Water Quality Compatibility Challenges in a Southwest Florida Regional System: Comprehensive Data Review and Tools to Predict Water Quality

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As regional interconnections among water supply systems increase statewide in order to meet potable water demands, a greater understanding of water quality issues is needed. The Peace River Manasota Regional Water Supply Authority (Authority) is an independent special district in southwest Florida operating as a regional wholesale water provider to Charlotte, DeSoto, and Sarasota counties, and the cities of North Port and Punta Gorda (Figure 1). These local government customers in turn serve over 600,000 retail customers across the region. The Authority meets the challenges in delivering water that can be effectively blended with each customer's finished waters, which are supplied from a variety of fresh groundwater, brackish groundwater, and surface water sources.

The Authority's surface water treatment plant experiences raw water quality variations due to seasonal trends and the use of aquifer storage and recovery wells, which impact the finished water quality entering the distribution system. Several water quality parameters vary with water age in the distribution system, including pH, chlorine residual, and corrosion control indices. To help manage the regional system and ensure continued delivery of high-quality water to customers, the Authority conducted a study to characterize regional and local finished water, transmission, and distribution system water quality.

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System Description and Operation

The Authority provides wholesale potable water to its customers with a permitted annual average flow of 32.8 mil gal per day (mgd). A summary of water supply characteristics of the Authority and its customers is presented in Table 1.

From 2011 to 2013, many of the Authority's customers purchased significantly more water from the Authority than they produced at their own water treatment plants (WTPs). Desoto County and Charlotte County purchased the majority of their water needs from the Authority. The North Port WTP had the capability to produce approximately 4 mgd from combined surface water and groundwater treatment trains and purchased the Authority's water on a consistent basis to meet the demand. Water in the distribution system of Sarasota County was a combination of water produced at its three WTPs (11 percent), water purchased from Manatee County (25 percent), and water purchased from the Authority (64 percent). Therefore, the water quality of the Authority either dominated or had a major impact on the overall distribution system water quality for every customer's system.

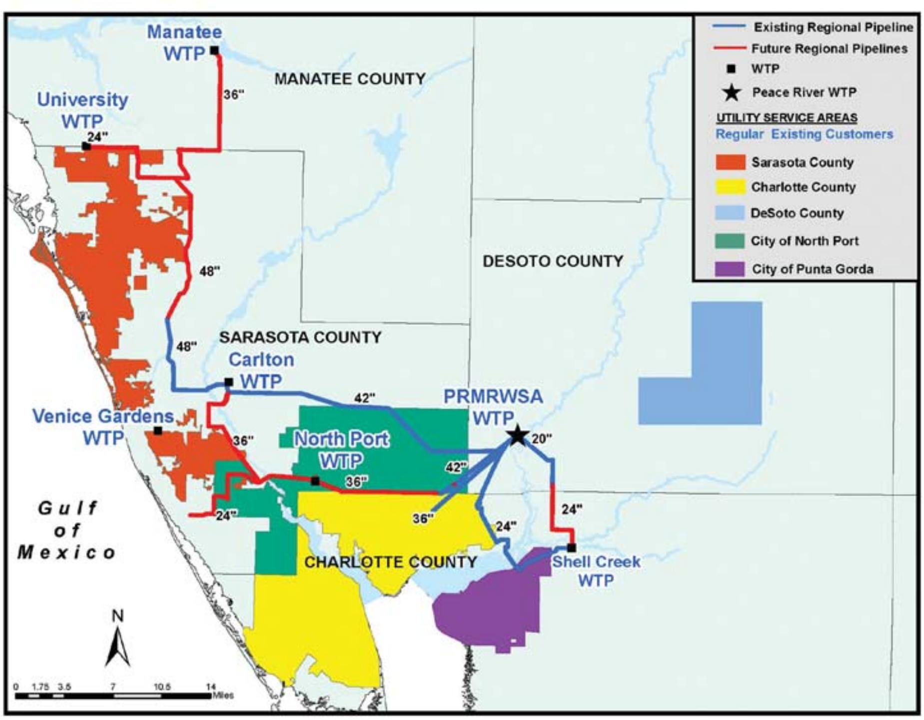

Figure 1. Schematic Diagram of the Authority System *(source: Peace River Manasota Regional Water Supply Authority Master Plan).*

Corrosion Regulations and Control Strategies

Lead and copper are present in materials used in water distribution systems (e.g., service lines, brass and bronze fixtures, solders, and fluxes). The U.S. Environmental Protection Agency (EPA) Lead and Copper Rule, or LCR [1] established action levels (ALs) for lead and copper of 0.015 and 1.3 mg/L, respectively, at the 90th percentile level. Three typical strategies can be used for corrosion control [2, 3]:

1. Calcium hardness adjustment (calcium carbonate precipitation)
2. Alkalinity and pH adjustment (carbonate passivation)
3. Corrosion inhibitor treatment (inhibitor passivation)

Calcium hardness adjustment involves the addition of a calcium source, such as calcium hydroxide ($Ca[OH]_2$), calcium chloride ($CaCl_2$), or calcium bicarbonate ($Ca[HCO_3]_2$), to precipitate calcium carbonate as a protective film on the inside of the pipe. A second strategy involving an increase in alkalinity and pH can be used to form a passivating metal carbonate film on the pipe interior through the addition of chemicals such as soda ash, sodium bicarbonate, and caustic soda. Both of these corrosion control strategies are monitored through the calcium carbonate equilibrium, based on the pH needed to maintain a calcium carbonate precipitation potential (CCPP) of 4-10 mg/L as $CaCO_3$. A third strategy consists of adding a corrosion inhibitor, such as phosphate. Divalent lead reacts with orthophosphate and forms a passivating lead orthophosphate film on the pipe interior. Orthophosphate appears to be most effective when the system pH is maintained within the range of 7.2 to 7.8, with increased phosphate precipitation metals like calcium above pH values of 7.8 [2]. Orthophosphate addition is beneficial for copper corrosion control, but a higher orthophosphate dose and residual are required, compared to lead corrosion control.

The Authority and City of North Port adjust alkalinity and pH as a corrosion control strategy and monitor the effectiveness through calcium carbonate equilibrium. Desoto County and Charlotte County purchased the majority of finished water from the Authority, so these systems also relied on a calcium carbonate equilibrium approach to corrosion control. Sarasota County dosed a phosphate-based corrosion inhibitor at each WTP and, therefore, the calcium carbonate equilibrium is not relevant.

