Water Blend, Caustic
TC Utility 3	RO	CO2, Caustic, Corrosion Inhibitor
TC Utility 4	NF & Blend	Caustic, Corrosion Inhibitor
TC Utility 5	RO & NF	CO2, Caustic, Corrosion Inhibitor
TC Utility 6	RO & Lime Softening	Caustic, Corrosion Inhibitor
TC Utility 7	RO & Lime Softening	Caustic, Blending

As shown, IRCU's lead sample data is relatively consistent with seven (7) analogous water system purveyors in the treasure coast area and in compliance with the LCR.

COPPER SAMPLING DISCUSSION

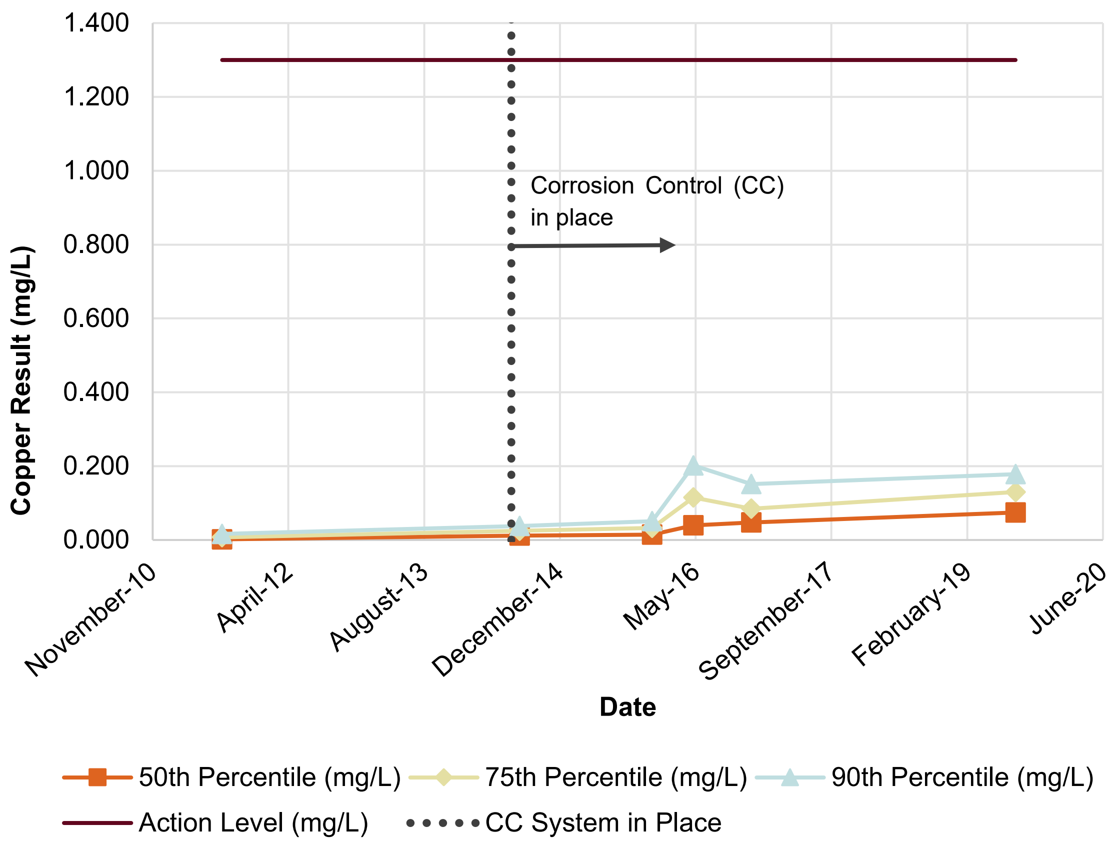
Copper enters drinking water primarily from distribution and copper piping materials used in household plumbing. The corrosion rate of copper is affected by pH, alkalinity, dissolved oxygen, chlorine residual and possibly calcium (AWWARF 1985). Copper-containing protective corrosion scales formed in non-phosphate-inhibited waters are pH sensitive (Reiber 1989). Experimental studies that investigated the effects of generalized corrosion in service piping systems have shown that soft, acidic or low pH waters develop high concentrations of copper during standing or stagnant conditions (Meyer 1981). The corrosion potential of the water was found to be less apparent in moderate- to high-alkalinity waters in which there was sufficient bicarbonate that allowed a protective film to form on the pipe wall. Increasing the pH to above pH 8.0 significantly reduces the copper solubility of water (AWWARF 1985; McNally, et. al., 1993). IRCU maintains relatively moderate alkalinity concentration (~60 mg/L as $CaCO_3$) at the Point-of-Entry to the distribution system at Hobart and Oslo.

