

April 1, 2014

**City Commission
Workshop Meeting
5:00 P.M.**

**Commission Chamber
City Hall
Port St. Joe, Florida**



City of Port St. Joe

Mel Magidson, Mayor-Commissioner
William Thursbay, Commissioner, Group I
Bo Patterson, Commissioner, Group II
Phil McCroan, Commissioner, Group III
Rex Buzzett, Commissioner, Group IV

[All persons are invited to attend these meetings. Any person who decides to appeal any decision made by the Commission with respect to any matter considered at said meeting will need a record of the proceedings, and for such purpose may need to ensure that a verbatim record of the proceedings is made, which record includes the testimony and evidence upon which the appeal is to be based. The Board of City Commission of the City of Port St. Joe, Florida will not provide a verbatim record of this meeting.]

BOARD OF CITY COMMISSION

City Commission Workshop Meeting

5:00 P.M.

Commission Chamber, City Hall

Tuesday April 1, 2014

Call to Order

Agenda

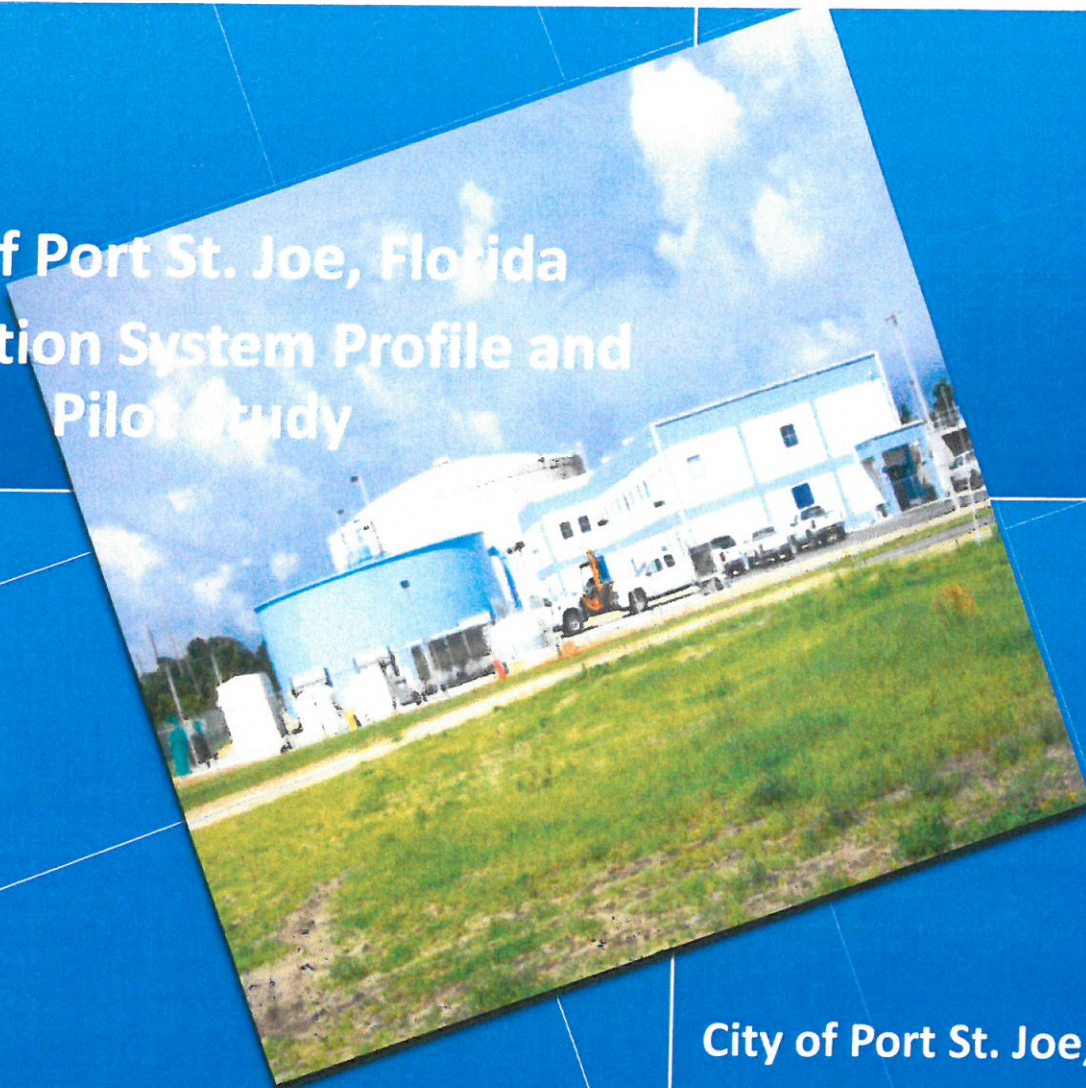
Water Study Report

Citizens to be Heard

Discussion Items by Commissioners

Motion to Adjourn

City of Port St. Joe, Florida Distribution System Profile and Pilot Study



City of Port St. Joe, Florida

DRAFT REPORT

March, 2014

**CDM
Smith**

Table of Contents

Section 1 Introduction, Objectives and Methodology	1-1
1.1 Introduction	1-1
1.2 Study Objectives and Methodology.....	1-1
Section 2 Background.....	2-1
2.1 Background	2-1
2.2 Description of Water System	2-2
2.2.1 Surface Water Treatment Plant	2-2
2.2.2 Distribution System	2-3
2.3 Previous Studies.....	2-4
2.4 Data Gap Analysis	2-4
Section 3 Profile Sampling and Results	3-1
3.1 Profile Sampling.....	3-1
3.2 Results	3-2
3.3 Findings and Conclusions.....	3-3
Section 4 Corrosion Control Pilot Testing and Results	4-1
4.1 Coupon Harvesting.....	4-1
4.2 Piloting Test Setup	4-1
4.2.1 Phase 0	4-1
4.2.2 Phase 1	4-2
4.2.3 Phase 2	4-2
4.3 Pilot Test Results	4-3
4.4 Conclusions	4-4
4.4.1 Conclusions from Bench Scale Testing Report.....	4-4
4.4.2 Requirements for Implementation of Phase 2 Alternatives	4-5
4.4.2.1 Requirements for Alternative 1	4-5
4.4.2.2 Requirements for Alternative 2	4-5
4.4.2.3 Requirements for Alternative 3	4-6
4.4.3 Conclusions from Draft Pilot Test Report Delivery Meeting	4-6
Section 5 Manganese Control	5-1
5.1 Background	5-1
5.1.1 Overview.....	5-1
5.1.2 Plant Pilot, Operational, and Profile Data.....	5-1
5.1.3 Plant Operations.....	5-3
5.2 Bench Scale Testing	5-3
5.2.1 Low Manganese Ferric Sulfate	5-3
5.2.2 Sodium Permanganate.....	5-4
5.2.3 Bench Scale Jar Testing Parameters.....	5-4
5.3 Bench Scale Testing Results	5-6
5.4 Conclusions and Next Steps.....	5-10

Section 6 Conclusions.....	6-1
Section 7 Recommendations and Next Steps	7-1
7.1 Water Treatment Plant Related Recommendations	7-1
7.1.1 Plant Modifications.....	7-1
7.1.2 Distribution and Operational Changes.....	7-1

Appendices

Appendix A – Gap Analysis Memo
Appendix B – Profile Testing Protocol and Sampling Memo
Appendix C – Coupon Harvesting Protocol
Appendix D – Water Quality or Color Complaint Response Procedure
Appendix E – Virginia Tech Pilot Testing Results
Appendix F – Manganese Recommendation Memorandum
Appendix G – Previous CDM Smith Memoranda

List of Tables

Table 2-1 Previous Technical Memoranda Concerning the City Discolor Water Situation...	2-2
Table 3-1 Summary of Profile Testing for High Flow Condition	3-2
Table 4-1 Summary of Treatment Alternatives in Phase 1	4-2
Table 4-2 Summary of Treatment Alternatives in Phase 2	4-3
Table 5-1 2004 Port St. Joe Pilot Mn Data.....	5-2
Table 5-2 City of Port St. Joe Surface Water Plant Mn Data.....	5-2
Table 5-3 Plant Manganese Profile by Unit Process.....	5-2
Table 5-4 October 15, 2013 Ferric Sulfate Coagulant Analysis	5-3
Table 5-5 Port St. Joe Mn Jar Test Results Summary.....	5-7

List of Figures

Figure 2-1 Galvanized Steel Distribution Main Removed from the Port St. Joe Distribution System in early 2010.....	2-3
Figure 3-1 Illustration of Sequential Profile Water Sampling Collected in each Premises....	3-1
Figure 4-1 Effect of pH on Buffer Intensity of Water Quality Conditions in Port St. Joe	4-2
Figure 4-2 Change in Total Iron Concentration in Cast Iron Coupons.....	4-3
Figure 4-3 Change in Total Iron in Galvanized Steel Coupons	4-4

Section 1

Introduction, Objectives and Methodology

1.1 Introduction

In September of 2009 the City of Port St. Joe, Florida (City) put online a new six million gallon per day (MGD) surface water treatment plant (Plant). The surface water plant replaced the City's aging groundwater treatment plant. Shortly after the Plant went on line, the City began receiving reports of discolored water in portions of its distribution system.

The Plant treats surface water from the Chipola River with ferric sulfate coagulant in solids contact clarifiers followed by microfiltration. Sodium hydroxide is used to adjust pH, and a phosphate based corrosion control product is added after disinfection. The Plant can use free chlorine or chloramines as a disinfectant, but only free chlorine has been used since the Plant went on line.

The City has attempted several measures to address the discolored water complaints, including changing the dose and composition of the corrosion control product, intermittent flushing (both unidirectional and spot flushing), installation of autoflushing devices, and replacement of selected galvanized and cast iron pipe portions of the distribution system. As of late 2012, these measures were unsatisfactory.

In December of 2012, the City engaged Preble Rish, Inc. (PRI) to study the discolored water complaints and make recommendations for a solution to the discolored water. PRI contracted with CDM Smith Inc. (CDM Smith) to lead the investigation. CDM Smith subsequently contracted with researchers from Virginia Tech to assist with the study. This Report is the result of that study.

1.2 Study Objectives and Methodology

The objectives of the study were to determine the cause of the colored water complaints and recommend long term solutions to the discolored water problem faced by the City.

The study consisted of three segments. The first was to study existing data. The second was to perform profile sampling to determine the cause of the discolored water. The third was to perform bench scale testing to find ways of mitigating the discolored water complaints.

As the early discolored water complaints were characterized as "red water" and scale inside old galvanized steel distribution pipe analyzed in 2010 was primarily iron, the original study plan was based on iron corrosion. Other potential causes of the complaints were investigated during the study, and the study plan was adapted to include supplemental testing and investigations as new data became available.

The following methodology was used to conduct the study and develop recommendations:

- CDM Smith, assisted by PRI, conducted a gap analysis to determine additional data required for the study. This included collecting and analyzing existing data from City records, meeting with City staff, and preparing a map to display selected data.

- CDM Smith, with the assistance of researchers from Virginia Tech and PRI, performed profile testing in the distribution system. This effort consisted of collecting samples from premises (both homes and institutional facilities) throughout the distribution system in areas identified in the gap analysis as having a high incidence of colored water complaints. Samples were collected after no water had been used in the premises for at least six hours. A total of 20 one-liter samples were collected from each site so a profile of water--from the on-premises plumbing, through the service line, and to the transmission main serving the premises could be analyzed.
- Once the profile data was analyzed, a bench-scale pilot test to study methods of reducing iron corrosion was designed and implemented at Virginia Tech. Samples of a six-inch unlined cast iron distribution main and a one-inch galvanized service line were taken from the City distribution system for use in the test. The samples were conditioned by exposure to finished water from the Port St. Joe distribution system. After conditioning, two phases of testing were conducted on the pipe samples. Both phases evaluated the impact of various changes in pH values, alkalinity values, and corrosion control chemicals on the rate of iron corrosion.
- After initial data analysis and profile testing it was determined that manganese was likely a potential contributing factor to the discolored water. Therefore, CDM Smith, with the assistance of PRI and the City, conducted jar tests on the Plant site to evaluate various methods of reducing finished water manganese concentrations.
- Results from the report were discussed with the Florida Department of Environmental Protection (FEDP) regulators, and their response was accounted for in the recommendations in this report.

Section 2

Background

2.1 Background

The City of Port St. Joe (City) is located in the Florida Panhandle, approximately 75 miles southwest of Tallahassee. The City is situated on the Gulf of Mexico in Gulf County and had a 2000 census year population of 3,644. In the late 1990s and early 2000s the City's economy transitioned from predominantly industrial to residential development. Land previously in silvaculture adjacent to the City was being prepared by the St. Joe Company for residential development. Because of this the City anticipated significant growth and demand on its potable water system.

The City operated a 2.0 (MGD) groundwater treatment plant that utilized lime softening with re-carbonation, sand filtration, and chlorine disinfection to supply potable water. The groundwater supply experienced degradation in quality including saltwater intrusion, and the Northwest Florida Water Management District (NFWFMD) required, by means of the Consumptive Water Permit, that the City decrease its groundwater use.

The City decided to investigate surface water as an alternative because the anticipated population growth and the poor condition of the existing groundwater plant. An existing 17-mile canal conveys water from the Chipola River to a site near the former paper mill. When the mill was in operation, the canal supplied approximately 30 MGD for paper production. When the mill closed, the City purchased rights to the canal.

Water from the canal can be described as seasonally variable, with relatively high color, low hardness, low alkalinity with a high potential for disinfection byproduct formation (DBP).

In 2004 CDM Smith, as a subcontractor to PRI, assisted the City in conducting a six-month pilot test of a treatment system consisting of solids contact clarification and microfiltration (MF). The pilot evaluated treatment of disinfection byproduct precursors, pathogens, color, turbidity, and manganese. Both ferric sulfate and alum were tested as coagulants.

The pilot ran from January 2004 through June of 2004. Data from the pilot showed that US Filter Memcor equipment, using ferric sulfate as a coagulant, was effective in treating turbidity, color, iron and manganese. Data from the pilot test indicated that a full scale plant utilizing the piloted process would remove enough organic material to meet DBP regulations.

In 2005 PRI and CDM Smith submitted a permit application for a 2.5 MGD Surface Water Treatment Plant (SWTP) based on the piloted technology. In November of 2006 the permit application was revised to increase the Plant capacity to 6 MGD.

PRI and CDM Smith completed final design shortly afterward.

The 6 MGD Plant was constructed and went online on September 15, 2009. Shortly afterward, the City observed an increase in complaints about red water. On February 16, 2010, the FDEP inspected the City's distribution system. The City received a letter from the FDEP concerning citizen complaints and distribution system maintenance. The letter noted that the Florida Rural Water Association

recommended to the City unidirectional flushing. The letter noted that the City's distribution system was not in compliance with various portions of Rule 62-555.350 of the Florida Administrative Code concerning distribution system maintenance, and required corrective action including: creation of an accurate distribution system map; exercising isolation valves; mapping of all isolation valves; and a creating a plan for replacement of mains in poor condition.

The City requested the assistance of PRI and CDM Smith, and CDM Smith, as a subcontractor to PRI, produced the technical memoranda described in the **Table 2.1**, below.

Table 2.1 Previous Technical Memoranda Concerning the City Discolor Water Situation

Date	Title	Description
February 11, 2011	City of Port St. Joe SWTP Water Quality Analysis	Analysis of potential causes of red water at Port St. Joe
February 25, 2011	City of Port St. Joe SWTP Process Modifications Analysis	Described alternatives for control of red water at Port St. Joe
December 29, 2011	City of Port St. Joe – Uniform Directional Flushing Procedures	Detailed procedures for unidirectional flushing.

These memoranda are further described below, in Section 2.3, Previous Studies.

In summer of 2012, the City asked PRI and CDM Smith to meet to discuss continued red water complaints.

In December of 2012 PRI and CDM Smith, in conjunction with Dr. Marc Edwards of Virginia Tech, agreed with the City to conduct a study of the distribution system and perform pilot testing of various methods of reducing iron corrosion. This Report is the result of that study.