Nitrification, an undesirable microbial process in the distribution system, can promote biofilm and decrease the disinfectant residual. Biofilm grows when organisms feed off nutrients in the drinking water, producing hydrogen ions that consume alkalinity and drop the pH. Systems with chloramine secondary disinfectants would benefit from keeping the pH above 8.0 to limit chloramine decay (Figure 2) and avoid dichloramines. They also would benefit from maintaining a total chlorine residual of 2.0 mg/L or greater, which is generally regarded as the level below which a system may begin to experience nitrification and biofilm growth [4, 5, 6]. Systems with chloramine secondary disinfectants and phosphate corrosion inhibitors compromise between the two competing pH ranges.

Table 1. Summary of Water Supply Characteristics of the Authority and its Customers

Responsible Utility*	Water Treatment Plant (WTP)	WTP Rated Capacity (mgd)	Raw Water Source	Treatment Type	Corrosion Control Strategy
The Authority	PRMRWSA WTP	48	Surface water	Conventional surface water w/ alum	Alkalinity and pH
Charlotte County	None**	-	-	-	Alkalinity and pH
Desoto County	None**	0.97	-	-	Alkalinity and pH
City of North Port	North Port WTP	4.4	Surface water and brackish groundwater	Conventional surface water w/alum and two-stage reverse osmosis (RO)	Alkalinity and pH
Sarasota County	Carlton WTP	12	Brackish groundwater	Electrodialysis reversal	Corrosion inhibitor
Sarasota County	University Wellfield WTP	2	Brackish groundwater	Partial treatment (degasification, disinfection)	Corrosion inhibitor
Sarasota County	Venice Gardens WTP	2.75	Brackish groundwater	Single-stage RO	Corrosion inhibitor

* The table includes the regular customers only; the emergency and possible future customers (like City of Punta Gorda, City of Venice, Englewood Water District, and Manatee County) are not shown.

** Burnt Store Water Treatment Plant (WTP) and Desoto Correctional Institute WTP service isolated areas in Charlotte County and Desoto County, respectively. Most of the service area in both counties is provided by the Authority.

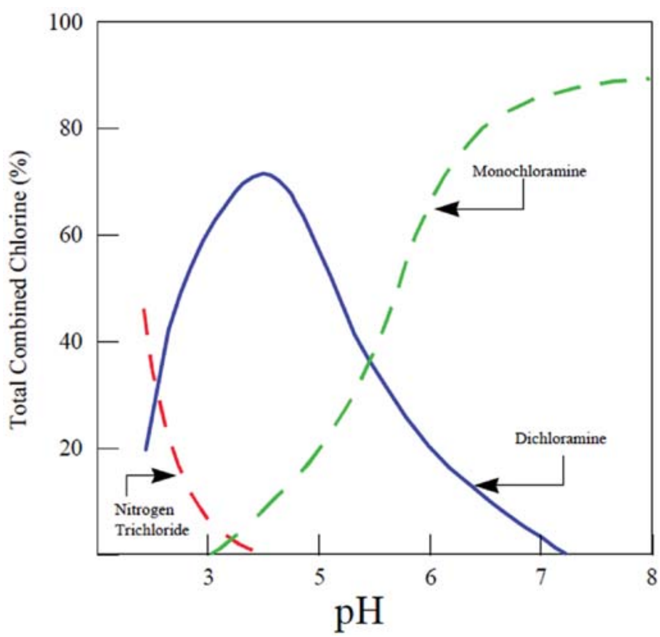

Figure 2. Distribution Diagram for Chloramine Species with pH *(source: Palin, 1950).*

Finished Water Quality Characterization

Data from 2011 through 2013 were collected and analyzed for disinfection residuals, pH, hardness, alkalinity, calcium carbonate equilibrium, organic content, inorganic ions, and corrosion inhibitors. The water quality data sources included monthly operating reports, annual Safe Drinking Water Act reporting (for primary and secondary contaminants), summaries of treatment facilities, routine lead and copper monitoring, disinfection byproduct (DBP) reporting, and total coliform and pH sampling in the distribution network. The Authority and its customers used chloramines as the secondary disinfectant residual. A spreadsheet calculation tool developed by Trussell Technologies was used to estimate CCPP based on given water quality [7]. A summary table of finished water quality of the Authority and its customers is provided in Table 2.

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The Peace River Manasota Regional Water Supply Authority Water Treatment Plant

The mineralization levels in the Authority's raw water varied seasonally, which resulted in seasonally variable finished water. Total hardness and total dissolved solids (TDS) were higher during summer months and lower during winter months. The finished water total organic carbon (TOC) varied between 3.9 and 5.2 mg/L. The combined chlorine residual was maintained near the maximum residual disinfectant level (MRDL) of 4.0 mg/L. No additional phosphate-based corrosion control chemical was used. The water quality parameters that significantly affected CCPP are presented over time as monthly averages in Figure 3.

Total hardness, on a monthly average, fluctuated between 180 mg/L as $CaCO_3$ in the summer and 140 mg/L as $CaCO_3$ in the winter; note that this is opposite to raw water hardness, which can be explained by the average detention time of six months in the raw water reservoirs. Alkalinity was between 40 and 50 mg/L as $CaCO_3$. Finished water pH levels were fairly consistent between 8.0 and 8.3. Langelier Index (LI) and CCPP values were calculated using the water quality based on monthly averages (Figure 4). Overall CCPP trends coincided with seasonal variations in hardness and TDS and varied from -0.9 to 0.8 mg/L as $CaCO_3$. Levels dropped below 0 mg/L as $CaCO_3$ during periods of low hardness levels. Therefore, the Authority's finished water typically was neutral with respect to corrosion, but slight seasonal variations were observed.