IRCU has maintained compliance with copper concentrations less than 90th percentile action level of 1.3 mg/L. Since 2011, the copper sample results in the 50th, 75th, and 90th percentile have increased slightly up until 2015, with a marked increase in the May 2016 data. There was a slight increase from 2011 to 2014, and from 2014 to 2015. The copper levels from 2015 to May 2016 showed a greater increase, where the 90th percentile of copper levels in the distribution system quadrupled. The December 2016 exhibited a 25% decrease in the 90th percentile values obtained in May 2016. The reduction in copper concentrations may be contributed to the increase in alkalinity and hardness in the finished water implemented in September 2016. Although this is an improvement, the statistical values are still currently higher than those observed in sampling prior to May 2016.

Table 4: IRCU - Copper Sample Tap Results

Sampling Date	Average (mg/L)	Maximum (mg/L)	50th Percentile (mg/L)	75th Percentile (mg/L)	90th Percentile (mg/L)	Action Level (mg/L)	Sample Size
Aug-11	0.008	0.150	0.002	0.007	0.017	1.3	50
Aug-14	0.019	0.120	0.012	0.025	0.038	1.3	50
Dec-15	0.022	0.075	0.015	0.033	0.051	1.3	50
May-16	0.075	0.350	0.040	0.115	0.202	1.3	50
Dec-16	0.071	0.300	0.048	0.084	0.151	1.3	50
Aug-19	0.086	0.370	0.075	0.130	0.178	1.3	52