2.2 Description of Water System

2.2.1 Surface Water Treatment Plant

Surface water is taken from the Chipola River, via a 17 mile long canal, and is treated at the 6 MGD Plant. Due to the length and water volume in the canal, coupled with the relatively low average daily demand from the plant (1.0 MGD to 2.0 MGD), any seasonal differences in raw water from the Chipola River are distorted in time.

The Plant consists of a raw water intake structure with three raw water vertical turbine pumps; basket strainers; approximately 450 feet of 20-inch diameter raw water pipeline leading to four 1.5 MGD US Filter Contraflo solids contact clarifiers; four submerged MF membrane bays with associated pumps, valves, cleaning equipment and piping; two chlorine contact chambers with three vertical turbine transfer pumps each; a 2 million gallon (MG) ground storage tank (GST); 11 vertical turbine high service pumps. The Plant also has associated chemical storage and feed equipment, electrical system, instrumentation and controls, a treatment building, and other ancillary equipment including solids handling.

The process involves injecting 12 percent (%) (as Fe^{+3}) ferric sulfate into the raw water upstream of the clarifiers, followed by 50% sodium hydroxide (caustic soda) to adjust clarifier influent pH to the target value range of approximately 5.5 Standard Units (SU) to 5.7 SU. The Plant reports ferric sulfate feed rates of 126-200 milligrams per liter (mg/L) as product. In the clarifier launder troughs, additional caustic soda is added to increase the pH value prior to the MF membranes. After membranes filtration, free chlorine, in the form of commercial 12% to 15% sodium hypochlorite, is

added prior to the chlorine contact chambers. After the chlorine contact chambers, caustic soda is further added to adjust pH to approximately 7.5 SU and a phosphate-based corrosion control chemical is added. The treated water is then pumped to the GST, from which high service pumps take suction.

Though the Plant was designed to use chloramines as the residual (disinfection system) disinfectant, the process proved effective enough at DBP removal that even with the use of free chlorine (as sodium hypochlorite solution) as both the primary and residual disinfectant, DBP formation has remained under control.

2.2.2 Distribution System

The City's distribution system consists of two zones, the Beaches Zone and the City Zone. The distribution system in the northwest and northeast (the Beaches Zone) areas is characterized by long transmission mains with sparse usage and plastic pipe. The south (the City Zone) distribution system is characterized by older galvanized steel, unlined and line cast iron piping.

In general, the City Zone, and particular the center of the City referred to as "Port St. Joe Proper", at the time the Plant went on line consisted primarily of older metallic pipe. Water distribution pipe in this area included small diameter (2-inch diameter to 4-inch diameter) galvanized steel and cast iron (generally unlined), with some larger diameter (6-inch diameter to -12-inch diameter) cast iron (both lined and unlined), some polyvinyl chloride (PVC), ranging from 2-inch diameter to 6-inch diameter, and some asbestos cement pipe. The unlined metallic pipe has been found to be in generally poor condition. The photograph shown in, **Figure 2-1**, show a segment of galvanized steel distribution pipe removed from the system in early 2010. This was typical of the condition of pipes removed for the Study. Analysis conduction on the scale inside the pipe removed in 2010 indicated that it was primarily iron. Note that galvanized steel pipe with relatively long periods of service life are often found to be in similar condition. The Beaches Zone and some of the outlying parts of the City Zone, consist primarily of PVC pipe.



Figure 2-1 Galvanized Steel Distribution Main Removed from the Port St. Joe Distribution System in early 2010

By the end of 2014, the City anticipates replacing up to 90% of the existing metallic pipe in the Port St. Joe distribution system with plastic pipe, most of which will be PVC.

See maps included in the "City of Port St. Joe Distribution System Summary of Findings from Profile Testing" in **Appendix B** for an illustration of line types and sizes by location as reported by the City at the time of the profile testing.

2.3 Previous Studies

Several previous studies have bearing on the discolored water issue at Port St. Joe. These studies include the following:

- “Treatment of Surface Water with Contraflo Solids Contact Clarifier and Continuous Microfiltration – Submerged (CMF-S) Pilot Systems” pilot study, by US Filter July, 2004.
- “City of Port St. Joe Surface Water Treatment Plant 6.0 MGD Expansion”, by CDM Smith and PRI, November 10, 2006.
- “City of Port St. Joe SWTP Water Quality Analysis” by CDM Smith for PRI, February 11, 2011.
- “City of Port St. Joe SWTP Process Modifications Analysis” by CDM Smith for PRI, February 25, 2011.
- “Review of CDM Technical Memoranda Addressing Occurrence of Red Water in the City of Port St. Joe Distribution System”, by King Engineering for the NFWFMD, March 9, 2011.
- “City of Port St. Joe – Uniform Directional Flushing Procedures”, by CDM Smith for PRI, December 29, 2011.

2.4 Data Gap Analysis

After the kickoff meeting for this study, CDM Smith, in conjunction with PRI, conducted a data gap analysis to determine what missing data existed and needed to be obtained prior to pilot testing. Initial findings were summarized in the “Data Gap Analysis Memorandum (Part I)”, dated February 6, 2013. This Memorandum can be found in **Appendix A**. Thorough discussion subsequent to delivery of Part I of the memo CDM Smith determined that a second part would not be required. CDM Smith did, however, develop a memorandum entitled, “Port St. Joe Water Quality Complaint Guidance”, dated February 19, 2013 for the City’s use in handling water quality complaints. This memo can be found in **Appendix D**.

Analysis of plant data prior to the kickoff meeting, and conversations during the kickoff meeting, indicated that discolored water may not be solely resulting from iron corrosion, as originally thought. Higher than expected levels of manganese leaving the Plant were identified as potential sources of discolored water.

As part of the gap analysis, CDM Smith tabulated water quality complaint data provided by the City, but limited water quality data and limited descriptions at complaint sites limited the usefulness of the data. For instance, in most cases (51%) discolored water was described as some variation of “dirty”, which CDM Smith found difficult to interpret.

As a result of the gap analysis memo, CDM Smith recommended supplemental investigations prior to final site selection and provided a list of specific action items and requested data. Supplemental investigation recommended included a Plant profile sample (in addition to the previously proposed distribution system profile sampling) to evaluate manganese levels through the plant.

Based on initial investigation, the Memorandum provided an initial set of profile sample locations, but recommended that a Geographical Information System (GIS) tool be developed with complaint and system data for use in finalizing a set of profile testing locations.

The City, working with PRI, was able to provide most of the requested data from the gap analysis memorandum. CDM Smith utilized the requested data and the GIS that was developed as a result of the gap analysis to develop a sample site list for profile sampling.

Prior to development of the profile sample locations, CDM Smith reviewed the additional data provided by the City as a result of the gap analysis. No strong correlation was found between rainfall, temperature, or plant water quality parameters and the number of water quality complaints per month. Anecdotal indications from City staff were that distribution system disturbances such as flushing, construction and plant power failures had a large impact on distribution system complaints, but data are not available to make a correlation.

Assessed data are in the attached "City of Port St. Joe Distribution System Summary of Findings from Profile Testing", dated August 19, 2013, in **Appendix B**.

Section 3

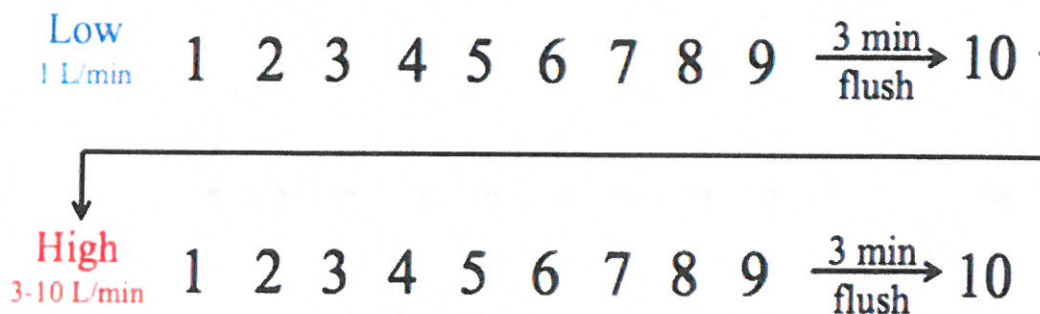
Profile Sampling and Results

3.1 Profile Sampling

CDM Smith, PRI, and the City collaborated to evaluate and select 11 profile sample sites. Sites were selected so that they were spread throughout the distribution system, were close to areas with frequent complaints, were in areas with various pipe materials, and were at premises where no water would be used at least six hours prior to the sampling. Sample sites are located on the maps in the "City of Port St. Joe Distribution System Summary of Findings from Profile Testing", dated August 19, 2013, in **Appendix B**.

Field sampling was conducted the week of April 15-19, 2013 in Port St. Joe and surrounding areas by staff from Virginia Tech in conjunction with City staff and CDM Smith Staff.

"Profiles" of the analyzed metals in water were taken by sequentially collecting a liter of water flowing from a tap after more than six hours holding (no flow) time. One set was collected using unrealistically low flow rates that have been used in previous studies. Another "profile" was also collected at a relatively higher flow rate. This sampling approach allows any relationship between discolored water and flow rate to be identified (Clark, B., S.V. Masters and M. Edwards. "3-D Profiling Detects Particulate Lead-in Water Risks as a Function of Flow Rate", Presented at the American Water Works Association Water Quality Technology Conference, 2012). For the low flow profile, nine sequential 1-liters (L) bottles were collected at a flow rate of approximately 1 liter per minute (L/min), followed by a 3-minute flush at the same rate before the tenth sample was collected. Immediately after, the profile was repeated at a higher flow rate (3-10 L/min) by fully opening the tap as shown on **Figure 3-1**. (Giani, R. Edwards, M., Chung, C. and Wujek. "Use of Lead Profiles to Determine Source of Action Level Exceedance from Residential Homes in Washington DC." Presented at the American Water Works Association Water Quality Technology Conference, 2004)



Modified from Clark (2012)

Figure 3-1 Illustration of Sequential Profile Water Sampling Collected in each Premises. One-liter Samples were Successively Collected at Low and High Flow After at Least Six Hours of No Flow (Stagnation).

Field sampling was conducted at ten premises and a stagnant potable line the Plant. Data from all sites was analyzed for the selected metals, but data from two sites was not used in the correlation analysis. The Plant, Site 3, was not used, and Site 11 (280 Chapel Lane, Overstreet) data were from the sample set, as the stagnation time at these two sites was less than six hours.

Disinfectant residual concentration, pH and dissolved oxygen were measured in the field for four of the low flow samples at each site. Samples were shipped to Virginia Tech and analyzed for the selected metals using inductively coupled plasma mass spectrometry (See "City of Port St. Joe Distribution System Summary of Findings from Profile Testing", dated August 19, 2013, in **Appendix B**, for details of the metals analysis and results.).

While the study was underway, the Plant took one of the chlorine contact chambers offline for cleaning. They observed a black residue on several of the surfaces. As preliminary Plant data analysis showed that manganese could be a contributing factor to the discolored water complaints, a sample of the residue was removed and sent to Virginia Tech for metals analysis.

3.2 Results

Results from each profile site can be seen in **Appendix B**. The iron and manganese profiles were not consistent throughout the distribution system, and instead depended on the sampling site.

Of the nine sites analyzed, significant correlation was found between iron and manganese at four of the sites.

Results for each site, and the correlations, can be seen in **Appendix B**.

Table 3-1 summarizes the results for profile sampling for the high flow condition.

Table 3-1 Summary of Profile Testing for High Flow Condition

Site	Address	Average High Flow Fe (ppb)	Average High Flow Mn (ppb)	Distribution System Pipe Material	Zone	Strong Correlation between Fe and Mn?	Comment
1	3800 Garrison Ave	469.9	22.1	6" PVC	City	Yes	Large Premesis: Room may have been stagnant a long time
2	101 20th St	675.4	38.2	6" Cast Iron	City	Yes	
4	520 Kenny St.	604.7	43.7	6" Cast Iron	City		
5	904 10th St.	6749.4	78.5	6" PVC	City	Yes	Possible Outlier: Premises stagnant for four weeks
6	603 16th St.	17.9	35.5	6" PVC	City		
7	1000 Costin Blvd	7.4	37.7	6" PVC	City		
8	429 Stebel Dr. WC	27.3	27.0	6" PVC	Beaches	Yes	
9	6714 Hiway 71, WC	22.9	25.7	6" PVC	Beaches		
10	204 Seapines Ln, SJB	-0.5	26.5	6" PVC	Beaches		
Mean		952.7	37.2				
Standard Deviation		2191.7	17.1				
Median		27.3	35.5				

The chlorine contact chamber residue analysis indicated the presence of both iron and manganese.

3.3 Findings and Conclusions

The City reported initial complaints as “red water”. Scale from the inside of galvanized steel distribution pipe removed from the system in 2010 was found to be mostly iron. These two factors caused the initial plan for this study to focus on iron corrosion. However, no systematic analysis of distribution system water to identify the cause of the discoloration in the water had been conducted prior to this study.

The original intent of this study, to evaluate means of controlling red water due to iron corrosion, was expanded after the profile testing to include supplemental analysis of Plant manganese treatment.

Excessive oxidized manganese can cause black water complaints and excessive oxidized iron can cause red water complaints. Iron, manganese and particulates in the distribution system each can contribute to “dirty” or “discolored” water complaints. It should be noted that Chapter 62-550.325(1) Florida Administrative Code does allow the use of polyphosphates as a sequester agent to “mask” iron and manganese. However, iron corrosion by-products or particulate forms of iron/manganese can still appear as turbidity.

Secondary Drinking Water Standards (SDWS) compliance limits are 0.3 mg/L for iron and 0.05 mg/L for manganese. Samples from four premises had iron levels in excess of the SDWS, and two had manganese levels in excess of the SDWS. The others had low concentrations of iron, and manganese levels between approximately 0.025 mg/L and 0.044 mg/L.

The results of the chlorine contact chamber residue analysis confirmed the presence of iron and manganese in the finished water.

Though Plant records show finished water iron levels to be generally low, the presence of iron in the chlorine contact chamber residue indicates the likelihood of iron carryover from the ferric sulfate coagulant. It is possible that this carryover occurred during the optimization phase of the plant, and that this iron is still present in the distribution system, potentially contributing to red water complaints. Additional monitoring of iron in finished water is recommended, particularly during periods of changing water conditions.

Manganese residue found in the chlorine contact chamber, along with Plant finished water manganese records, indicate that the plant is the likely source of the manganese found in the distribution system. Additional monitoring of manganese in raw water is recommended, particularly during periods of changing water conditions.

High flow profile sampling showed iron levels in the distribution system to vary more than manganese levels. This tends to support the conclusion that iron primarily comes from the distribution system, rather than the Plant, and that the source of manganese is the Plant.

Colored water complaints in areas with iron distribution piping is likely a result of both iron released from distribution system piping and manganese from the Plant. Iron released into the distribution system from the Plant optimization process may be a contributing factor, as well as potential hydraulic disturbances when the new plant went on line.

Colored water complaints in areas with primarily plastic distribution piping is likely primarily a result of manganese from the Plant, though iron released from other parts of the system or residual iron released into the distribution system from the Plant optimization process could be a contributing factor.

Where water sits stagnant in galvanized steel premises plumbing, premises plumbing likely contributes to colored water complaints.

Since colored water complaints are inconsistent, it is likely that unusual hydraulic events in the distribution system release iron and manganese that cause periods of higher complaint volume.

These findings indicate that it is important to control the effects of iron and manganese in the distribution system.

Section 4

Corrosion Control Pilot Testing and Results

Profile testing indicated the need for approaches to mitigate the discolored water and corrosion problems associated with iron pipe. CDM Smith, PRI, Virginia Tech, and the City worked to develop a bench scale pilot program to test various means of altering water chemistry to mitigate discolored water resulting from iron.

This section summarizes the results of the pilot testing report provided to CDM Smith by Virginia Tech. Details of the testing and results can be found in “Examining Iron Corrosion Control Alternatives in the Port St. Joe Drinking Water Distribution System” in **Appendix E**.