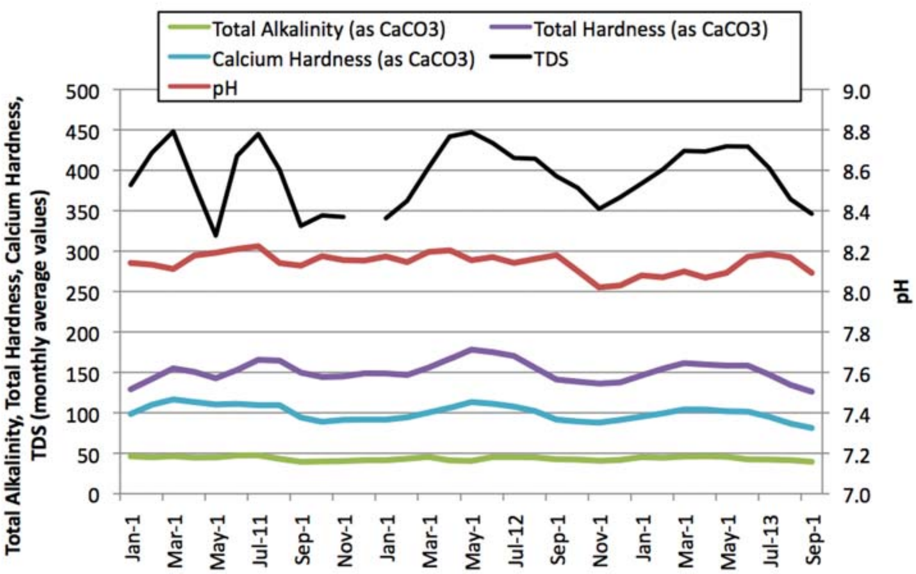

Figure 3. Variations in Alkalinity, Hardness, Total Dissolved Solids, and pH in Peace River Manasota Regional Water Supply Authority Water Treatment Plant Finished Water Based on Average Monthly Values.

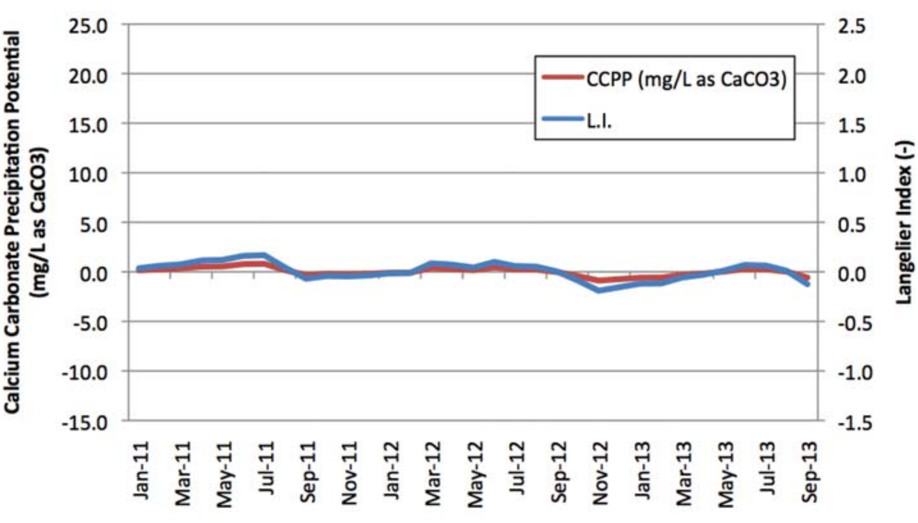

Figure 4. Variations in Corrosion Indices in Peace River Manasota Regional Water Supply Authority Water Treatment Plant Finished Water Based on Average Monthly Values.

North Port Water Treatment Plant

The City of North Port used both surface water and brackish groundwater reverse osmosis (RO) treatment trains. In the City's surface water source (Myakkahatchee Creek), the finished water mineralization varied seasonally as a result of similar raw water mineralization trends (Figure 5).

In contrast to the Authority's seasonal trends, the North Port WTP finished water had higher mineralization in the winter and lower mineralization in the summer. Total hardness fluctuated between approximately 70 to 470 mg/L as $CaCO_3$ in the period of review (2011 to 2013). The addition of a brackish groundwater RO system in March 2013 helped the City to decrease TDS, hardness, and TOC by blending treated flows from the surface water treatment and RO treatment processes.. The combination of seasonally variable water quality and water sources resulted in variable corrosion indices in the final blended water (Figure 6). The CCPP, based on monthly averages, ranged from -5.1 to 24.6 mg/L as $CaCO_3$.

Sarasota County Carlton Water Treatment Plant

Finished water quality from the electrodialysis reversal (EDR) system was more consistent than finished water from a surface water system because the product water quality could be controlled by setting a target conductivity. Based on the calculated conductivity levels, TDS in the treated water ranged from 350 to 400 mg/L; calcium, magnesium, and sulfate concentrations were the major constituents of TDS. Caustic soda was used to adjust the pH of the treated water to 7.5-8.0. The finished water was slightly aggressive based on calculated CCPP values, but a 50/50 poly/orthophosphate blend was used for corrosion control. Chloramine lev-

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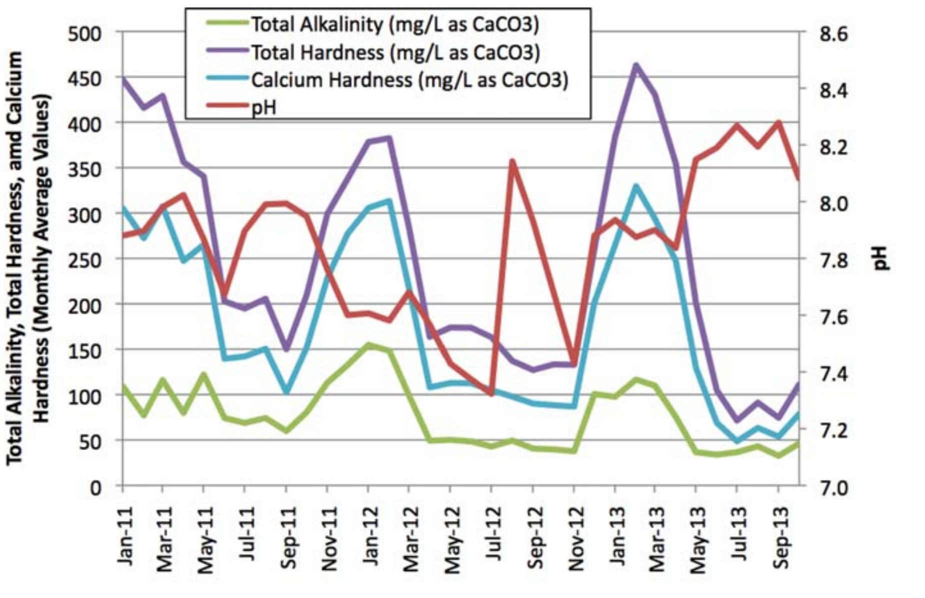

Figure 5. Seasonal Variation of Total Dissolved Solids, Hardness, Alkalinity, and pH in Surface Water Treatment Train in the City of North Port Water Treatment Plant Finished Water.