Figure 11: Copper Sample Tap Results



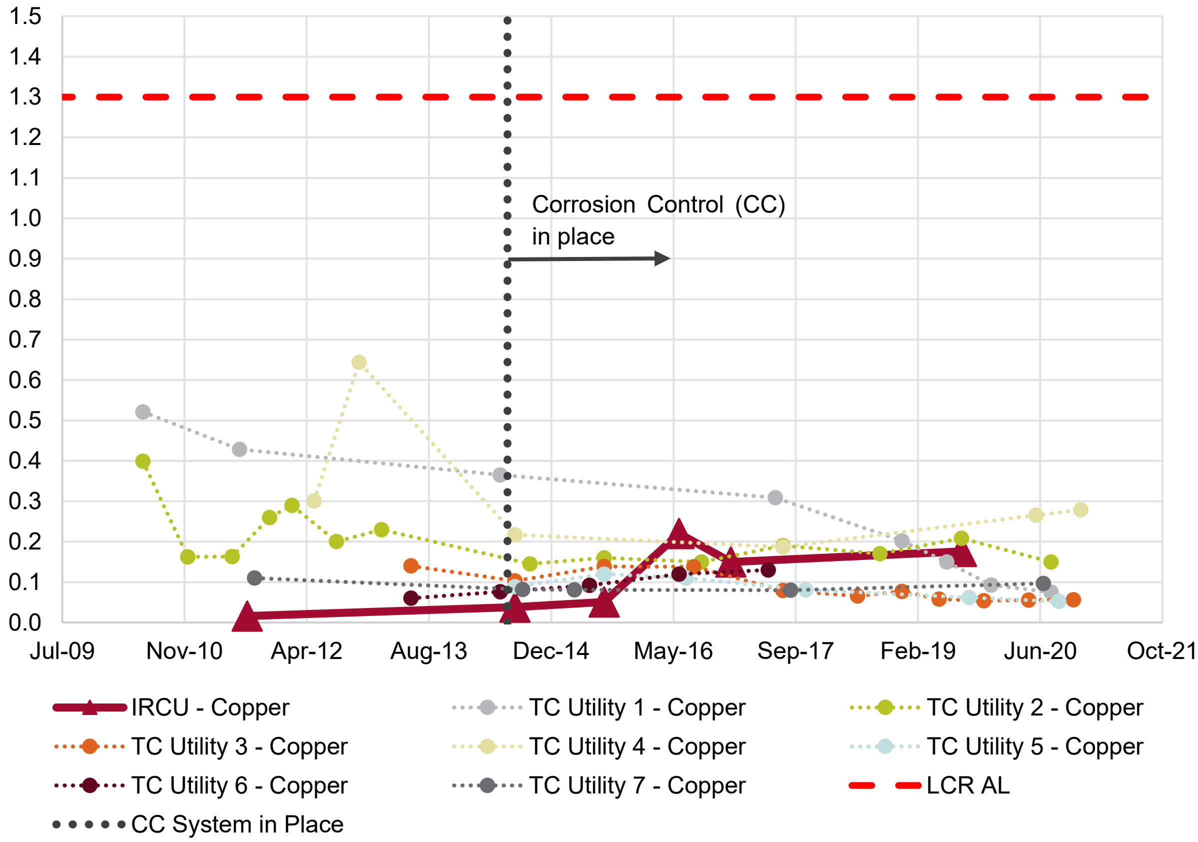
The following table presents the sites that exhibited the highest ranking with respect to copper sample results:

Table 5: Copper Rankings by Location and WTP

Location	Year	Copper Rank	# of Samples	WTP
1850 6th St	Aug-11	49	50	OSLO
681 23rd Place SW	Aug-11	50	50	OSLO
24 Highland Drive SW	Aug-11	45	50	OSLO
1021 2nd Street	Aug-11	48	50	OSLO
1050 31st Ave	Aug-11	47	50	OSLO
2206 16th Ave	Aug-14	48	50	OSLO
8345 Chinaberry Road	Aug-14	50	50	HOBART
2075 7th Drive SW	Aug-14	49	50	OSLO
9612 Riverside Drive	Aug-14	47	50	HOBART
1991 W Sand Dollar Lane	Dec-15	50	50	HOBART
150 43rd Ave	Dec-15	49	50	OSLO
3575 Marthas Lane	Dec-15	48	50	HOBART
1021 2nd Street	Dec-15	47	50	OSLO
9455 Frangipani Drive	Jun-16	50	50	HOBART
1991 W Sand Dollar Lane	Jun-16	49	50	HOBART
1980 Coco Plum Lane	Jun-16	48	50	HOBART
1235 Palmetto Court	Jun-16	47	50	HOBART
1175 Winding Oaks	Nov-16	50	50	HOBART
1991 Sandpiper Road	Nov-16	49	50	HOBART
5730 Turnberry Lane	Nov-16	48	50	HOBART
9455 Fangipani Drive	Nov-16	47	50	HOBART
1582 Damask Lane	Aug-19	52	52	HOBART
5730 Turnberry Lane	Aug-19	51	52	HOBART
618 Browning Terrace	Aug-19	50	52	HOBART
1960 S Garden Grove Circle	Aug-19	49	52	OSLO

As shown, over time, the highest-ranking sites appears to have shift from areas served by Oslo WTP to areas in the system primarily served by Hobart. The following graph presents IRCU's copper sample data with respect to other nearby treasure coast utilities that utilize similar source water and treatment techniques.