4.1 Coupon Harvesting

CDM Smith, PRI, and the City harvested one-inch diameter galvanized steel service line and six-inch diameter unlined cast iron pipe segments from the distribution system on August 29, 2013, per the coupon harvesting protocol included in **Appendix C**. Locations were changed as described below because 4-inch cast iron pipe shown on the map in “REVISED Coupon Harvest Area with 4” Cast Iron” was found to be lined with cement mortar, and thus was not suitable for iron corrosion testing.

One-inch diameter galvanized service line pipe was removed from the City ball field north of 10th Street between Woodward Avenue and Marvin Avenue.

Six-inch diameter unlined cast iron pipe was removed from the alley between Baltzell Avenue and Hwy 98, north of Fifth Street.

Pipe coupons were subsequently shipped to Virginia Tech where they were utilized in the bench scale pilot test.

4.2 Pilot Test Setup

The bench scale pilot test consisted of three phases. Phase 0 involved four weeks of conditioning the iron pipe coupons using finished water shipped from the City. In Phase 1 of the experiment, the coupons were exposed to four different water chemistry conditions (one control and three alternatives) for four weeks. Based on the results from Phase 1, the water chemistry was altered in order to optimize the corrosion control in Phase 2, which ran for six weeks. Water for use in Phase 1 and Phase 2 was collected from the Plant after membrane filtration but prior to chemical addition, and shipped to Virginia Tech.

4.2.1 Phase 0

Phase 0 consisted of conditioning the pipe samples using a dump and fill process three times a week for the four weeks of conditioning. Weekly composite data was collected to establish a baseline. The one-inch diameter galvanized pipe was cut into 20, six-inch long segments and after conditioning, 16 were selected for Phase 1 and 2 testing. The six-inch unlined cast iron pipe was cut into 2-inch squares and epoxied to the base of glass containers. Of the 45 samples conditioned, 20 were selected for Phase 1 and 2 testing.

4.2.2 Phase 1

Phase 1 tested three alternative water chemistries, with one control for four weeks. Water changes were also accomplished with a dump and fill procedure three times a week.

A summary of the Phase 1 treatment alternatives is shown below in **Table 4-1**.

Table 4-1 Summary of Treatment Alternatives in Phase 1

Alternative	Targeted Values			
	pH (SU)	Alkalinity (mg/L as CaCO_3) ¹	Corrosion Inhibitor (mg/L as P) ²	Chlorine Disinfectant (mg/L)
Control	7.2	30	0.5 Orthophosphate/ Polyphosphate blend	2.1
Alternative 1	7.8	30	1.5 Orthophosphate	2.1
Alternative 2	9.0	30	1.5 Orthophosphate	2.1
Alternative 3	9.0	45	1.5 Orthophosphate	2.1

Notes 1) mg/L as CaCO_3 = milligrams per liter calcium carbonate

2) mg/L as P = milligrams per liter as phosphorous

4.2.3 Phase 2

Buffer intensity is one of the key variables that can impact iron corrosion, especially in lower alkalinity surface water supplies such as that for the City. Higher buffer intensity is associated with lower iron corrosion. As such, Dr. Edwards and his team at Virginia Tech developed a buffer intensity model using MINEQL+ Chemical Equilibrium Modeling System (See **Figure 4-1** below). Based on the results of Phase 1 and the buffer intensity model, three different alternatives were selected and tested with for four weeks in Phase 2. Alternatives were selected to avoid the lowest part of the buffer intensity curve. Water changes were also accomplished with a dump and fill procedure three times a week.

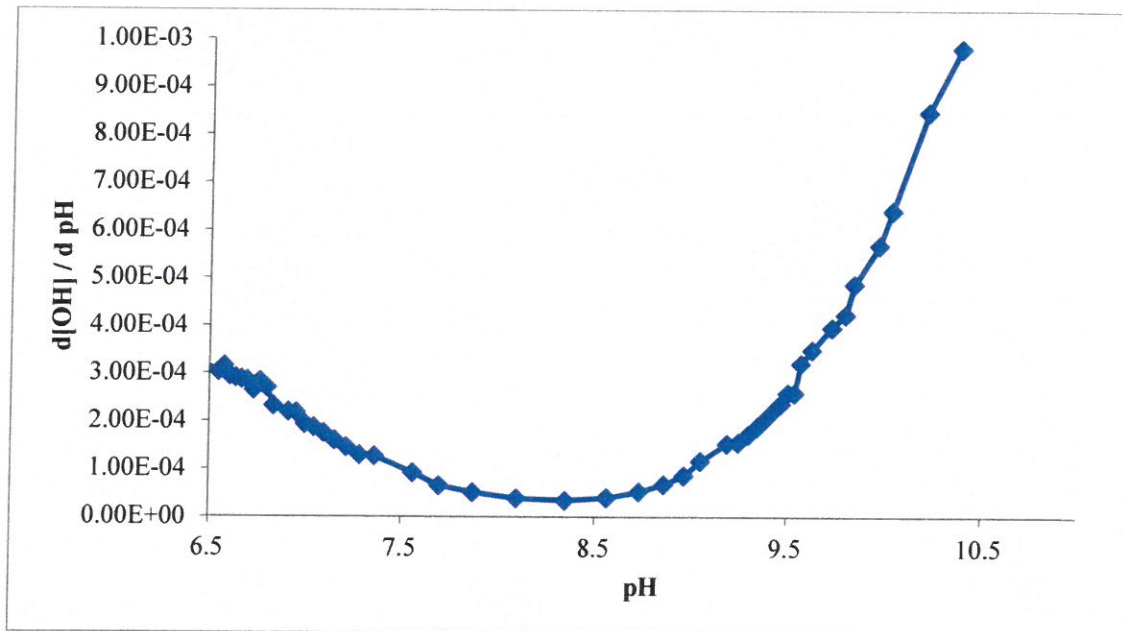


Figure 4-1 Effect of pH on Buffer Intensity of Water Quality Conditions in Port St. Joe

A summary of the Phase 2 treatment alternatives is shown below in **Table 4-2**.

Table 4-2 Summary of Treatment Alternatives in Phase 2

Alternative	Targeted Values			
	pH (SU)	Alkalinity (mg/L as CaCO ₃) ¹	Corrosion Inhibitor (mg/L as P) ²	Chlorine Disinfectant (mg/L)
Control	7.5	30	0.5 Orthophosphate/ Polyphosphate blend	2.1
Alternative 1	7.5	30	3.0 Orthophosphate	2.1
Alternative 2	10.0	No Target	1.5 Orthophosphate	2.1
Alternative 3	7.5	45	1.5 Orthophosphate	2.1

Notes 1) mg/L as CaCO₃ = milligrams per liter calcium carbonate

2) mg/L as P = milligrams per liter as phosphorous

4.3 Pilot Test Results

Results of the pilot testing for iron are summarized in **figures 4-2 and 4-3**.

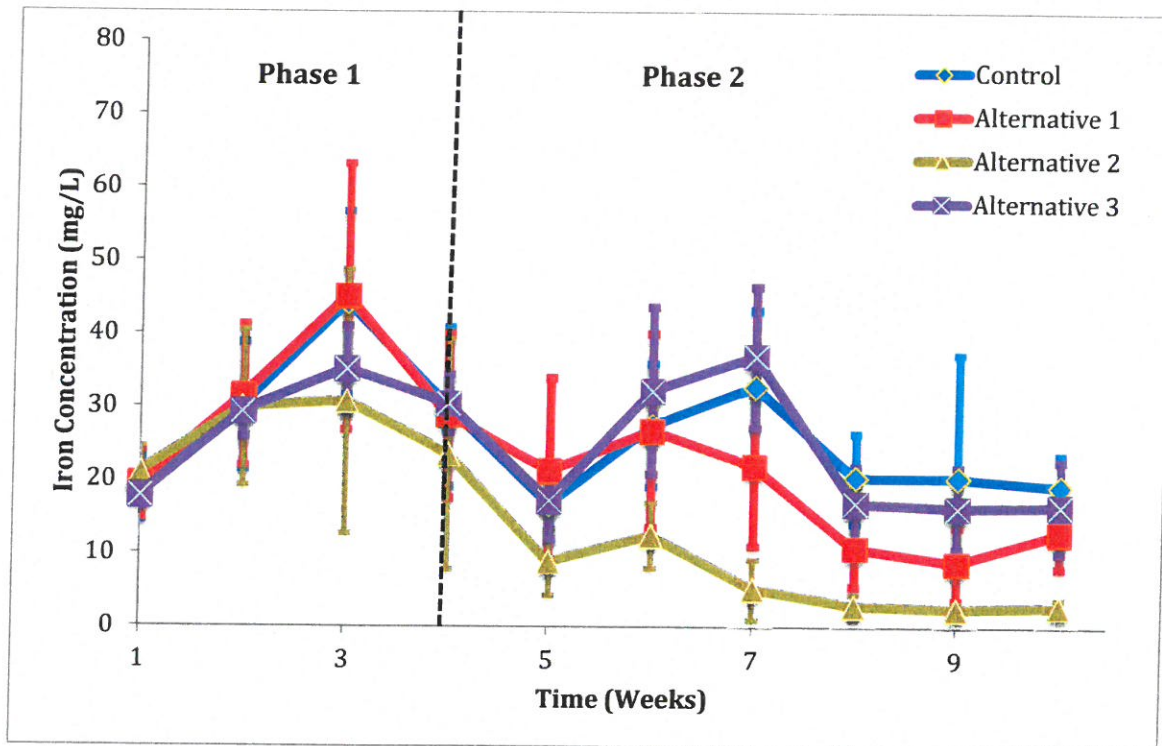


Figure 4-2 Change in Total Iron Concentration in Cast Iron Coupons

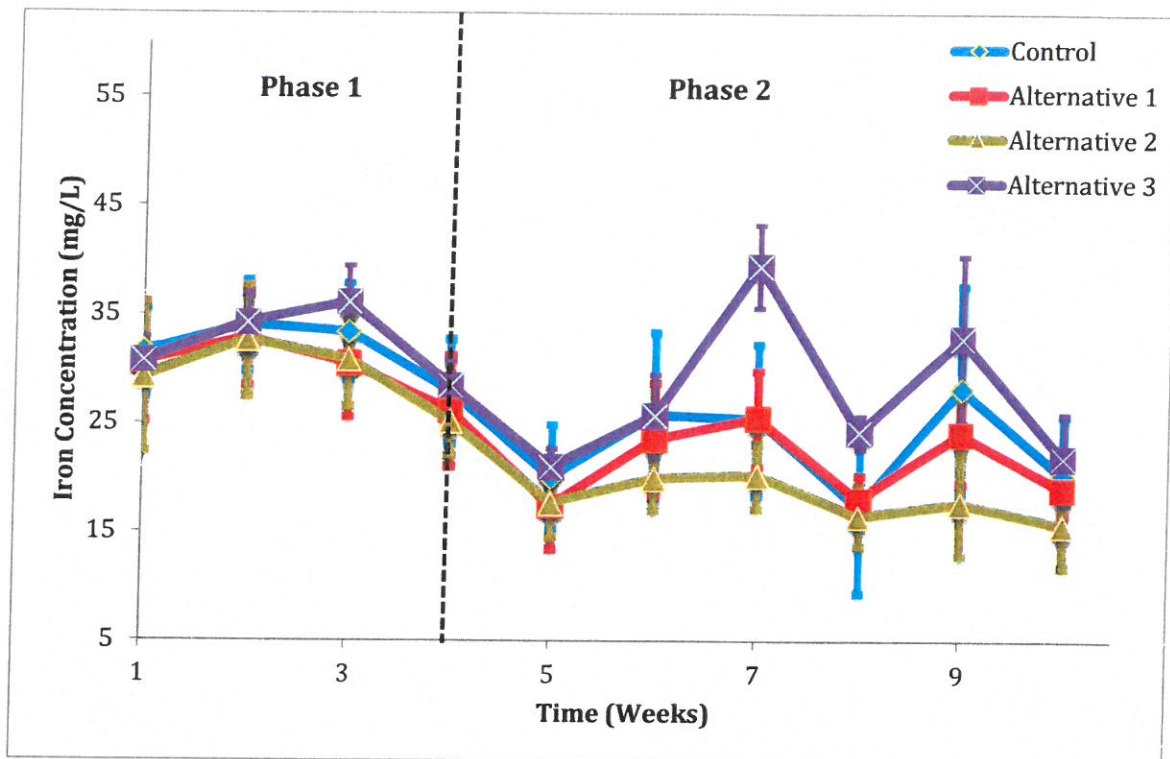


Figure 4-3 Change in Total Iron in Galvanized Steel Coupons

Phase 2 showed that Alternate 2 had less iron release than the other alternatives, with Alternative 1 showing potential for improvement.

Similar analysis was conducted for manganese, but there was less difference between the various alternatives for manganese concentrations. Alternative 2 did perform nominally better than the other alternatives for manganese. Results of the manganese analysis for the bench scale pilot test can be seen in Appendix E, with other details about the bench scale pilot testing methods and results. Manganese concentrations were relatively low compared to iron concentrations.

Results of the manganese analysis for the bench scale pilot can be seen in Appendix E, with other details about the bench scale testing methods and results.

Ideally the study would have continued in order to investigate Alternative 1 further, as it may have continued to improve with time. However, hoped for funding from the private foundation of Jessie Bell DuPont did not materialize, and the study was ended.

4.4 Conclusions

4.4.1 Conclusions from Bench Scale Testing Report

In Phase 1 of the experiment, Dr. Edwards and his staff concluded that none of the Alternatives tested revealed any significant decrease in iron and manganese release when compared to the Control. However, this is possibly due to the short timescale and limited data of the experiment. After extending the study in Phase 2, Alternative 2 had much less iron release when compared to all other conditions for both cast iron and galvanized iron tests and the benefits were observed in very short time periods. This Alternative required the highest pH (10 SU), which also resulted in a substantial

increase in the buffer intensity and alkalinity. In Phase 2, Alternative 2 was also tested using chloramines as opposed to free chlorine to reduce the likelihood of DBP, because the concentration of some regulated DBP compounds, specifically total trihalomethanes (TTHM) increases as pH values increase (Initial Distribution System Evaluation Guidance Manual Appendix A, US Environmental Protection Agency, 2006)

Based on these results it appears that increasing the finished water pH to 10 SU, dosing 1.5 mg/L (as P) orthophosphate, and switching the disinfectant to chloramine should be effective at reducing iron corrosion and consumer "red water" complaints.

It should be noted that the results of this study represent short terms trends in iron and manganese release and similar corrosion studies have indicated that long-term trends can sometimes be different. In particular, testing the higher doses of orthophosphate with a pH value of 7.5 SU was starting to look promising in controlling iron release by the end of the study. A proposal for additional funding from the Jessie Ball DuPont foundation was written by Virginia Tech to further study the issue. However, after representatives of the Jessie Ball DuPont Foundation (Foundation) met with the City and learned that the City had procured funding to replace most of the iron and steel pipe in its system, the Foundation decided not issue grant money at this time for further water quality study. The additional funding from the Foundation would have extended the testing duration to determine the longer-term performance of Alternatives 1 and 2 from Phase 2.

4.4.2 Requirements for Implementation of Phase 2 Alternatives

4.2.2.1 Requirements for Alternative 1

Alternative 1, operation at pH 7.5 SU and a change to 100% orthophosphate at 3.0 mg/L as P, would be the least difficult alternative to implement and operate. It would require a step-wise transition of orthophosphate chemical as well as pH control and monitoring. Implementation of this alternative would require monitoring of water stability indices, system nitrification, and lead and copper.

4.2.2.2 Requirements for Alternative 2

Alternative 2, an increase of pH to 10 SU (or near 10 SU) and a change to 100% orthophosphate at 3.0 mg/L as P, would require significant operational changes. The increase in pH would require that the plant operate the distribution system residual disinfection system with chloramines. This is because free chlorine is a poor disinfectant at high pH, and elevated pH tends to increase TTHM formation. Primary disinfection with free chlorine would continue at the lower pH currently used through the microfiltration membranes, with chloramine formation in the chlorine contact chamber prior to pH adjustment to 10 SU in the transfer pump wet well.