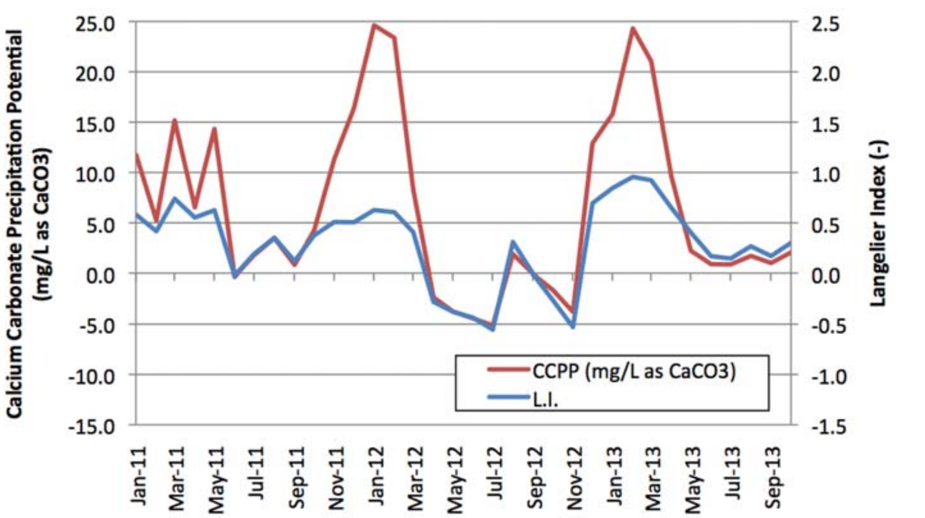

Figure 6. Variations in Corrosion Indices in North Port Water Treatment Plant Finished Water Based on Average Monthly Values.

Table 2. Range of Finished Water Quality of the Authority and its Customers in 2011-2013.

Water Treatment Plant	TDS (mg/L)	Total Hardness ($mg/L\ CaCO_3$)	Alkalinity ($mg/L\ CaCO_3$)	pH (SU)	CCPP ($mg/L\ CaCO_3$)
PRMRWSA	320-450	140-180	40-50	8.0-8.3	(1.0)-1.0*
North Port	300-880	70-470	30-150	7.3-8.3	(5.0)-24.0
Carlton	375	180	45	7.9	(1.0)
University Wellfield	1100	290	60	7.5	2.0
Venice Gardens	370	100	20	8.7	(3.0)

* Values between brackets are negative.

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els in the finished water were maintained between 4.8 and 6.8 mg/L. Alkalinity levels were around 45 mg/L as $CaCO_3$, which provided a moderate buffering capacity in the finished water.

Sarasota County University Water Treatment Plant

The brackish groundwater was treated with acidification with carbon dioxide, degasification, and disinfection prior to blending with Manatee County finished water, typically in a 5:1 ratio, with Manatee County water as the major component. The TDS concentrations in the groundwater were approximately 1,100 mg/L, but the TDS was diluted down in the blended product. The University wellfield compliance point was downstream of the blending point, so detailed treated water quality data of the University WTP were not available. The main constituents of the TDS in the groundwater were sulfate (at 700 mg/L), calcium (at 195 mg/L as $CaCO_3$), and magnesium (at 95 mg/L as $CaCO_3$). The County used chloramines for secondary disinfection, with typical levels between 3.5 and of 4.5 mg/L. Alkalinity levels were typically 60 mg/L as $CaCO_3$. A 50/50 poly/orthophosphate blend was used for corrosion control.

Sarasota County Venice Gardens Water Treatment Plant

Brackish groundwater was withdrawn from 10 production wells to feed multiple single-stage RO trains. Finished water TDS concentrations ranged from 350 to 375 mg/L from the RO system. The County bypassed approximately 5 percent of the RO feed flow to remineralize the RO permeate. Also here, a 50/50 poly/orthophosphate blend was used for corrosion control. Chloramines were dosed for secondary disinfection, with typical levels of 4.0 to 4.5 mg/L. Alkalinity levels were around 20 mg/L as $CaCO_3$ which provided limited buffering capacity in the finished water.

Distribution Water Quality Characterization

Distribution water quality data were obtained from monthly operating reports, lead and copper sampling, DBPs, and total coliform sampling in the distribution networks. All lead and copper results were significantly below the ALs (Figure 7). All systems dosed combined chlorine at levels close to or just above the MRDL of 4.0 mg/L. In addition, each customer operated chlorine booster stations in the distribution systems. All utilities reported concentrations of total trihalomethanes (TTHMs) and haloacetic acids

(HAA5) at less than 51 µg/L and 40 µg/L, respectively. These concentrations were below the respective maximum contaminant levels (MCLs) of 80 µg/L and 60 µg/L, respectively.

Several systems used blending of several water supply sources to help meet system goals that can include meeting flow demands and offsetting water quality that may exceed goals from one or more sources. For example, brackish groundwater sources that were treated with membrane processes, such as reverse osmosis, might be used for blending to decrease TDS of a water source that has a higher TDS.

Peace River System

Residual chloramine levels dropped from 4.0 mg/L at the WTP to around 3.3 to 3.7 mg/L at the delivery points with the Authority's customers, showing a chloramine decay of approximately 0.5 mg/L within hours. The level and speciation of minerals in water, including pH levels, do not change significantly between WTP and distribution system sample points. As a wholesale provider, the Authority only measured lead and copper in the finished water, and levels were below ALs.

Charlotte County

Charlotte County purchased approximately 95 percent of its potable water from the Authority; the remainder was produced at the Burnt Store WTP for an isolated service area. The County's distribution system is extensive and has low-flow zones with long hydraulic residence time (i.e., water age of multiple days), which resulted in significant chloramine decay. The distribution of total chlorine residual samples in the Charlotte County system compared to the Authority's finished water shows that the County maintained a residual greater than 0.8 mg/L in 90 percent of samples in 2013 (Figure 8a). The County managed this issue by executing a flushing program. The pH distribution of the Charlotte County system and the Authority's finished water showed that, in all samples taken in 2013, the median (i.e., 50 percentile) pH drop in the distribution system was 0.5 units, from 8.1 to 7.6 (Figure 8b). Using the median pH value of 7.6, the CCPP of the water in the distribution system was calculated to be -2.6 mg/L as $CaCO_3$ compared to 0.1 mg/L as $CaCO_3$ in the Authority's finished water. The possible reasons for pH drops in the distribution systems were explained earlier and include chloramine decay, biofilm growth, and nitrification.