Figure 12: Treasure Coast Utilities Copper 90th Percentile Data



Utility	Treatment	Stabilization Method
TC Utility 1	RO & NF	Caustic, Corrosion Inhibitor
TC Utility 2	RO & Blend	Raw Water Blend, Caustic
TC Utility 3	RO	CO2, Caustic, Corrosion Inhibitor
TC Utility 4	NF & Blend	Caustic, Corrosion Inhibitor
TC Utility 5	RO & NF	CO2, Caustic, Corrosion Inhibitor
TC Utility 6	RO & Lime Softening	Caustic, Corrosion Inhibitor
TC Utility 7	RO & Lime Softening	Caustic, Blending

As shown, IRCU's copper sample data is relatively consistent with seven (7) analogous water purveyors located in the treasure coast area and in compliance with the LCR. The slight variation in copper 90th percentile is noted and may be attributed to the pH variances in the distribution system. However, the copper data is indicative of non-corrosive water and correlates closely with other neighboring utilities along the southeast and Treasure Coast.

Disinfection Byproduct Review

The National Primary Drinking Water Regulations (NPDWRs) establish monitoring and other requirements for municipalities to achieve compliance with maximum contaminant levels based on locational running annual averages (LRAA) for total trihalomethanes (TTHMs) and haloacetic (HAA5) and maximum residual disinfectant residuals. The USEPA determined that regulating these two groups of DBPs would yield an overall reduction in all DBPs and set MCLs of 80 ppb and 60 ppb for TTHMs and HAA5s, respectively. Operational Evaluation Levels (OELs) are also established to provide greater level of guidance for water purveyors through putting higher weight towards the most recent quarter of DBP concentrations. These requirements are defined under the Stage 1 and Stage 2 Disinfection Byproducts Rule. The intent of this rule is to improve protection of public health through reducing exposure to disinfection byproducts, which may cause liver, kidney or central nervous system issues.

DBP formation is a function of total organic carbon (TOC) and bromide concentrations, disinfectant utilized and water age. Drinking water systems utilize disinfection to inactivate, or “kill,” viruses or organisms to protect customers from waterborne diseases and pathogens. IRCU utilizes source water from the upper Floridan Aquifer (UFA) for treatment, which is relatively free of TOC. The source water has hardness and alkalinity that is helpful in stabilizing the finished water, but also has bromide (ranging from 1-3 mg/L) which is a precursor to DBP formation. The membrane softening system rejects bromide similar to calcium, allowing for reduction in bromide species, but the pre-treated raw water bypass flows utilized for stabilization yield bromide concentrations, albeit minimal, in the finished water resulting in DBP formation. In reviewing the 2016-2021 DBP compliance sampling data, bromide species DBPs attribute to high percentage of the overall HAA5 and TTHM concentrations. Previous recommendations have been made, and implemented, to reduce blend water flows, thereby lowering the overall bromide concentrations in the product water and yielding reduced DBP formation. As discussed previously, there is an ongoing project to increase membrane softening capacity and reduce blend flows at Oslo to approximately 17%. The loss in alkalinity through reduced blend flow rate is to be offset through operational changes to increase carbonic acid solution and caustic feed for post-treatment. This change in blend percentage should be mimicked at Hobart to maintain consistent water quality throughout the system.

The following graphs display the LRAA and OEL values from 2016 – 2021 for the six (6) distribution sites for TTHMs and HAA5s.