Chloramination would require the reinstallation of ammonia feed equipment. The Plant has successfully controlled DBPs since it went on line in 2009 and been able to operate the distribution system with free chlorine since then. Because of this, the plant removed and mothballed ammonia feed equipment rather than bear continued operation and maintenance costs for it.

Chemical feed and storage equipment is in place for the required pH adjustment, which could be accomplished with sodium hydroxide. Dosing requirements to reach a pH of 10 SU should be confirmed with on-site jar testing, and the capacity of existing caustic feed pumps used for final pH adjustment should be verified. Implementation of this alternative would require monitoring of water stability indices, system nitrification, and lead and copper. Prior to full scale implementation, on-site lead and copper monitoring with this condition should be conducted.

4.2.2.3 Requirements for Alternative 3

Alternative 3, operation at a pH of 7.5 SU, an increase in alkalinity to 45 ppm as CaCO_3 , and a change to 100% orthophosphate at 1.5 mg/L as P, would require the installation of another chemical feed system to increase alkalinity. A previous CDM Smith study ("City of Port St. Joe SWTP Process Modifications Analysis", February 2011, **Appendix G** of this report) assessed methods for doing this. CDM Smith recommended the addition of calcium hydroxide and carbon dioxide, if a change in alkalinity was deemed beneficial after assessing other alternatives.

Significant modifications to the plant would be required for the implementation of a calcium hydroxide and carbon dioxide system. These modifications include the design, permitting, and installation of new calcium hydroxide and carbon dioxide storage and feed systems at the SWTP.

The new calcium hydroxide storage and feed system is preliminarily expected to consist of a bulk storage tank; a tank mixer to ensure the slurry remains suspended; three metering pumps to deliver the slurry to the chlorine contact chamber; and all associated piping, valves, and appurtenances. The new carbon dioxide storage and feed system is preliminarily expected to consist a refrigerated and insulated bulk storage tank including refrigeration, vaporizer, and vapor heater units; an automatic pressure solution feed panel; and all associated insulated piping, valves, and appurtenances.

Sizing should be conducted in consultation with the City for anticipated water production.

Mixing of the calcium hydroxide and carbon dioxide would be provided by turbulence created by finished water falling over the existing sharp-crested weirs and by the existing finished water transfer pumps.

Pilot testing would be required to verify design assumptions and mixing capacity at the weirs.

It should be noted that while the Virginia Tech pilot study used sodium bicarbonate to adjust alkalinity in the pilot study, using this chemical at the full scale plant has not been previously considered due to the high cost of the chemical. However, City staff has indicated that they do not anticipate an increase in production at the Plant in the near future. A life cycle cost analysis of a sodium bicarbonate feed system, in conjunction with a water demand study, could be conducted to verify that this is not the most cost effective option for the current low (1 MGD to 2 MGD) flows.

4.4.3 Conclusions from Draft Pilot Test Report Delivery Meeting

On February 5th, 2014, CDM Smith, PPI and City staff met to discuss the draft pilot testing report from Virginia Tech.

After delivering a summary of the report, CDM Smith noted that a private foundation, The Jessie Ball DuPont foundation, was potentially interested in providing funding to continue Virginia Tech's pilot work to investigate more thoroughly the potential for Alternative 1, as Alternatives 2 and Alternative 3 both require significantly more operational complexity. Virginia Tech had written a proposal to the Foundation, and the Foundation indicated in telephone conversations that funding was likely.

Previous discussions with City staff had indicated that the City would consider the use of chloramines if required, but at this meeting the City stated that they did not want to use chloramines in the Port St. Joe system due to operational concerns.

This makes Alternative 2 unattractive to the City, as elevated pH in distribution system operation requires the use of chloramines to control DBPs.

At the meeting the City stated that they anticipate having 90% of the iron pipe in the distribution system replaced with plastic pipe by 2014. They have found that after an initial adjustment period discolored water complains go down significantly in areas that have had iron pipe replaced with plastic pipe. They now consider manganese the primary concern in the distribution system.

Section 5

Manganese Control

5.1 Background

The initial data collection and subsequent profile testing indicated that manganese is likely a contributing factor to the colored water complaints experienced by the City. Though the original objective of the Study was the control of iron corrosion, CDM Smith performed a supplementary investigation of manganese control. This section the results of the limited investigation conducted on managnese.

5.1.1 Overview

Manganese can cause aesthetic complaints such as “black water”, laundry spotting, or similar problems (“Occurrence of Manganese in Drinking Water and Manganese Control”, American Water Works Association Research Foundation (AWWARF), 2006) . Control of manganese can be difficult because of its complex chemistry and it tendency to accumulate in distribution systems over time (“Occurrence of Manganese in Drinking Water and Manganese Control”, AWWRF, 2006, and “Legacy of Manganese Accumulation in Water Systems”, Brandhuber, Water Research Foundation (WRF), 2013). Research has shown that systems with variable levels of manganese in raw water generally have the most difficulty in successfully treating manganese to compliance limits (“Legacy of Manganese Accumulation in Water Systems”, Brandhuber, WRF, 2013).

The surface water source used by the City has varying concentrations of raw water manganese. The 2004 pilot study conducted prior to the design of the Plant recognized the need for manganese treatment and evaluated the effectiveness of the proposed process at manganese treatment. The pilot process demonstrated effective treatment of manganese.

Data collected since the plant went online in 2009 shows that the raw water has varying levels of manganese, and that the removal effectiveness of the Plant is limited.

Profile data obtained from the distribution system for this study shows that manganese can be found throughout the distribution system. Water quality complaints in areas without iron distribution pipe and water quality complaints of “black” water indicate that manganese is an issue of aesthetic concern in the City’s Distribution system.

An aggressive distribution system rehabilitation program by the City will result in the removal of 90% of iron-containing pipe by the end of 2014. The City stated that they observed a significant reduction in red water complaints in areas with newly replaced pipe and now feels the issue to resolve is manganese.

5.1.2 Plant Pilot, Operational, and Profile Data

Table 5-1 below summarizes manganese data from the 2004 pilot test report by US Filter for the City for raw water, clarified water and finished water manganese. The pilot plant achieved an averaged an average of 0.027 mg/L of manganese in the filtered water, significantly below the SDWS of 0.05 mg/L.

Table 5-1 2004 Port St. Joe Pilot Mn Data

Sample Location	Average Manganese Concentration (mg/L)
Raw Water	0.067
Clarified Water	0.042
Filtered Water	0.027

The City measures raw water manganese concentrations at approximately weekly intervals, as well as clarified and finished water manganese concentrations daily. March 1, 2010 through September 20, 2013 plant water quality data for manganese at the Plant is summarized in **Table 5-2**.

Table 5-2 City of Port St. Joe Surface Water Plant Mn Data

Sample Location	Average Manganese Concentration (mg/L)
Raw Water	0.036
Clarified Water	0.042
Filtered Water	0.033

These data result in a total manganese removal of approximately 8% through the plant. Average manganese measured in the clarified water showed an increase of 17%, an unusual situation.

On October 10, 2013 CDM Smith, with the assistance of City staff, collected a set of profile samples at the Plant. The samples were analyzed by Dr. Marc Edward's staff at Virginia Tech. The results are provided below in **Table 5-3**.

Table 5-3 Plant Manganese Profile by Unit Process

Point No.	Description	pH at Time of sample (SU)	pH at Time of Analysis (SU)	Manganese Concentration, mg/L		
				Unfiltered	0.45 Micron Filtered	10K Molecular Weight Ultra Filtered
1	Raw Water	6.1	5.8	0.033	0.016	0.017
2	Clarifier (Before Caustic Soda Addition)	5.5	5.3	0.044	0.046	0.042
3	Clarifier Effluent (After Caustic Soda Addition)	6.1	6.1	0.043	0.045	0.038
4	Filtered Water	6.5	6.3	0.046	0.046	0.041
5	Finished Water	7.5	7.3	0.031	0.000	0.000

Based on data supplied by the Plant, manganese concentrations generally increased by passage through the clarifier. Over 80% of the plant measurements showed an increase in manganese concentration from clarifier influent to clarifier effluent. The Plant profile conducted on October 10, 2013, confirmed this tendency. Because of this situation, CDM Smith also had a sample of the ferric sulfate coagulant (Kemira PIX-117, Iron (III) Sulfate) in use at the plant on October 15, 2013 analyzed by Virginia Tech. The analysis results are below in **Table 5-4**.

Table 5-4 October 15, 2013 Ferric Sulfate Coagulant Analysis

Parameter	Value
Iron	13.9 % by weight
Manganese	219 mg/L of product

This level of manganese in the ferric sulfate (assuming less than 100% capture in the formed flocs) is believed to account for a significant portion of the manganese concentration increase through the clarifier.

5.1.3 Plant Operations

In December of 2013 plant staff changed chemical feed points so that the current 50/50 ortho-poly blend of phosphate is now fed upstream of the chlorine contact chamber. No data is yet available on the effectiveness of this change. The Plant staff did this in an effort to sequester manganese in the filtered water before it reached the chlorine contact chamber where it could react with chlorine and come out of solution. CDM Smith experience is that this sequestered manganese is eventually released in the distribution system when the polyphosphate breaks down. If the City wants to continue to this sequestration, a small chemical feed system to feed enough polyphosphate for sequestration will be required. This is because the current feed system downstream of the chlorine contact chamber would be utilized for orthophosphate feed under the recommendations of this report in Section 7.

5.2 Bench Scale Testing

CDM Smith, in conjunction with PRI, and assisted by City staff, performed a series of jar tests to investigate methods of improving manganese removal at the Plant.

CDM Smith investigated low-manganese content ferric sulfate coagulant as well as low-manganese content ferric sulfate in conjunction with sodium permanganate.

5.2.1 Low Manganese Ferric Sulfate

CDM Smith identified a ferric sulfate coagulant supplier with a specified maximum manganese content of 90 mg/L. (Based on analysis data provided to CDM Smith from the supplier, the manganese content is generally lower than this specified maximum. For example, an analysis conducted in November of 2012 showed a manganese content of 50.3 mg/L.) CDM Smith obtained a sample of ferric sulfate coagulant from this supplier meeting the specification below for use in jar testing.

Budgetary pricing in November of 2013 indicated that this product would cost \$0.143 per pound delivered to the City in a tanker truck.

Key specifications of the Ferric Sulfate and supplier contact information are provided below.

- Total Iron: 13%
- Ferrous Iron <0.1%
- Insolubles <0.1%
- Manganese <90 mg/L
- Product shall meet AWWA B-406 specifications

- Product shall be certified to conform to ANSI 60 standard for drinking water
- The liquid ferric sulfate shall be manufactured from a source of virgin mined Iron OFV (i.e., magnetite, hematite, etc.) and a "water white" grade of sulfuric acid. Liquid ferric sulfate produced from non-virgin ores will not be acceptable. This specification strictly prohibits the use of liquid ferric sulfate manufactured from the by-products generated from titanium dioxide production. The use of reclaimed materials to produce the liquid ferric sulfate material is expressly prohibited under this specification.

Sales point of contact:

Monica Thorsen
Sales Representative
Brenntag Mid- South, Inc.
Cell 407-754-6503
Customer Service & Orders 407-857-9310
Fax 407-851-3512
MThorsen@Brenntag.com

5.2.2 Sodium Permanganate

CDM Smith reviewed various means of treating raw water for manganese removal (see "City of Port St. Joe Surface Water Treatment Plant Ferric Sulfate and Manganese" for a summary of the assessment) and recommended jar testing sodium of permanganate solution as a pre-oxidant for conversion of soluble manganese to particulate manganese. Permanganate is commonly used to oxidize manganese in raw water so that it can be removed by clarification and filtration. Sodium permanganate is a liquid that makes chemical feed simple and dependable.

CDM Smith obtained a sample of NSF 60 certified sodium permanganate to use for jar testing. The sodium permanganate was CARUSOL-20, 20% purity sodium permanganate by Carus Corporation. Local representative contact information is below.

Local Carus Corporation contact information:

Phil Tyson
Tyson Services
Mobile: 229-894-7797
tysonservices@yahoo.com

Sodium permanganate is more effective at oxidizing manganese at pH values somewhat higher than the natural pH of the source water (pH 6.8 SU) and much higher than the pH used in the Port St. Joe clarifiers (pH 5.5 SU +/-). Research has identified effective manganese removal with permanganate at pH 7.5 SU to 8.0 SU in as little as ten minutes ("Occurrence of Manganese in Drinking Water and Manganese Control", AWWRF, 2006). However, existing literature data show that as pH values drop below 7.0 SU and/or temperatures drop below 10 degrees Celsius, filtered water total manganese concentrations can substantially increase.

5.2.3 Bench Scale Jar Testing Parameters

Oxidizing raw water manganese with permanganate in the clarifiers creates competing process requirements. The City of Port St. Joe reports that the pH condition in the clarifiers needs to be low,

below 6 SU, to effectively remove DPB formation precursors (enhanced coagulation). However, permanganate is not generally effective at oxidizing manganese at those relatively low pH values.

Ideally, therefore, the permanganate would be used to oxidize the manganese in the raw water pipeline prior to the clarifiers. The Plant has limited detention time in the raw water pipeline, so CDM Smith conducted a series of jar tests to investigate various alternatives. HACH method 8149 was utilized to analyze manganese concentration.

- Set A: Investigated existing conditions under low flow (three MGD with two clarifiers online) with raw water manganese of 0.025 mg/L and permanganate injected at the intake pump station.
- Set B: Investigated existing conditions under high flow (three MGD with two clarifiers online) with raw water manganese of 0.025 mg/L and permanganate injected at the intake pump station.
- Set C: Investigated existing conditions under low flow (one MGD with two clarifiers online) with raw water manganese of 0.06 mg/L and permanganate injected at the intake pump station.
- Set D: Investigated existing conditions under high flow (three MGD with two clarifiers online) with raw water manganese of 0.06 mg/L and permanganate injected at the intake pump station.
- Set E: Investigated increased pH in the raw water pipeline and clarifiers under low flow (one MGD) with raw water manganese of 0.06 mg/L and permanganate and caustic injected at the intake pump station.
- Set F: Investigated increased pH in the raw water pipeline and clarifiers under high flow (three MGD with two clarifiers online) with raw water manganese of 0.06 mg/L and permanganate and caustic injected at the intake pump station.
- Set H: Investigated increased pH in the raw water pipeline and clarifiers under high flow (three MGD with two clarifiers online) with raw water manganese of 0.06 mg/L. Ferric was injected ahead of the caustic and permanganate.
- Set I: Investigated increased pH in the raw water pipeline and clarifiers under low flow (one MGD with two clarifiers online) with raw water manganese of 0.06 mg/L. Ferric was injected ahead of the caustic and permanganate.
- Set J: Investigated existing plant process with both the ferric sulfate in use at the Plant at the time and low-manganese ferric sulfate. Raw water manganese was 0.06 mg/L and no sodium permanganate was used.
- Set K: Investigated increased pH in the raw water pipeline only under low flow (one MGD with two clarifiers online) with raw water manganese of 0.06 mg/L. Used increased detention time (20 minutes) in the raw water pipeline to simulate a larger or longer pipeline. Used low-manganese ferric to simulate clarification process. Permanganate and caustic were injected at the raw water pump station.
- Set L: Investigated increased pH in the raw water pipeline only under low flow (one MGD with two clarifiers online) with raw water manganese of 0.06 mg/L. Used increased detention time (40 minutes) in the raw water pipeline to simulate a larger or longer pipeline. Used low-

manganese ferric to simulate clarification process. Permanganate and caustic were injected at the raw water pump station.

- Set M: Investigated increased pH in the raw water pipeline only under low flow (one MGD with two clarifiers online) with raw water manganese of 0.06 mg/L. Used increased detention time (40 minutes) in the raw water pipeline to simulate a larger or longer pipeline. Used low-manganese ferric to simulate clarification process. Permanganate and caustic were injected at the raw water pump station. Used a somewhat higher increase in clarifiers (pH 6.5). (A higher pH in the clarifier was simulated because permanganate would also oxidize the naturally occurring organic matter that makes up disinfection byproduct precursors, and potentially allowing the clarifiers to run at a higher pH and still accomplish the total organic carbon reduction required.)