City of North Port

The City of North Port purchased and blended water from the Authority routinely

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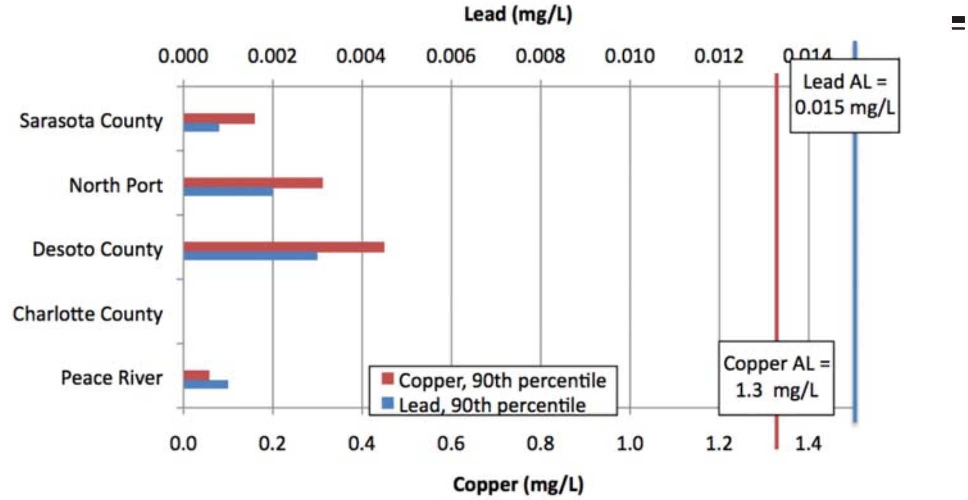

Figure 7. Lead and Copper 90th Percentile Concentrations in the Distribution Systems of the Authority and its Customers (Charlotte County was not available).

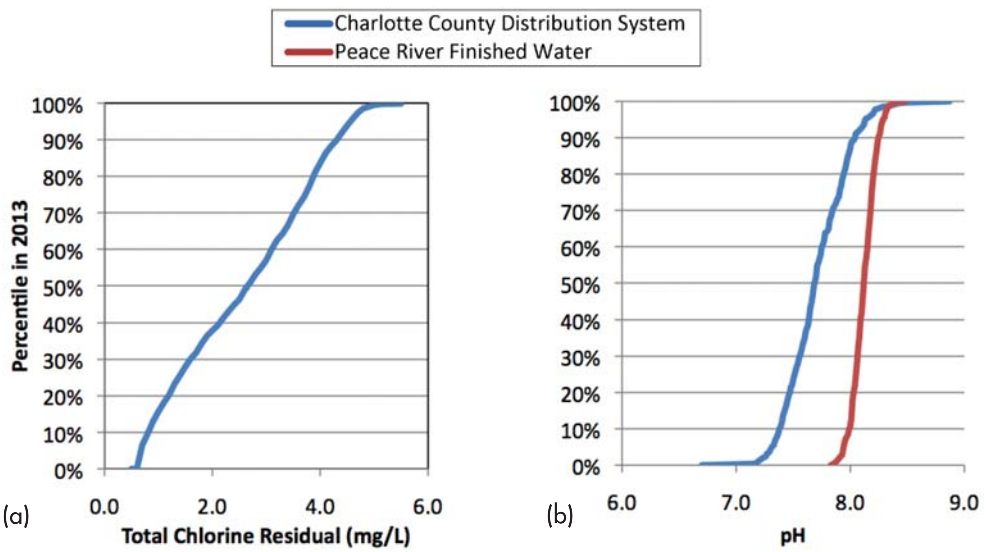

Figure 8. Percentile Distribution in Charlotte County Distribution System of (a) Total Chlorine Residual and (b) pH.

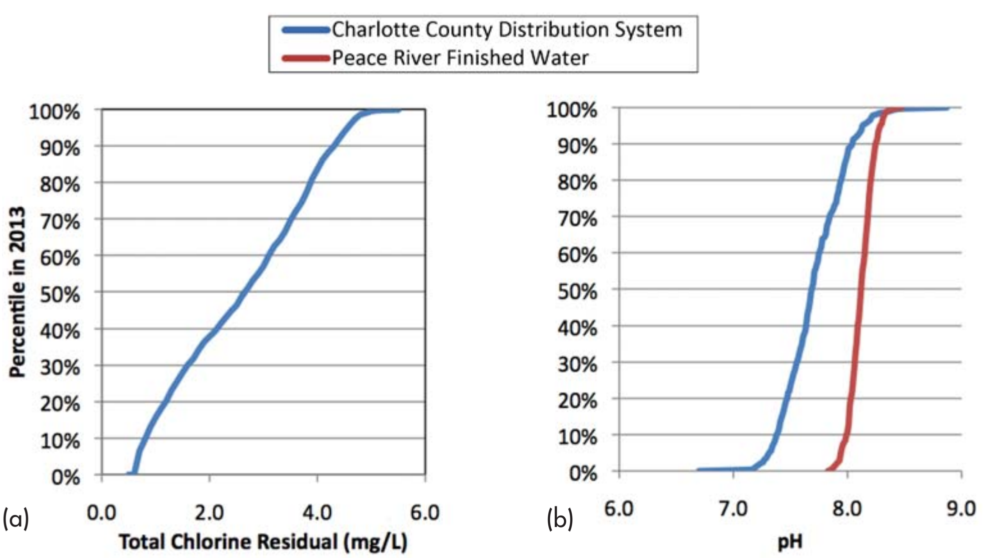

Figure 9. Percentile Distribution in North Port Distribution System of (a) Total Chlorine Residual and (b) pH.