Figure 13: TTHM Locational Running Annual Average (LRAA)

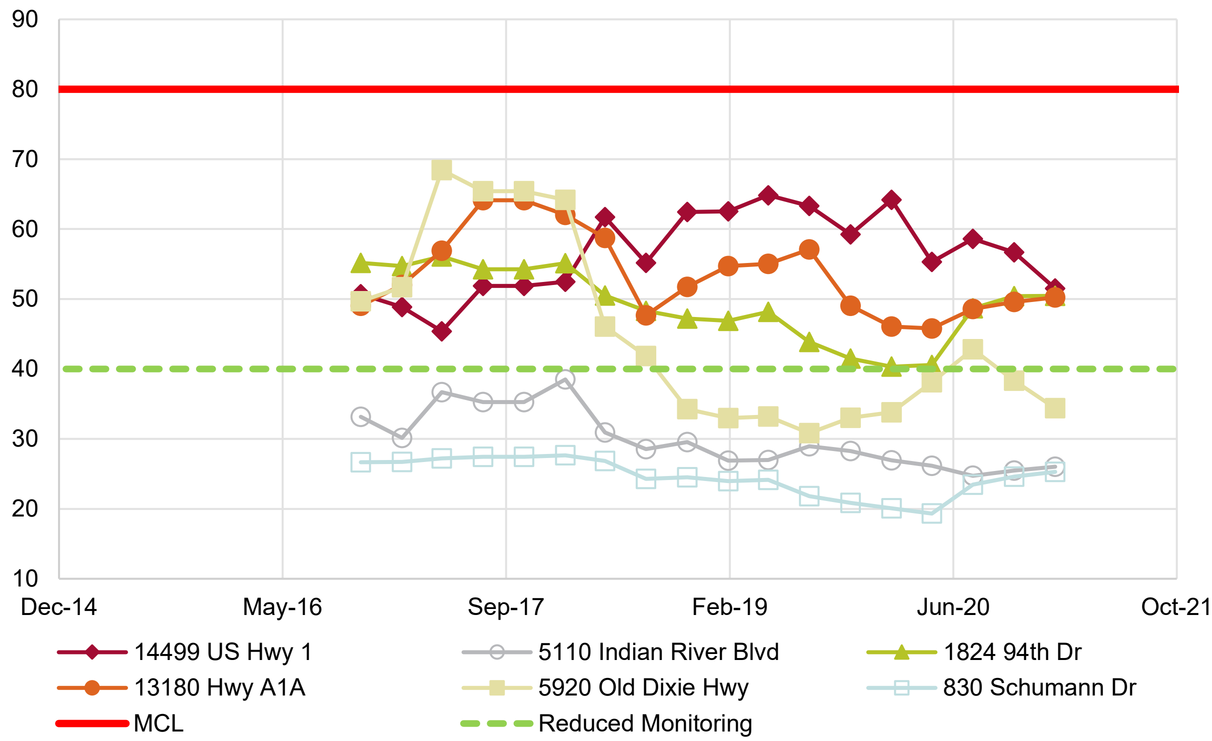


Figure 14: TTHM Operation Levels (OELs)