5.3 Bench Scale Testing Results

CDM Smith staff in conjunction with PRI and City staff conducted 12 sets of jar tests between October 17, 2013 and November 13, 2013.

A description of each jar test series with a summary of results is provided below in **Table 5-5**, "Port St. Joe Mn Jar Test Results Summary".

When testing with the current ferric sulfate used at the Plant, the results show that adding sodium permanganate to the raw water upstream of the clarifiers without increasing the pH of the raw water or the clarifiers generally resulted in increased filtered water manganese.

This may be due to organics interfering with the oxidation of manganese, or due to unfavorable pH conditions for manganese oxidation. The exact reasons are not clear from the data available.

Tests A through D modeled existing conditions as described above with the addition of permanganate added at the raw water intake. All of these tests showed an increase in finished water manganese.

Tests E-I and M examined the effect of increasing pH in both the raw water and the clarifiers. Tests E-I used substantially increased clarifier pH and demonstrated reduction in filtered water manganese concentrations. However, the need to operate the clarifiers at a low pH to remove NOM (enhanced coagulation) likely precludes these alternatives. Test M simulated increased detention time, increased pH in the raw water pipeline, and an increase in the clarifier pH from 5.6 SU to 6.5 SU. This alternate did demonstrate a reduction in finished water manganese concentration, but not much better than the current process with low-manganese content ferric sulfate coagulant.

Table 5-5 Port St. Joe Manganese Jar Test Results Summary

Test	Description of Plant Operation Simulated by Jar Test	Raw Water Manganese Concentration (mg/L)	Type of Ferric Sulfate Coagulant	Range for Stoichiometric Base Dose of Sodium Permanganate (%)	Filtered Water Manganese (mg/L)	Change in Manganese Concentration, Raw to Filtered (%)
A	Existing conditions with permanganate Simulated use of raw water pipeline then clarifiers as reaction vessels with permanganate injected at intake. Flow @ 3 MGD with 4 minutes in raw water pipeline and two clarifiers on line. Raw water pH 6.43. Clarifiers operating at pH 5.5-5.7.	0.025	Existing	50 to 200	0.074 to 0.144	196 to 476 (Increase)
B	Existing conditions with permanganate Simulated use of raw water pipeline and clarifiers as reaction vessels with permanganate injected at intake. Flow @ 1 MGD with 12 minutes in raw water pipeline and two clarifiers online. Raw water pH 6.43. Clarifiers operating at pH 5.5-5.7.	0.025	Existing	50 to 200	0.08 to 0.188	220 to 652 (Increase)
C	Existing conditions with permanganate Simulated use of raw water pipeline and clarifiers as reaction vessels with permanganate injected at intake. Flow @ 1 MGD with 12 minutes in raw water pipeline and two clarifiers online. Raw water pH 6.43. Clarifiers operating at pH 5.5-5.7.	0.06	Existing	50 to 200	0.559 to .142	832 to 137 (Increase)
D	Existing conditions with permanganate Simulated use of raw water pipeline and clarifiers as reaction vessels with permanganate injected at intake. Flow @ 3 MGD with 4 minutes in raw water pipeline and two clarifiers online. Raw water pH 6.41. Clarifiers operating at pH 5.5-5.7.	0.058	Existing	50 to 200	0.42 to 0.127	624 to 119 (Increase)

Test	Description of Plant Operation Simulated by Jar Test	Raw Water Manganese Concentration (mg/L)	Type of Ferric Sulfate Coagulant	Range for Stoichiometric Base Dose of Sodium Permanganate (%)	Filtered Water Manganese (mg/L)	Change in Manganese Concentration, Raw to Filtered (%)
E	Elevated pH in raw water and clarifiers with permanganate Simulated use of raw water pipeline then clarifiers as reaction vessels with permanganate and caustic injected at intake. Flow @ 1 MGD with 12 minutes in raw water pipeline two clarifiers online at elevated pH. 3 TESTS: (1) raw water at pH 7, clarifier at 7 (2) raw at 8, clarifier at 7.2 (3) raw at 9, clarifier at 7.8	0.06	Existing	100 and 250	0.127 to 0.009	112 to -66 (Decrease with increasing pH)
F	Elevated pH in raw water and clarifiers with permanganate Simulated use of raw water pipeline and clarifiers as reaction vessels with permanganate and caustic injected at intake. Flow @ 3 MGD with 4 minutes in raw water pipeline. Two clarifiers online at elevated pH. 3 TESTS: (1) raw water at pH 7, clarifier at 6.6 (2) raw at pH 8, clarifier at 7 (3) raw at pH 9, clarifier at 7.5	0.063	Existing	100 and 250	0.144 to 0.022	129 to -65 (Decrease with increasing pH in raw water and clarifier)
H	Elevated pH in raw water and clarifiers with permanganate Simulated use of raw water pipeline and clarifiers as reaction vessels with permanganate and caustic injected at intake. 3 MGD with 4 minutes in raw water pipeline. Two clarifiers online at elevated pH. 3 TESTS: (1) raw water at pH 7, clarifier at 6.6 (2) raw at 8, clarifier at 6.8 (3) raw at 9, clarifier at 7.1 Ferric added before caustic	0.059	Existing	100 and 250	0.139 to 0.057	136 to -3 (Decrease with highest pH and highest permanganate dose)

Test	Description of Plant Operation Simulated by Jar Test	Raw Water Manganese Concentration (mg/L)	Type of Ferric Sulfate Coagulant	Range for Stoichiometric Base Dose of Sodium Permanganate (%)	Filtered Water Manganese (mg/L)	Change in Manganese Concentration, Raw to Filtered (%)
I	Elevated pH in raw water and clarifiers with permanganate Simulated use of raw water pipeline and clarifiers as reaction vessels with permanganate and caustic injected at intake. 1 MGD with 12 minutes in raw water pipeline. Two clarifiers online at elevated pH. 3 TESTS: (1) raw water at pH 7, clarifier at 7 (2) raw at 8, clarifier at 7.2 (3) raw at 9, clarifier at 7.8 Ferric added before caustic	0.059	Existing	100 and 250	0.095 to 0.010	61 to -83 (Decrease with highest pH and highest permanganate dose)
J	Existing and Low Mn Ferric Sulfate Simulated existing plant process with existing ferric sulfate and low-manganese ferric sulfate (No sodium permanganate)	0.062	Existing and Low Mn	0	0.044 to 0.62	-29 to 0 (Decrease with Low Mn ferric)
K	Increased pH in Raw Water and Permanganate Permanganate and caustic injected at intake. Simulated use of larger raw water pipeline as reaction vessel with 20 minutes detention time, then through clarifiers as usual. Flow @ 1 MGD with two clarifiers online at pH 5.4. 2 TESTS: (1) raw water at pH 8 (2) raw water at pH 9	0.062	Low Mn	250 to 550	0.112 to 0.084	81 to 35 (Increase)
L	Increased Raw Water pH and Permanganate Permanganate and caustic injected at intake. Simulated use of larger raw water pipeline as reaction vessel with 40 minutes detention time, then through clarifiers as usual. Flow @ 1 MGD with two clarifiers online at pH 5.4. 2 TESTS: (1) raw water at pH 8 (2) raw water at pH 9	0.065	Low Mn	250 to 550	0.107 to 0.62	65 to -5 (Increase to nominal decrease; decrease with highest pH and permanganate dose)

Test	Description of Plant Operation Simulated by Jar Test	Raw Water Manganese Concentration (mg/L)	Type of Ferric Sulfate Coagulant	Range for Stoichiometric Base Dose of Sodium Permanganate (%)	Filtered Water Manganese (mg/L)	Change in Manganese Concentration, Raw to Filtered (%)
M	<p>Increased Raw Water pH, Slightly Increase Clarifier pH, and Permanganate</p> <p>Permanganate and caustic injected at intake.</p> <p>Simulated use of larger raw water pipeline as reaction vessel with 40 minutes detention time, then through clarifiers as usual.</p> <p>Flow @ 1 MGD with two clarifiers online at pH elevated pH.</p> <p>2 TESTS:</p> <p>(1) raw water at pH 8; clarifier 6.5</p> <p>(2) raw water at pH 9; clarifier 6.5</p>	0.063	Low Mn	250 to 550	0.036 to 0.084	-43% to 33% (Decrease with highest permanganate dose)

5.4 Conclusions and Next Steps

Jar testing showed adding sodium permanganate, in the amounts tested, to the raw water with the current process conditions would be unsuccessful.

The Plant cannot use the clarifiers effectively as reaction vessels for manganese oxidation without substantial operational changes. This is because the Plant has found effective DBP formation precursor removal with a clarifier pH below 6.0 SU. However, this pH is too low for permanganate to effectively oxidize manganese.

Jar testing showed the most effective alternative to be simply changing to a low manganese content ferric sulfate coagulant. This new coagulant usage should provide a reduction in finished water manganese.

Section 6

Conclusions

The following conclusions can be drawn from the investigation conducted for this study.

Increasing finished water pH to 10 SU and changing corrosion control chemical to 1.5 mg/L of 100% orthophosphate would likely significantly reduce iron corrosion, based on the limited tests performed at Virginia Tech. FDEP regulators, when questioned about this recommendation stated that they would allow these conditions provided assurance could be provided that it would not create lead or copper compliance problems. However, this alternative would require the use of chloramines, and the City does not currently want to use chloramines due to operational concerns.

Operating at a finished water pH of 7.5 SU and changing corrosion control chemical to 3.0 mg/L of 100% orthophosphate also showed promise in reducing iron release after longer period. Laboratory test results showed that this alternative was not as effective as a pH of 10 SU, especially in the short term, but it also has the advantage of being much easier to implement and operate.

The City anticipates having 90% of the unlined iron pipe in its distribution system replaced by the end of 2014. The City has observed a significant reduction in red water complaints in areas that have had iron pipe replaced by plastic pipe and now feels their biggest distribution system problem is manganese.

Profile testing at the plant has shown that the ferric sulfate currently in use at the plant is compounding the manganese problem.

Jar testing has shown that finished water manganese could be reduced by changing to a low-manganese content ferric sulfate coagulant.

Analysis of the manganese jar testing data show that there is a fundamental conflict between the conditions necessary for enhanced coagulation to remove NOM and pH conditions necessary for effective oxidation of reduced manganese to particulate manganese using permanganate.

Section 7

Recommendations and Next Steps

7.1 Water Treatment Plant Related Recommendations

7.1.1 Plant Modifications

No plant modifications are recommended at this time. Chemical feed pump capacities should be verified for the operational changes recommended below. See the recommended distribution and operational changes for potential plant modifications required if other alternates are implemented in the future.

7.1.2 Distribution and Operational Changes

CDM Smith recommends the following distribution system and operational changes:

For iron:

The City should continue its program to replace unlined cast iron and galvanized distribution system pipe with plastic pipe. The City should also replace galvanized service lines with plastic pipe.

Though the City believes that the iron issue will no longer be a problem once cast iron and galvanized steel distribution pipe is replaced, until that time the City should change its corrosion control chemical to 3.0 mg/L as P, 100% orthophosphate and operate at its distribution system at a pH of 7.5 SU to address iron corrosion. The chemical feed transition should be made gradually. The City should monitor the impact of the change on lead and copper in the distribution system during and after the transition. The City may choose to keep this operational scheme in place to help control iron release from service laterals and other pipe containing iron.

While the previous recommendation is being implemented, the City should conduct an on-site lead and copper pilot with a pH of 10 SU and 1.5 mg/L as P, 100% orthophosphate. Data should be recorded in case it is needed to demonstrate to the FDEP that lead and copper would stay within regulatory limits under these operating conditions should the City determine that it needs to implement the recommendation below.

If the City wants to implement further red water control measures, the City should reconsider implementing a change to pH 10 SU and 1.5 mg/L as P, 100% orthophosphate with chloramines as a distribution system disinfectant. If this is implemented, the City should monitor the impact of the change on lead and copper in the distribution system before and after the change, and monitor for the effects of nitrification.

The City should also monitor iron in finished water a minimum of four times daily during changing raw water or process conditions to check that iron from the ferric sulfate coagulant is not leaving the Plant.

For manganese:

The City should monitor manganese concentration in the raw water twice daily.

The City should change to change to a low-manganese content ferric sulfate coagulant to reduce finished water manganese, and then monitor raw and finished water manganese concentration for at least a month before making the next change.

If further manganese reduction is needed, the City should consider an evaluation of increasing the pH between the clarifier and filter when raw water is higher than secondary standard. Manganese removal and the potential for membrane fouling should be assessed.

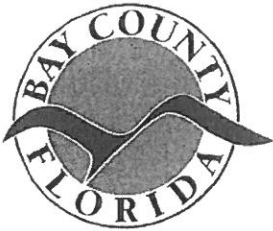
If further manganese reduction is needed, the City should test increasing the pH level in the raw water pipeline and clarifiers, and adding sodium permanganate as a pre-oxidant at the raw water intake during periods of high raw water manganese content. The impact of DBP formation in the clarifier must be tested.

If the City wants to continue to feed polyphosphate upstream of the chlorine contact chamber, the City should conduct jar testing to determine the proper polyphosphate dose and estimate the time the manganese will remain sequestered. The City should conduct distribution testing to evaluate if and when the manganese is released from sequestration. The City should note that additional flushing may be required with sequestration.

Other:

The City should monitor and record data on water quality complaints per the February 19, 2013 memo entitled, "Port St. Joe Water Quality Complaint Guidance" to provide additional data for future decision making.

The city should maintain a unidirectional flushing program at least annually to continue to flush accumulated manganese and oxidized iron from the system.



BAY COUNTY UTILITY SERVICES DEPARTMENT
3410 TRANSMITTER ROAD
PANAMA CITY, FL 32404
OFFICE: 850-248-5010 FAX: 850-248-5006

BOARD OF COUNTY
COMMISSIONERS

www.baycountyfl.gov

March 14, 2014

Mr. Larry Mc Clamma, Plant Manager
City of Port St. Joe
455 County Rd.382
Port St. Joe, FL 32456

POST OFFICE BOX 1818
PANAMA CITY, FL 32402

Dear Mr. Mc Clamma:

Bay County Utility Services (BCUS) is pleased to provide assistance to the City of St. Joe water treatment plant staff. BCUS is always willing to assist our neighbors and fellow utility operators through sharing our knowledge and experience in the area of water treatment.

BCUS's Jake Hollingsworth, Water Division Process Supervisor, enjoyed working with you and your staff yesterday and feels strongly that collectively made progress and identified some treatment changes that could greatly improve not only your process and the resulting finished water, but the cost effectiveness of the plant as well.

I have reviewed the work that both you and Jake performed and concur with Jakes observations and recommendations as follows;

Chemical Treatment Change Recommendations By Jake Hollingsworth, C.A.O.

- 1) **Convert your pretreatment alkalinity adjustment chemical from sodium hydroxide (caustic soda (NaOH)) to calcium hydroxide (lime (Ca(OH)²)).**

Given the quality of your raw water, based on my experience at Bay County water plant (BCWTP) lime is a more efficient chemical to use for adjusting alkalinity. The calcium in lime increases the alkalinity more and reacts more effectively with the ferric sulfate ($\text{Fe}_2(\text{SO}_4)_3$) than the sodium in caustic soda does. In the jar testing I performed on 3/13/14, I was able to treat the same raw water with both lime and caustic soda as pretreatment and found that I could use approximately 10-15% less ferric sulfate with lime than I could with caustic soda and achieved the same end results. The dosage of lime and caustic soda was the same in the jar testing, which further proves that lime is more efficient. A switch to lime for pretreatment would mean an immediate and direct reduction of chemical costs, due to the fact that lime is cheaper than caustic and would reduce the ferric sulfate dosage used in the process.

COMMISSIONERS:

MIKE NELSON
DISTRICT I

GEORGE B. GAINER
DISTRICT II

WILLIAM T. DOZIER
DISTRICT III

GUY M. TUNNELL
DISTRICT IV

MIKE THOMAS
DISTRICT V

EDWIN L. SMITH
COUNTY MANAGER

2) Relocate and change your pretreatment alkalinity (from caustic soda to lime) adjustment chemical feed point to inject immediately after the raw water pumps.