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with production from its own surface water and brackish water RO treatment plants. The distribution of total chlorine residual samples in the North Port system, compared to the Authority's finished water, shows that the City maintained a residual greater than 1.0 mg/L in 90 percent of samples in 2013 (Figure 9a). The pH of the North Port distribution system water was, as expected, in between the pH of City of North Port and the Authority's finished waters (Figure 9b). The calculated CCPP of the distribution system water ranged from -7.5 to 1.6 mg/L as $CaCO_3$.

In 2013, the City modified the pressures at the remote booster pump stations to create better blending of North Port WTP water with the Authority's water, which improved the CCPP in the distribution system compared to North Port WTP finished water. The distribution system was designed for build-out conditions, and with the large numbers of residential lots remaining undeveloped, the system experienced long hydraulic residence time. Similarly to Charlotte County, the City managed this issue by executing a flushing program.

To predict the water quality in the distribution system under varying operation regimes, a spreadsheet was developed to combine water quality parameters for given blending scenarios. Four blending scenarios with North Port and the Authority finished water are summarized in Figure 10. The following operation scenarios were modeled using average monthly values:

1. Only North Port surface water and groundwater blended, current ratio (4:1 blending ratio)
2. North Port blend from Scenario 1 with current Authority allocation added (4:2:1 SW:PR:GW)
3. Blending from Scenario 2 with groundwater treatment train flow doubled (2:1:1 SW:PR:GW)
4. Blending from Scenario 2 with one quarter of surface water flow (1:2:1 SW:PR:GW)

The figure presents average finished water quality from each of the three sources that supply the North Port system. Each blending scenario shows the weighted average of selected water quality parameters based on the stated blending ratios (blended pH was calculated using a weighted average of the hydrogen concentration). Lastly, blending ratios were calculated using finished water quality for the months that experienced the minimum and maximum CCPP values.

The calculated CCPP values were 6.5, -11.7, and 0 on average in 2012 for the North Port surface water, North Port groundwater treatment train, and the Authority's water, respectively. Blending scenarios showed a CCPP range of between -5.7 and -2.4 mg/L as $CaCO_3$, on average. The CCPP in each scenario is below the recommended guideline of 4 to 10 mg/L as $CaCO_3$.

Sarasota County

The Sarasota County distribution system receives water from the County's three WTPs, Manatee County, and the Authority. Manatee County water is blended at the University Wellfield WTP in the north part of the service area, and Authority water is blended at Carlton WTP in the southeast part of the service area; the Venice WTP serves a small part of the southwest service area. The distribution of total chlorine residual samples in the Sarasota County System shows that the County maintained a residual greater than 1.8 mg/L in 90 percent of samples in 2013 (Figure 11a). From sample points taken in 2013, the median pH residual decreased approximately 0.2 units (from 8.0 to 7.8) in the distribution system (Figure 11b). The County

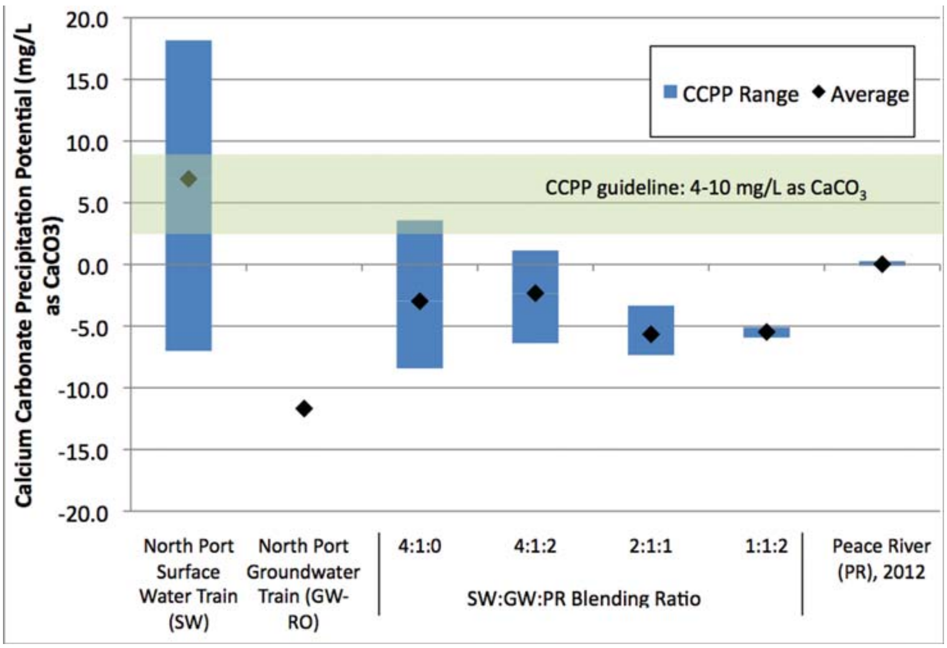

Figure 10. Summary Graphic of Blending Scenarios for City of North Port.

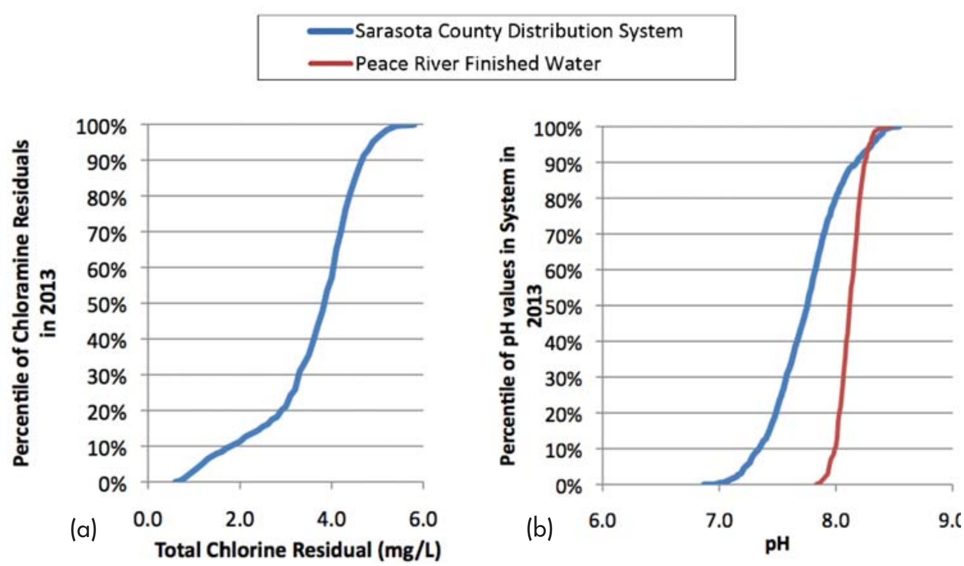

Figure 11. Percentile Distribution in Sarasota County Distribution System of (a) Total Chlorine Residual and (b) pH.

managed chloramine decay and a decrease in pH with a flushing program using autoflushers.