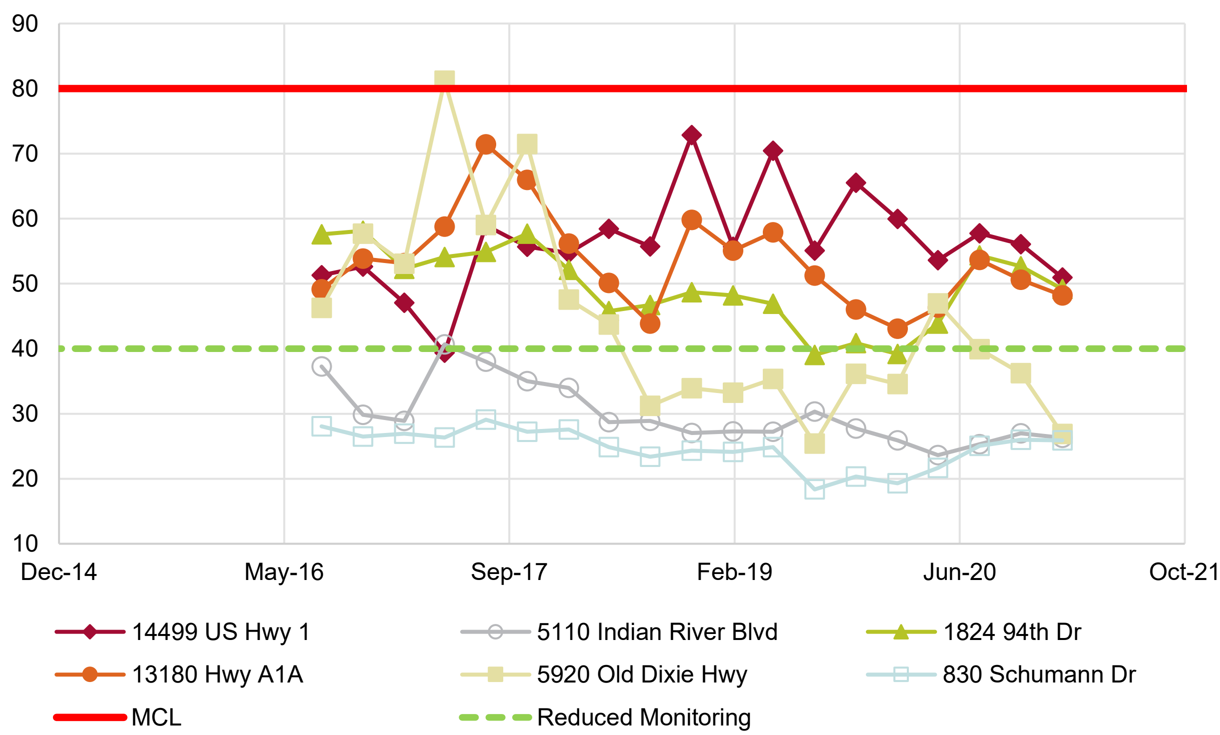


Figure 15: HAA5 Locational Running Annual Average (LRAA)