By moving the pretreatment chemical feed point it would give more time for the lime to fully react with the water before the ferric sulfate is added. As your chemicals are currently fed, the ferric sulfate and the caustic soda are injected within inches of each other, there is not enough time for the caustic soda to fully adjust the raw water alkalinity, which is minimal, before the ferric sulfate is injected. The two chemicals are actually counter acting each other and making the chemical process less efficient and more costly. The further away these two feed points are from each other, the better the treatment will be.

3) Lower your ferric dosage.

Based on jar tests performed on 3/13/14, ferric dosage is playing a key role in the problems you are having. In my jar tests, I was able to treat your source water with 100 mg/l of ferric sulfate and accomplish the same, if not better, results than you were getting with your current dosage of 195mg/l. Ferric sulfate is extremely pH sensitive and it has a wide range of effectiveness on the pH scale. It is impossible to run a surface water plant that has constantly changing source water at the same pH all the time. The pH in the plant should change depending on the optimized ferric sulfate dosage. In order to run that plant at a 5.3-5.4 at all times requires a massive overdose of ferric sulfate and caustic soda due to chemistry. The plant operators should run jar tests and determine the optimal pH of the plant and the optimal ferric dosage. The optimal pH could vary greatly. At BCWTP, depending on source water quality, the treatment pH could be 4.2-6.0; it all depends on the ferric sulfate dosage. By lowering the ferric sulfate, you will eliminate a lot of floc carryover to your filters. This will improve the efficiency of your filters and will produce higher quality finish water.

4) Change your polymer and feed point location.

I suggest you change the charge of polymer you are currently using according to the chemical makeup of the source water. I performed jar testing on your water with the polymer you currently use with the polymer BCUS uses (when on pre-lime). I had to dose your polymer at 0.8mg/l to attain the proper floc and I was able to cut that dose down to 0.25mg/l using a less negatively charged polymer. Not only did the dose get cut drastically, but, the floc that was formed with less negative polymer was much bigger, denser, and settled much faster. By switching to a more efficient polymer, it should improve your filtration and will also cut costs. I also suggest you move the feed point to the influent pipe in order to increase mixing velocity gradient, this will enhance floc formation.

5) Run the plant continuously.

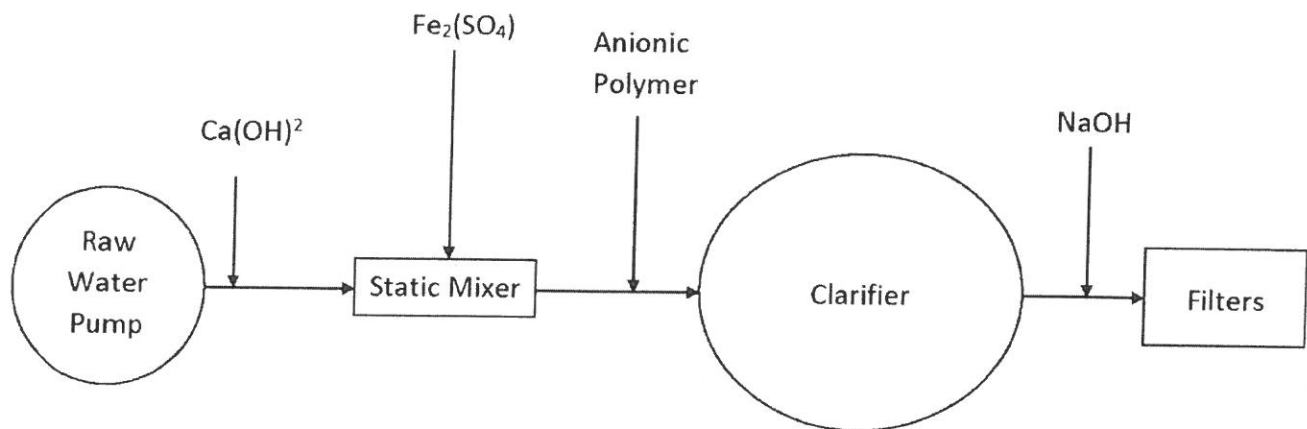
In an effort to eliminate turbidity spikes during start up, optimization of your process could be achieved by running the plant continuously for 24 hours. Continuous operation

of the system would eliminate turbidity spikes normally seen during start-up of any water treatment process.

Conclusion

While there is not one single action that can solve the problems you are currently experiencing, switching to lime for alkalinity adjustment will be a very important step in the right direction. However, switching to lime will only truly make a difference if the ferric sulfate dosage is optimized. If you switch to lime and do not adjust the ferric sulfate dosage down, you will deal with many of the same issues you are currently dealing with.

As stated here in I recommend that the following treatment scenario be used:



Should you have any questions or need further assistance, please do not hesitate to contact myself or Jake Hollingsworth at (850) 248-5010.

Respectfully,

Paul Lackemacher
Utility Services Director

FLORIDA RURAL WATER ASSOCIATION

2970 WELLINGTON CIRCLE • TALLAHASSEE, FL 32309-7813
(850) 668-2746

March 12, 2014

BOARD of DIRECTORS

WILLIAM G. GRUBBS
Quincy
President

ROBERT MUNRO
Orlando
Vice President

BRUCE MORRISON
Destin
Secretary/Treasurer

PAUL BRAYTON
Harbour Heights
National Director

MICHAEL MCKINNEY
Perry

SCOTT KELLY
Jacksonville

TOM JACKSON
Punta Gorda

EXECUTIVE
DIRECTOR

GARY WILLIAMS
Tallahassee

Mr. Larry G. McClamma, Plant Manager
City of Port St. Joe
P.O. Box 278, 309 Water Plant Road
Port St. Joe FL 32457
Phone: (850) 229-1421
E-mail: lmccclamma@psj.fl.gov

 COPY

**Re: Preliminary Engineering Report
Proposed Replacement of Caustic Soda with Hydrated Lime for
Coagulation / Flocculation Pretreatment
City of Port St. Joe, Gulf Co, PWS: 1230545**

Dear Mr. McClamma:

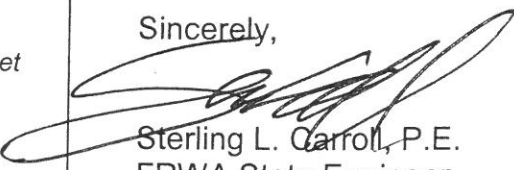
Thank you for opportunity to evaluate your proposed replacement of Caustic Soda with Hydrated Lime for coagulation / flocculation pretreatment for the Port St Joe WTP Microfiltration Membrane. We concur with your assessment that hydrated lime can be used in lieu of caustic soda. This is a result of performing several jar tests, conducting research, and discussing the switch with Siemens.

Hydrated lime will increase water alkalinity providing better ferric pre-treatment and higher quality finished water. The estimated annual chemical savings is 72% or \$37,300 by substituting lime for caustic.

Chemical	Estimated Usage	Monthly Cost	Annual Cost
NaOH	334 lbs/day	\$4,312	\$51,800
Ca(OH)2	167 lbs/day	\$1,205	\$14,500
Savings:		\$3,107	\$37,300

We have enjoyed serving you and wish you the best. FRWA is dedicated to helping water and wastewater systems provide Floridians with an ample affordable supply of high quality water, while protecting natural systems.

Sincerely,


Sterling L. Carroll, P.E.
FRWA State Engineer

Copy: Jason Southerland, Gary Williams, FRWA



EMAIL
frwa@frwa.net

WEBSITE
www.frwa.net

Preliminary Engineering Report

for

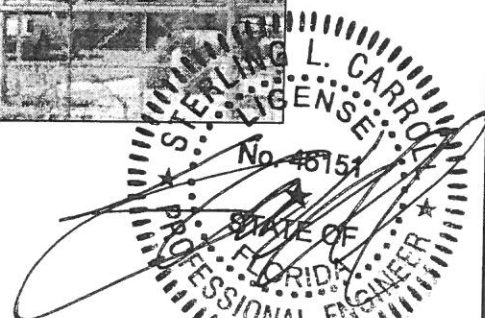
City of Port St. Joe

**Proposed Replacement of Caustic Soda
with Hydrated Lime for coagulation /
flocculation pretreatment for the
Microfiltration Membrane at the
Port St Joe WTP**



Florida Rural Water Association

2970 Wellington Circle ~ Suite 101 ~ Tallahassee FL 32309
Telephone: 850-668-2746 ~ e-mail: FRWA@frwa.net
Certificate of Authorization: 29291



Sterling L. Carron, P.E.
FL PE #46151
March 12, 2014

Table of Contents

Section	Preliminary Engineering Report	Page
	Cover	1
	Table of Contents	2
1	Executive Summary	3
1.1	Executive Summary	3
1.2	Problem Statement	4
2	Proposition of Substituting Hydrated Lime for Caustic Soda	5
2.1	Caustic Soda Chemistry	7
2.2	Choice of Hydrated Lime Over Dry Lime	7
2.3	Hydrated Lime Supply	8
3	Siemens Ultrafiltration Membranes	9
3.1	Comments by Siemens	9
4	Hydrated Lime Jar Tests	9
4.1	Hardness, Total, & P Alkalinity	10
4.2	Turbidity, pH & Temperature	11
4.3	Langelier Saturation Index	12
4.4	Lime Dosing and Feed Costs	13
5	Lime Addition	14
5.1	Chemistry of Lime Addition	14
5.2	Lime & Caustic Chemistries	14
5.3	Coagulation, Flocculation, and Sedimentation	14
5.4	Sludge Removal	15
5.5	Alkalinity	15
5.6	Treatability	16
6	Line Addition	18
6.1	Next Step – Pilot Study	18
6.2	90 Day Pilot Study	18
6.3	FRWA Offer of Pilot Study Assistance	18
6.4	Hydrate Lime Installation, Engineering, and Permitting	19
	Photographs	20 – 24

ABBREVIATIONS

ADDaverage daily demand	MDDmaximum day demand
Ca(HCO ₃) ₂calcium bicarbonate	Mg(HCO ₃) ₂bicarbonate
Ca(OH) ₂calcium hydroxide / hydrated lime	Mg(OH) ₂magnesium hydroxide
CaCO ₃calcium carbonate	MgCO ₃magnesium carbonate
CaO.....quicklime	MgSO ₄magnesium sulfate
CaOHhydrate lime	Na ₂ CO ₃sodium carbonate or soda ash
CaSO ₄calcium sulfate	NaCO ₃soda ash
CO ₂carbon dioxide	NaOH.....caustic soda / sodium hydroxide
DBPsdisinfection by-products	O&Moperations and maintenance
Fe ₂ (SO ₄) ₃ferric sulfate	PERpreliminary engineering report
H ₂ Owater	TTHMs.....total trihalomethanes
HAA5shaloacetic acids	

Section 1 ~ Executive Summary

1.1 ~ Executive Summary.

We concur with the proposed replacement of Caustic Soda with Hydrated Lime for coagulation / flocculation pretreatment for the Port St Joe WTP Microfiltration Membrane. This is a result of performing several jar tests, calculating the Langelier saturation index (LSI), and carrying out research. Hydrated lime is less expensive than caustic soda and can be easily substituted. Unit cost for caustic soda \$0.725 per gallon instead of \$0.425 per pound of sodium hydroxide.

FRWA concurs with the proposed replacement of Caustic Soda with Hydrated Lime for coagulation / flocculation pretreatment for the Port St Joe WTP Microfiltration Membrane. This is a result of performing several jar tests, discussing this with the Siemens representative, and carrying out research.

Mr. Aaron Balczewski, Director of Process Technology, at Siemens indicated that several surface water treatment plants are using lime softening prior to Siemens Microfilters with success. These are conventional slake lime plants surface water plants – the proposed hydrated lime feed would be better behaved than on-site lime hydration. Additionally the Siemens Operations and Maintenance Manual S.O. 12027, page 3-7 at the water plant describes the use of lime in treatment for clarification or iron removal.

“Lime is normally employed to provide sufficient alkalinity with the coagulant and/or to adjust the pH to produce a stable effluent or to promote conditions for optimum removal of iron and/or turbidity.”

The operators at these plants carefully observe the performance of the microfilters. Acid maintenance washes are particularly effective with restoring membrane flux when using lime coagulation pretreatment. Operators vigilantly observe for progressive decline in membrane and accumulation of retained organic and lime particulates.

Hydrated lime can be easily substituted caustic soda and has the following advantages:

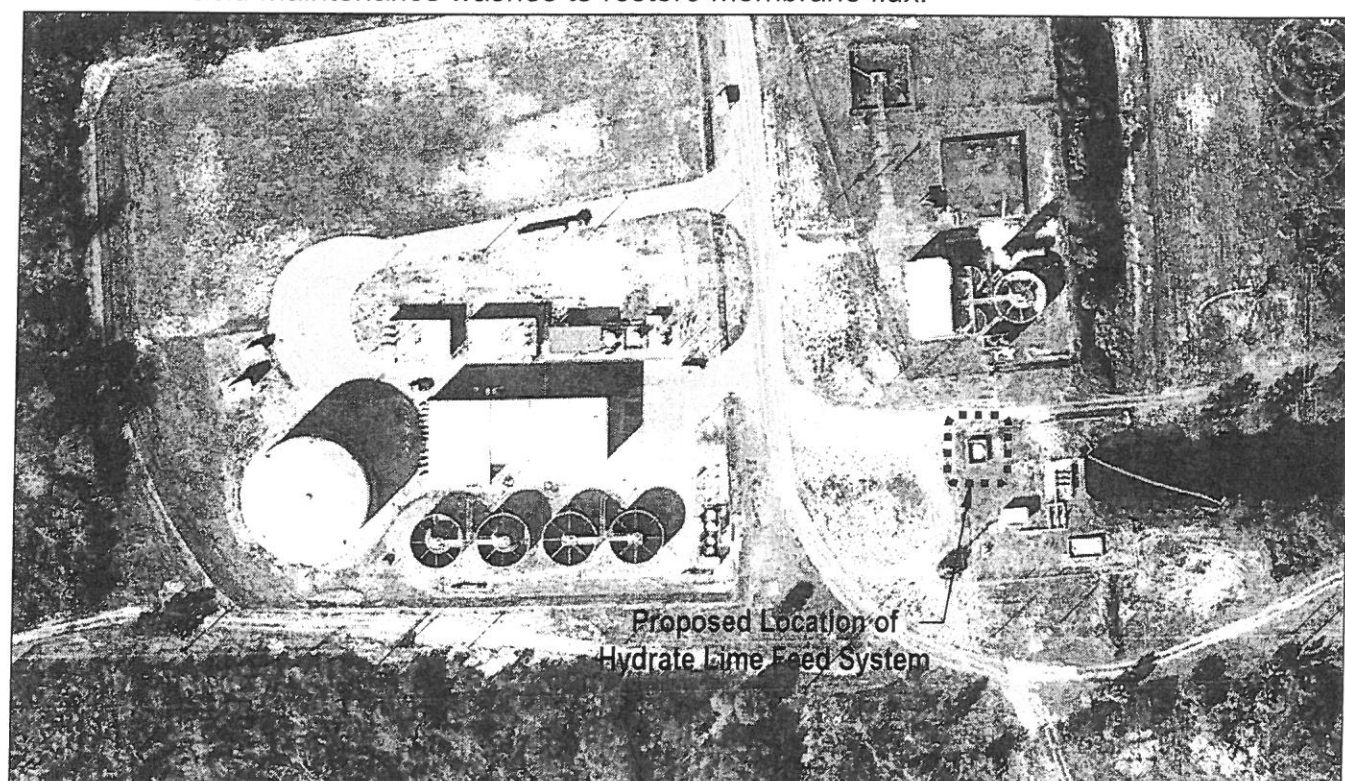
- Better treatment. The higher alkalinity will enhance and stabilize PSJ's surface water treatment.
- Lower ferric usage. The high alkalinity that hydrated lime provides will lower ferric dosage.
- More stable sludge blanket. The higher molecular weight hydrated lime will enhance coagulation, flocculation and sedimentation in the US Filter CONTRAFLO clarifier.
- Better treatment flexibility. Caustic soda can still be used with hydrated lime.
- Lower chemical costs. Caustic soda is much more expensive than hydrated lime.
- The estimated savings is \$37,300 annually

Hydrated lime can be easily fed to balance and stabilize the finished water thus providing Port St. Joe customers with a higher quality water.