Two blending scenarios for Sarasota County and Peace River are summarized in Figure 12. The blending ratios included 10:1 and 5:1 from the Authority to Carlton WTP water that reflected operational regimes in 2013. The CCPP values varied from -1.0 to -0.2 mg/L as $CaCO_3$ for all blending scenarios, but the slight corrosiveness of the water toward lead and copper was effectively controlled by a phosphate-based corrosion inhibitor. The average and range of pH values of the different blend scenarios are shown, as well as the recommended pH ranges for phosphate and chloramines.

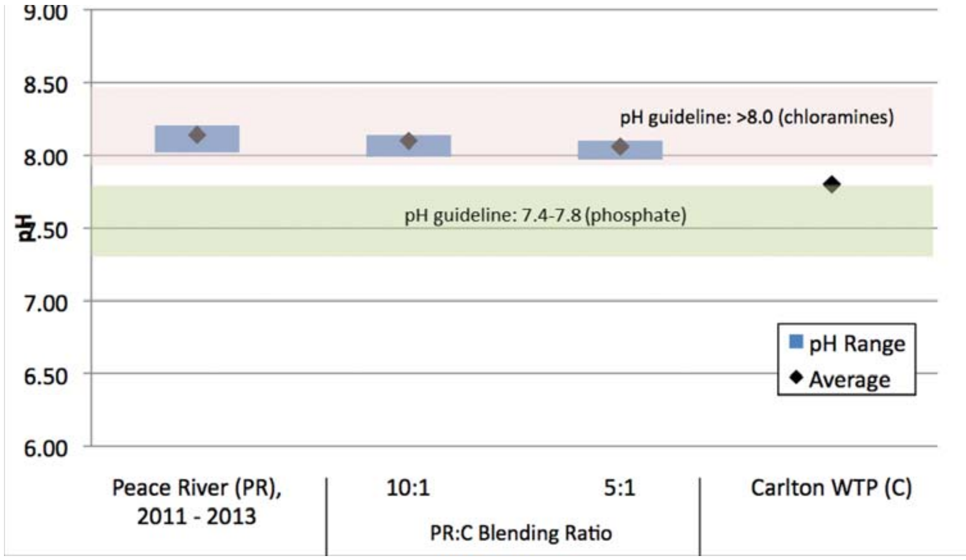

Figure 12. Summary Graphic of Blending Scenarios for Sarasota County.

Calcium Carbonate Precipitation Potential Comparison

A summary of CCPP values in the finished and distribution waters of the Authority and its customers is presented in Table 3. None of the systems produced finished water with a CCPP in the recommended range of 4 to 10 mg/L as $CaCO_3$. The finished water of the Authority varied between -0.9 and 0.8 mg/L as $CaCO_3$, which is close to equilibrium conditions with respect to calcium carbonate equilibrium. Similarly to the Authority, finished water from the North Port WTP surface water treatment train varied considerably with respect to calcium carbonate equilibrium as a result of varying mineralization in the finished water. The CCPP, on a monthly average basis, varied only about 2 mg/L as $CaCO_3$ in the Authority's finished water, but varied about 24 mg/L as $CaCO_3$ in North Port WTP surface-water finished water. Based on all blending scenarios, distribution system water in the North Port system ranged from moderately corrosive to slightly supersaturated. Charlotte County purchased the most water from the Authority, but the pH decrease in the distribution system made the water moderately corrosive. The corrosiveness of Sarasota County finished water was managed by corrosion inhibitors in the finished water and distribution system.

Table 3. Calcium Carbonate Precipitation Potential Comparison Summary of Finished and Distribution Waters of the Authority and its Customers Based on Monthly Averages.

Sampling Point	Peace River WTF	Charlotte County Utilities	Desoto County	North Port WTP Surface Water	North Port WTP Brackish Groundwater	Sarasota County
Finished Water	(1.0)-1.0	n/a	n/a	(5.0)-24.0	(12.0)	(4.0)-(2.0)
Distribution System Water	0.10	(2.60)	(0.10)	(7.0)-(1.0)		(1.0)-(0.0)

Calcium Carbonate Precipitation Potential Blending Model

Although the previous graphics were useful in calculating CCPP for a given blending ratio, a visual analysis was needed to convey a more intuitive understanding of the water quality variations for a range of blending ratios. A CCPP blending model was created to predict the water quality of blended water from two sources for an average, minimum, and maximum case. Example charts (Figures 13a and 13b) show CCPP for all possible blending combinations of Carlton WTP and the Authority WTP finished waters, and North Port WTP and the Authority WTP finished waters, using average, minimum, and maximum total hardness water quality data based on monthly averages.

The shaded area of the graph shows the operational range of blending that was used in 2013. The graph was combined with the CCPP spreadsheet to calculate the predicted corrosiveness of the modeled blended water quality. After the water quality of each water source is entered, the graph calculates the blended water quality at several different blending ratios, and graphs them using a PivotChart. For instance, when the blend ratio between North Port WTP and Peace River WTP increases (moving to left in Figure 13b) the finished water may become slightly more corrosive in terms of CCPP. This may be corrected at the North Port WTP by dosing additional caustic soda in the blended water to create slightly higher pH values to maintain CCPP values in the recommended range.

The model has the potential to be used as a predictive tool for operational decision making. Scenarios of theoretical water quality set points can be entered to predict blended water quality and verify possible treatment changes to maintain optimal distribution water quality with CCPP values within the recommended range. Predictive water quality would be valuable to the Authority and its customers in several situations when the parties either:

1. Modify the water blend ratio due to operational and maintenance needs, such as piping and valve rehabilitation and replacement requiring partial shutdowns.
2. Modify the water blend ratio due to water production needs and changing demands.
3. Add a new source or interconnection.
4. Observe a (sudden) change in water quality in one or more water sources.