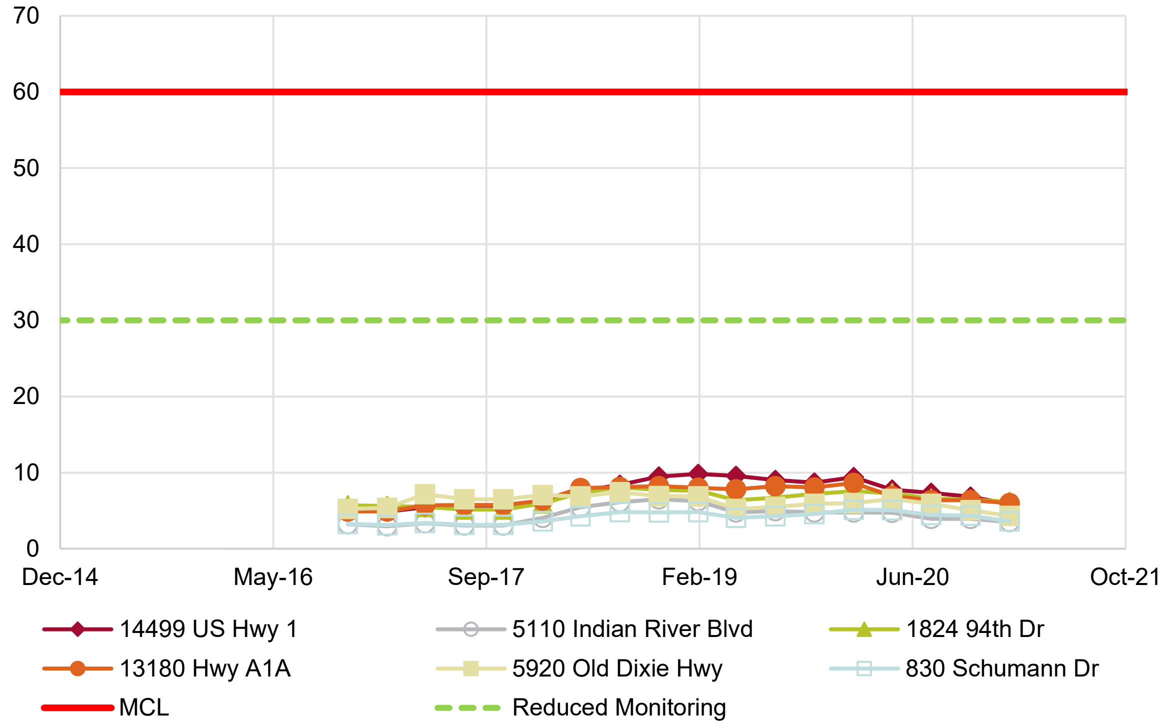
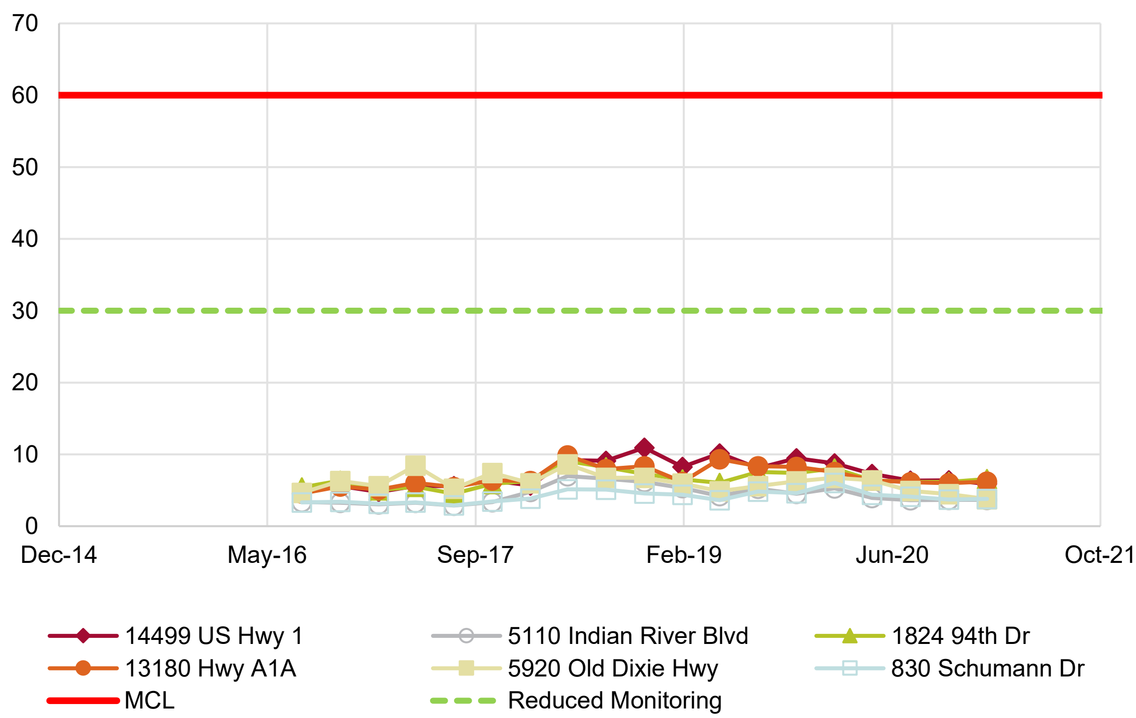


Figure 16: HAA5 Operational Evaluation Levels (OELs)



With exception of one (one) OEL exceedance in TTHM at a single location (2017 2nd Quarter), IRCU has maintained compliance with MCL values for TTHM and HAA5's with respect to the LRAA and the OEL. The DBP concentrations are not low enough to trigger reduced monitoring but appear to be exhibit a downward trend over the previous year.

The DBP sample data correlates well with the recently completed calibrated water model, where the areas in the distribution system that exhibit higher water age had higher concentrations of DBPs (between 144 and 168 hours). The water age map is included in Appendix A for reference.

Appendix A – IRCU System Water Age and Water Quality

IRCU System Water Age and Water Quality