Set up cost for hydrated lime by CAL-FLO system and slurry were estimated at under \$250,000 – a 7-year pay back for the investment. Port St. Joe could design and install an alternative / less expensive design should it wish. The lime storage and feed system is anticipated to be located in the existing raw water intake containment area west of the plant site, see Figure 1 below. FRWA is available to assist if desired, or may use its consulting engineer.

The operational parameters for the Siemens Memcor CS Module #119104 (Hollow Fiber Ultra Filtration Membranes) are as follows. We have more definitive information from Mr. Aaron Balczewski, Director of Process Technology, at Siemens – at this writing he has yet to respond.

- pH between 2-10
- Max pH =10.5
- Acidic pH is better for membranes
- Presently the sodium hydroxide feed produces a pH between 9 to 10
- Carefully monitor lime feed rates – lime should not bleed from the clarifiers on to the microfilters. Raw water quality and resulting lime demand can vary daily and seasonally.
- Vigilantly observe membrane performance for decline in membrane flux that might result in fouling with accumulation of retained organic and lime particulates.
- Calculate LSI for membrane influent or conduct a marble test daily.
- Plan acid maintenance washes to restore membrane flux.



**Figure 1 ~ Water Plant Aerial Photograph and
Proposed Location of Hydrate Lime Feed System**

1.2 ~ Problem Statement.

Water quality at the tap has been less than satisfactory for Port St Joe customers. The city has had many challenges and negative press with the more corrosive and unbuffered nature of finished water from the new plant flowing into its distribution system. The new water is more aggressive and corrosive causing leaching and scouring of the inert / benign lime deposits.

The other significant change includes switching from groundwater to surface water sources. The city and its consultant have considered many options and are still looking at alternatives to mitigate these troubling issues -- the draft report was recently delivered.

Prior to the new system coming on line the city operated a traditional lime softening plant for decades. It is likely that the plant used excess lime treatment to remove magnesium hardness. The resulting precipitation or excess lime often continues out into the distribution system promoting the formation of calcium carbonate deposits within the water mains. See the photographs of calcium deposits in water lines on the next page.

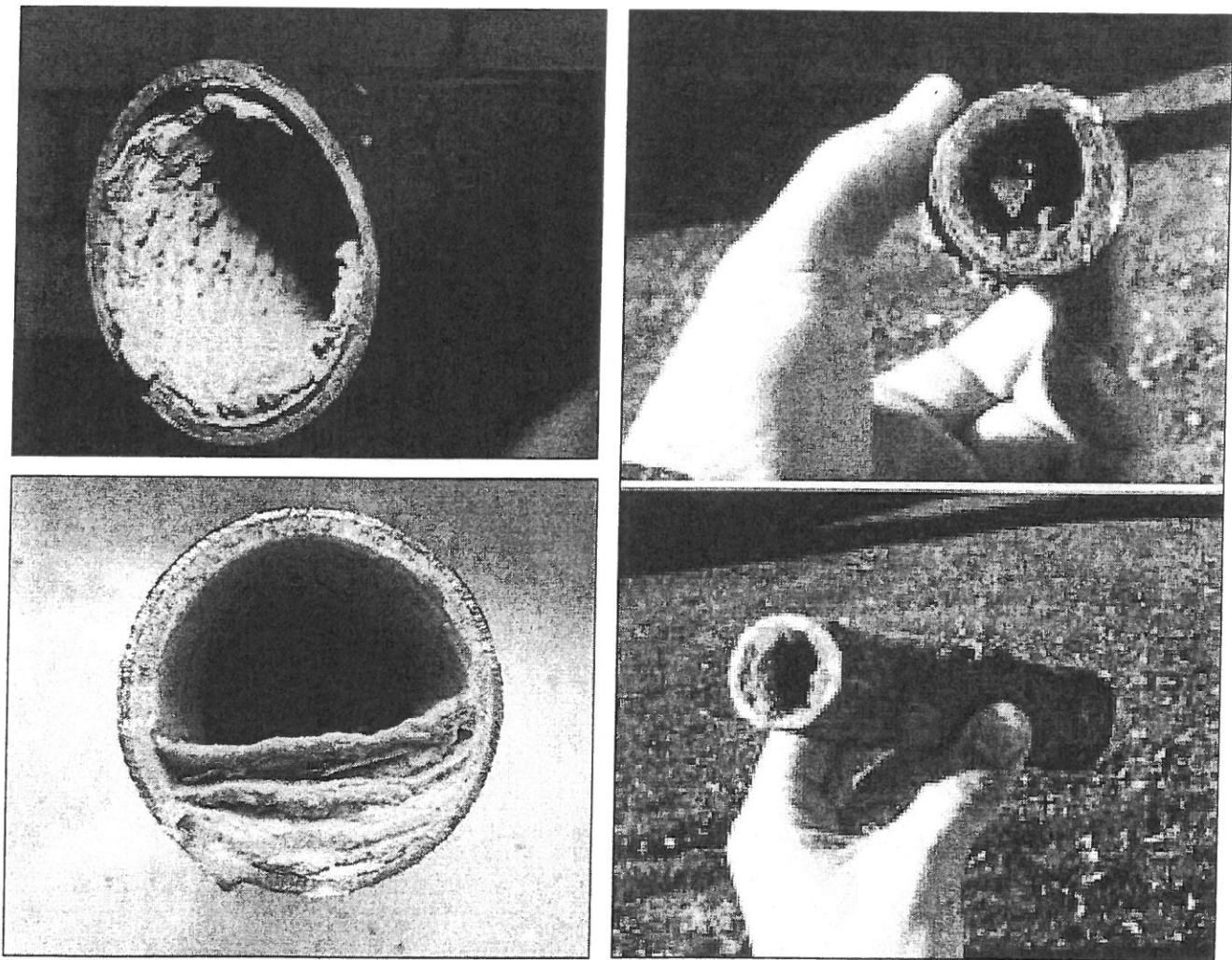


Figure 2 ~ Examples of Calcium Deposits in Water Lines

Predictably the distribution main has become well coated with calcium deposits and lime-scale buildup after decades of lime softening. The precipitate can buildup and grow until they clog pipes and lines. The calcium is understandably dissolving with the changed finished water chemistry. It is no surprise to this author that drastically different finished water chemistries from the old to the new plant would cause these problems.

It took a long time (decades) for the calcium to precipitate and it would take a long time to dissolve the pipe coatings at the present rate. Meanwhile customers will continue to suffer with low quality water – calcium sloughing, clogging sink aerators, hot water heater problems, color and taste issues. These are all aesthetic issues, non-health related, but it makes little difference to your customers. The unanswered question is if the designer knew about this probability -- if they knew, whether it was a concern addressed during engineering.

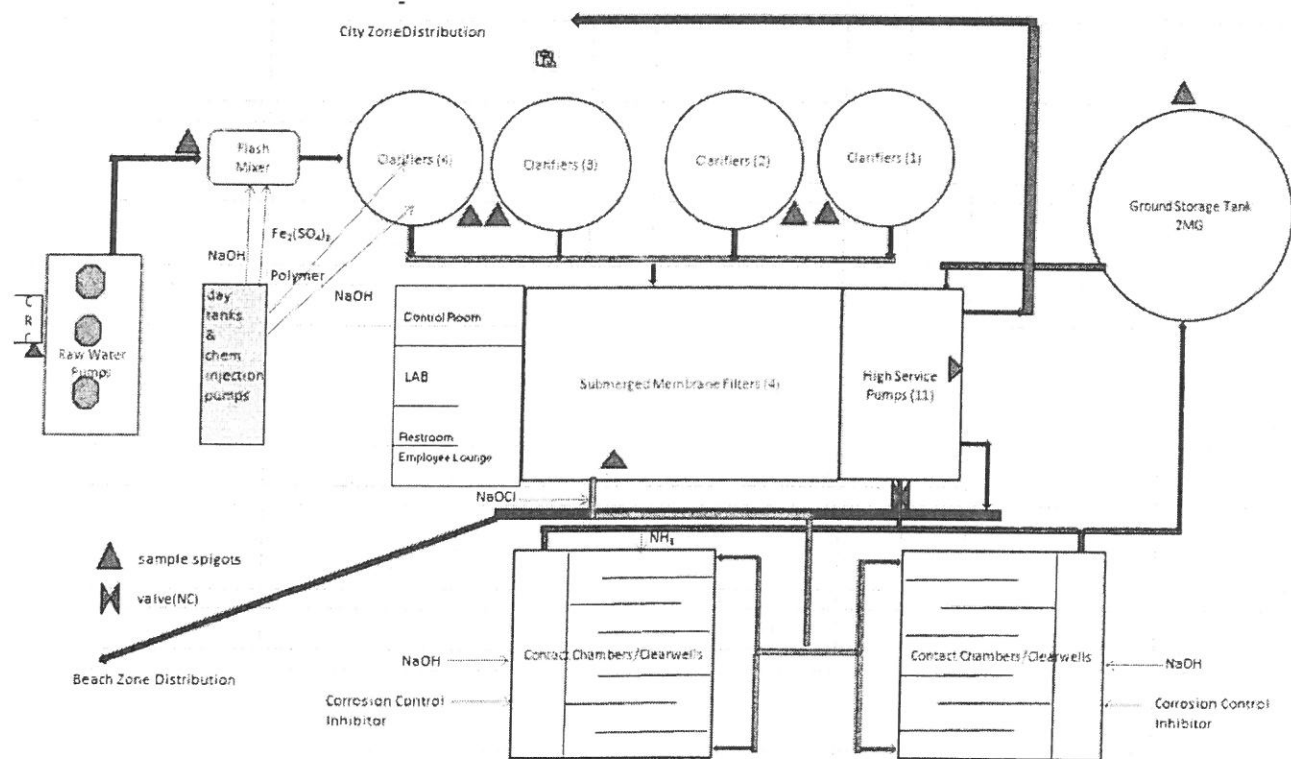


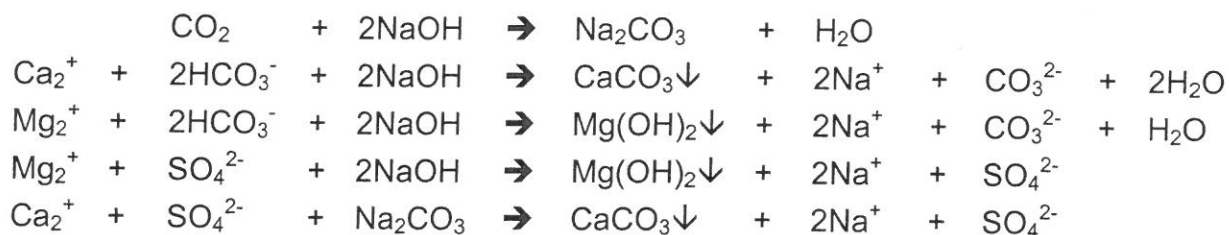
Figure 3 ~ Water Plant Schematic from FDEP Sanitary Survey

Section 2 ~ Proposition of Substituting Hydrated Lime for Caustic Soda

2.1 ~ Caustic Soda Chemistry

Caustic soda (NaOH) is an alternative to the use of lime softening when there is insufficient carbonate hardness present in raw water to react with lime. The choice between using soda will depend upon the economics and other factors such as the ease of handling (NaOH is purchased as a 50 percent solution) and magnesium content. Some concern has been expressed about the use of sodium-containing compounds, because when noncarbonated hardness is removed, both use of soda ash and caustic soda result in the replacement of divalent hardness ions with sodium.

The reactions for caustic soda are



The sodium carbonate that is formed is available for calcium carbonate precipitation. In situations where more sodium carbonate is formed than there is calcium noncarbonate hardness to remove, the excess must remain in the solution. This presents a problem of very high carbonate alkalinity, which can be reduced by acidification, but none of the excess sodium will precipitate. In contrast, when lime is used, the excess calcium is precipitated as the carbonate. Calcium carbonate precipitation is particularly important in those cases with high pH (and the concomitant high caustic alkalinity) must be attained to precipitate magnesium as Mg(OH)_2 .

2.2 ~ Choice of Hydrated Lime Over Dry Lime

Either hydrated lime [Ca(OH)_2] or quicklime (CaO) may be used in the softening process. The choice depends upon economic factors, such as the relative cost per ton of the two materials as well as the size and equipment of the softening plant. Hydrated lime is generally used more in smaller plants because it stores better and does not require slaking (producing a chemical change in lime by combining it with water) equipment. On the other hand, quicklime costs less per ton of available calcium oxide and is thus more economical for use in large plants. Hydrated lime is less likely to have carryover from the clarifiers to the membranes.

One of the difficult aspects of lime softening is the operation and maintenance of lime feeders and lines carrying lime slurry to the point of application. In addition, plant operators must understand lime softening chemistry. Measurement of pH must be accurate, and the operator must know that the pH meter is properly calibrated. Failure to maintain the proper pH in softened water prior to filtration at a lime softening plant could result in precipitation or excess lime in the filter beds and formation of calcium carbonate deposits within the filters.

Softened water has high causticity and scale-formation potential; hence, recarbonation is employed to reduce pH and mitigate scaling of downstream processes and pipelines. Onsite combustion generation of carbon dioxide (CO₂) or liquid CO₂ is the most common source of carbon dioxide for recarbonation.

2.3 ~ Hydrated Lime Supply

Hydrated lime can be delivered by one of several vendors. Burnett Inc. provide as this estimate:

- Truckload size = 4,600 Gallons
- Unit cost = \$0.725/gal
- Total cost = \$3,335 per bulk load of slurry
- Estimated freight charge included in chemical cost and total cost.
- Concentrated strength = 30% concentrate solution (1.22 specific gravity)

There are several benefits when converting to hydrated lime over caustic soda.

- Lower pound for pound chemical cost – on average about \$100 per ton cheaper than liquid caustic.
- Feed rate reduction – usually reduced the caustic dosage at least 10% to achieve the same pH.
- Eliminate or reduce hazardous chemicals – lime is non hazardous and caustic is hazardous. By eliminating or reducing the use of a hazardous chemical increase operator safety.
- Natural stabilization – adding lime to the water helps increase LSI. Adding sodium (caustic) does not.
- Operator friendly – the lime system (feed equipment) is specifically designed for high grade calcium hydroxide slurry and requires minimal maintenance (2-4 hours per year). The system also comes with a functional guarantee which is no clogged feed line around 52 degrees F. Lime dose not gel or have feed problems associated with cold weather at Port St. Joe.

Section 3 ~ Siemens Ultrafiltration Membranes

3.1 ~ Comments by Siemens

We conducted a telephone conversation with Mr. Aaron Balczewski, Director of Process Technology, at Siemens several points to consider.