Conclusions

Water quality compatibility was evaluated in the finished water, transmission, and distribution systems of the Authority and its customers. For period 2011-2013, water quality parameters, including pH, chloramine residuals, DBPs, lead, copper, and calculated CCPP values, were analyzed in each system and water quality models were developed for several applicable blending scenarios. The data analysis

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supports the following conclusions:

1. The ability of Charlotte County, DeSoto County, Sarasota County, and the City of North Port to meet typical water supply goals is highly dependent on the Authority's operations and water quality because the Authority supplies a major portion of the water in these systems.
2. The Authority, City of North Port, Charlotte County, and Desoto County relied on a calcium carbonate equilibrium approach for corrosion control, while Sarasota County dosed phosphate-based corrosion control inhibitors.
3. Finished water hardness and TDS of the surface water treatment plants varied seasonally due to variations in mineralization of the raw water. Total hardness levels varied by approximately 50 mg/L as $CaCO_3$ in the Authority WTP finished water and varied by approximately 400 mg/L as $CaCO_3$ in North Port WTP finished water. The seasonal changes in calcium hardness, alkalinity, and pH resulted in variable CCPP values in the finished waters.
4. Water treatment plants with brackish groundwater sources in North Port and Sarasota County had more consistent finished water quality (independent of the season) and lower TDS values when blended with surface water, but the calculated CCPP values suggested slightly corrosive water.
5. Although the CCPP values in the finished water of the utilities were slightly outside of the recommended CCPP range of 4 to 10 mg/L as $CaCO_3$, all utilities measured lead and copper concentrations that were well below the ALs, regardless of corrosion control strategy. Also, levels of DBPs were in compliance with regulatory standards in the distribution systems.
6. Chloramine was typically dosed at or near the MRDL of 4.0 mg/L and each customer's system had several chloramine booster stations. Customers use flushing programs to control water age, creating significant water losses. The median pH value decreased from 8.1 to about 7.7 to 7.8 in each distribution system, and the 10th percentile of chloramine residual ranged from 0.8 to 1.8 mg/L. Calculated CCPP values of water in the distribution systems indicated water that ranged from moderately corrosive (-7.4 mg/L as $CaCO_3$) to slightly supersaturated (1.0 mg/L as $CaCO_3$).
7. The CCPP blending models were created as predictive distribution water quality tools to actively plan for events in the distribution system, including maintenance work and change in water demands, which may modify the water blend ratios, add a new source or interconnection, or cause a (sudden) change in water quality of one or more sources.

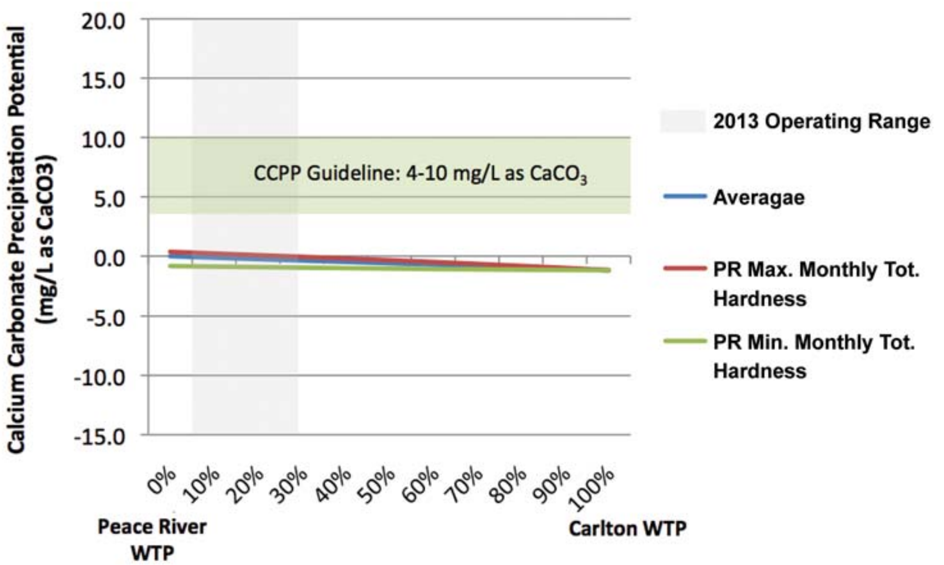

Figure 13a. Examples of Results of Dynamic Water Quality Blending Analysis for Carlton Water Treatment Plant.

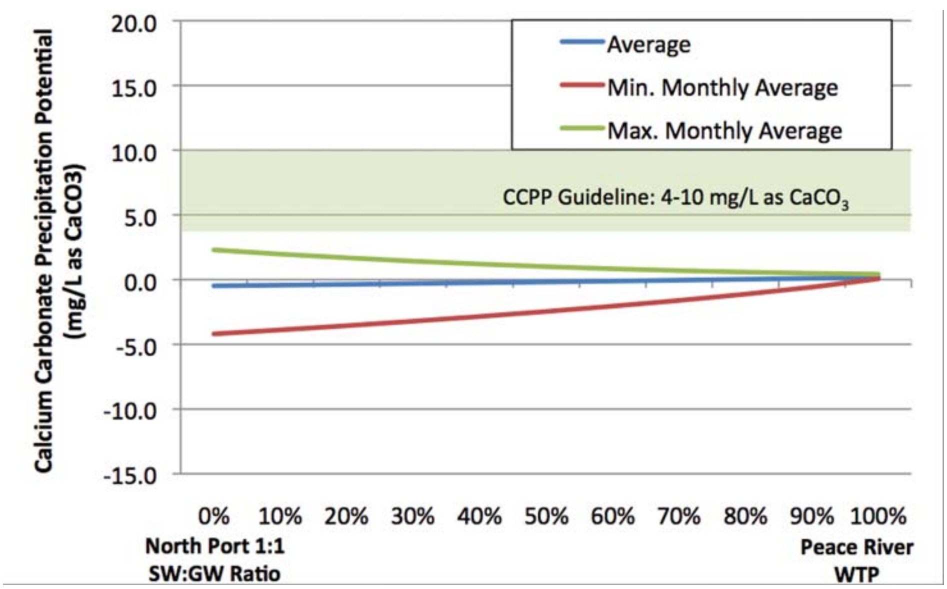

Figure 13b. Examples of Results of Dynamic Water Quality Blending Analysis for North Port Water Treatment Plant.

References

1. EPA, Lead and Copper Rule (1991).
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