1. At least two other water treatment plants are using lime softening prior to Siemens Microfilters with success. These are conventional slake lime plants surface water plants. We have asked for these plants so that the operators can be contained and queried.
2. These plants must be monitored carefully and lime feed rates – lime should not bleed through the clarifiers on to the microfilters. In more northern latitudes surface water lime demand can vary as much as 40% between night and day. Raw water quality and resulting lime demand also varies seasonally. Summer frequently requires a higher lime demand as water quality tends to degrade.
3. The operators at these plants carefully observe the performance of the microfilters -- for progressive decline in membrane flux that might result in fouling because of the accumulation of retained organic and lime particulates.
4. Acid maintenance washes are particularly effective with restoring membrane flux when using lime coagulation pretreatment.
5. The pH ranges for the membranes still hold and with lime the concern is that the pH not exceed 10.5.
6. Under no circumstance should an organic based polymer be used.
7. Several statements were made about the Laugelier Saturation Index (LSI) that we have been unable to verify. More data has been requested from Aaron Balczewski Director of Process Technology

Section 4 ~ Hydrated Lime Jar Tests

Jar tests were conducted at the Port St. Joe water plant on November 12, 2013. The results are shown on the next pages along with dosing calculations and cost estimates

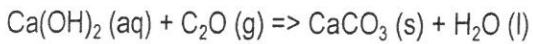
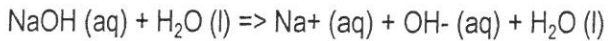
Florida Rural Water Association

Member: Port St. Joe, City of
 Contact: Larry G. McClamma, Plant Supervisor
 City: Port St. Joe Florida 32457

Date: 12-Nov-13
 Connections: 3712
 PWS: 1230545
 County: Gulf

Ca(OH)₂ Jar Tests for Port St Joe Water Treatment Plant

Substitute Liquid Lime Ca(OH)₂ (aq) for NaOH



Molecular Wt: 40.0 g/mole

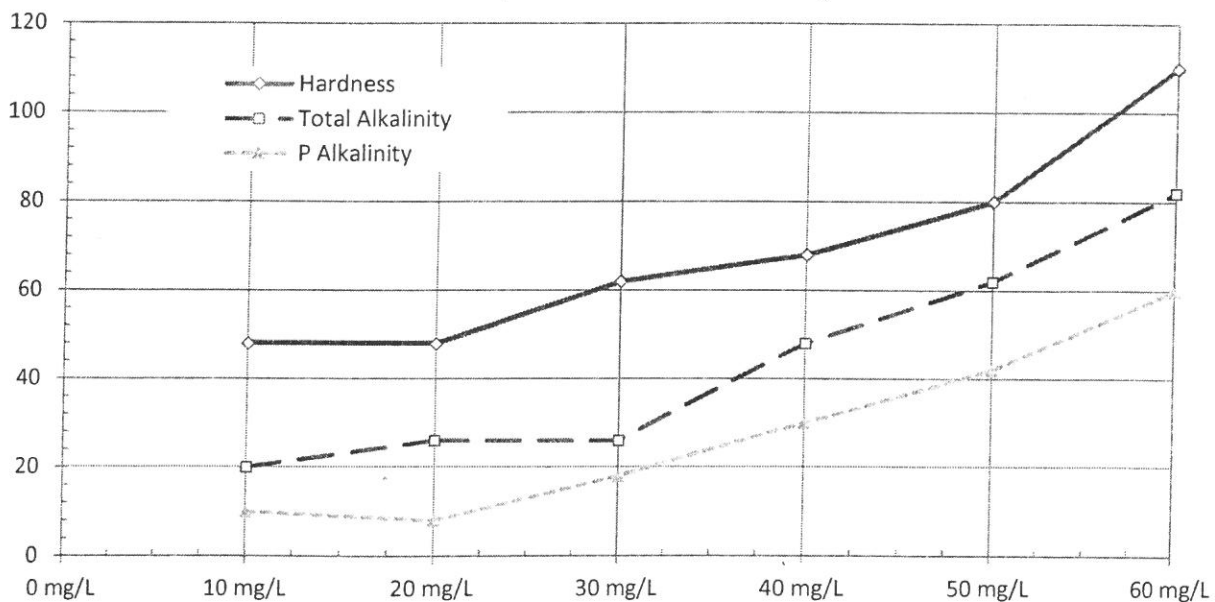
Molecular Wt: 74.0 g/mole

Jars*	Ca(OH) ₂ Sol'n**	Ca(OH) ₂ Conc	Turbidity	pH	Temp	P Alkalinity	Total Alkalinity	Hardness	LSI
1	2 ml	10 mg/L	2.00	9.22	20.8	10	20	48	1.99
2	4 ml	20 mg/L	1.96	9.53	20.7	8	26	48	2.66
3	6 ml	30 mg/L	2.16	10.31	20.8	18	26	62	3.30
4	8 ml	40 mg/L	2.44	10.53	21.0	30	48	68	3.71
5	10 ml	50 mg/L	2.83	10.82	21.0	42	62	80	4.06
6	12 ml	60 mg/L	2.81	11.06	21.0	60	82	110	4.40

* each jar is 2 liters each

** 1 ml of 1% NaOH solution equals 10 ppm in 1 liter

Hardness, Total & P Alkalinity



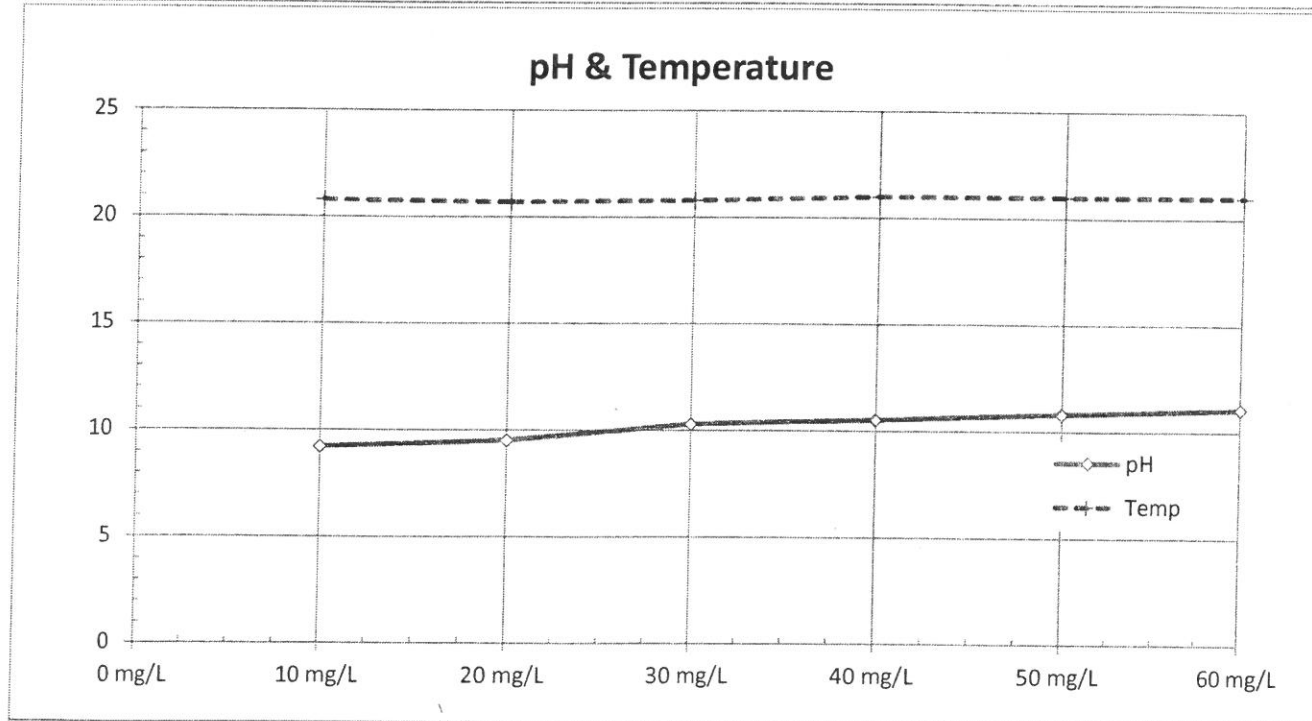
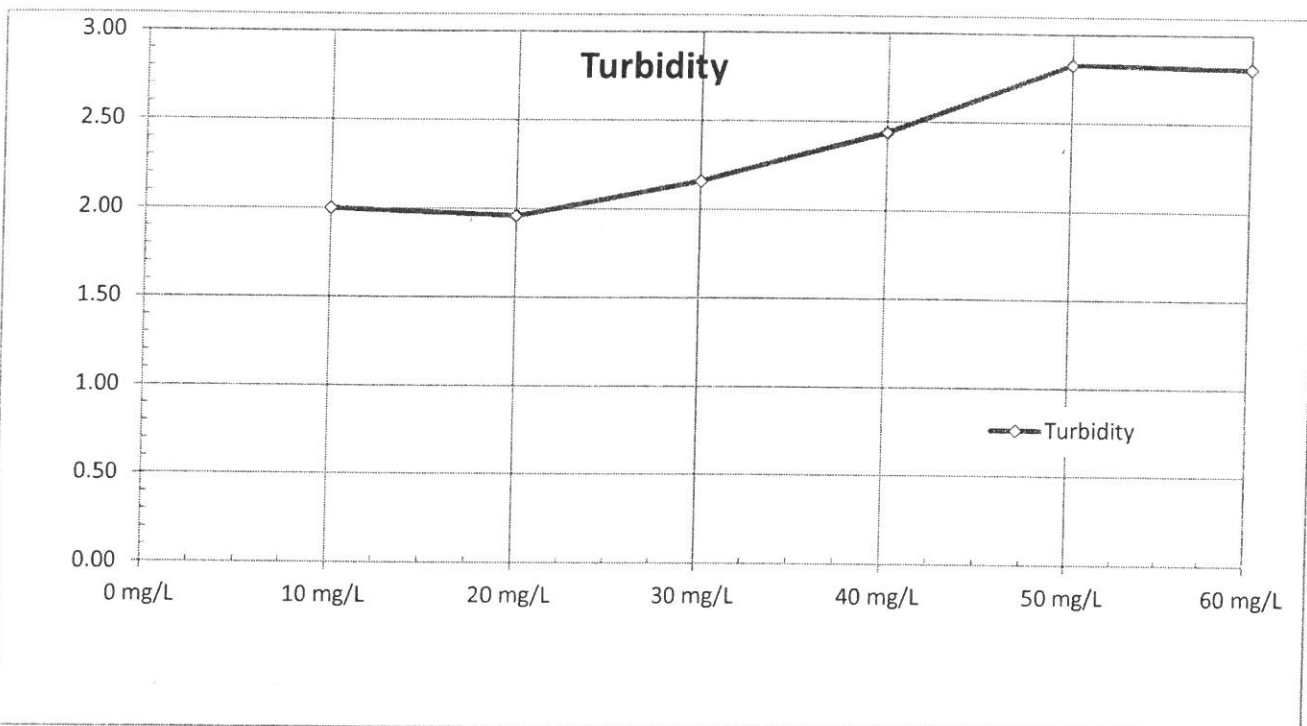
Florida Rural Water Association

Member: Port St. Joe, City of
Contact: Larry G. McClamma, Plant Supervisor
City: Port St. Joe Florida 32457

Date: 12-Nov-13
Connections: 3712
PWS: 1230545
County: Gulf

Ca(OH)₂ Jar Tests for Port St Joe Water Treatment Plant

Substitute Liquid Lime Ca(OH)₂ (aq) for NaOH



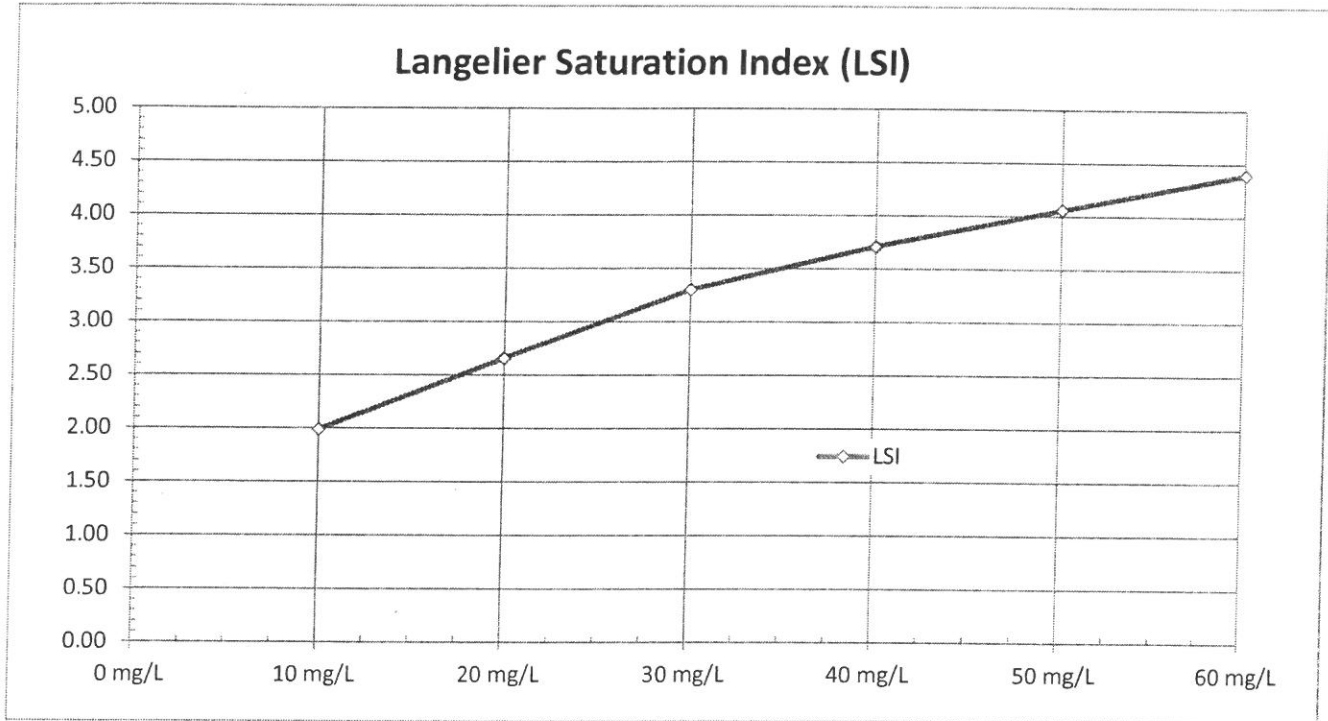
Florida Rural Water Association

Member: Port St. Joe, City of
Contact: Larry G. McClamma, Plant Supervisor
City: Port St. Joe Florida 32457

Date: 12-Nov-13
Connections: 3712
PWS: 1230545
County: Gulf

Ca(OH)_2 Jar Tests for Port St Joe Water Treatment Plant

Substitute Liquid Lime Ca(OH)_2 (aq) for NaOH



Florida Rural Water Association

Member: Port St. Joe, City of
Contact: Larry G. McClamma, Plant Supervisor
City: Port St. Joe Florida 32457

Date: 12-Nov-13
Connections: 3712
PWS: 1230545
County: Gulf

Ca(OH)₂ Feed Costs for Port St Joe Water Treatment Plant

Substitute Liquid Lime Ca(OH)₂ (aq) for NaOH

Existing Water Demands from 2013

Average Daily Demand	1,000,000 gpd	1.000 MGD	694 gpm
Maximum Daily Demand	2,000,000 gpd	2.000 MGD	1,389 gpm

Feed Costs for NaOH at Average Daily Demand:

$$\text{Feed Rate} = \text{ADD}_{\text{MGD}} \times \text{chemical}_{\text{ppm}} \times \text{Conversion Factor}$$

Feed Rate = 1.000 MGD 40 mg/L 8.34 lbs/gal **334 lbs/day** of NaOH

Unit Price (delivered)

\$0.425 / lbs

Chemical Cost per month **\$4,312.48**

Chemical Cost per year **\$51,749.70**

Feed Costs for Ca(OH)₂ at Average Daily Demand:

$$\text{Feed Rate} = \text{ADD}_{\text{MGD}} \times \text{chemical}_{\text{ppm}} \times \text{Conversion Factor}$$

Feed Rate = 1.000 MGD 20 mg/L 8.34 lbs/gal **167 lbs/day** of Ca(OH)₂

Assume: Purchase 30% Ca(OH)₂ Solution

30%

Sp Gr: 1.22

Weight per gal: 10.17 lbs/gal

Given: 30% Ca(OH)₂ Solution (by weight) =

3.05 lbs/gal Ca(OH)₂

ADD NaOH Usage =

166.8 lbs/day

of Ca(OH)₂

54.64 gpd

Ca(OH)₂ Solutic

3.05 lbs/gal

Ca(OH)₂

Unit Price (delivered)

\$0.725 /gal

Chemical Cost per month **\$1,205.03**

Chemical Cost per year **\$14,460.38**

Estimated Chemical Cost Savings

72%

\$37,289.32

Section 5 ~ Lime Addition

5.1 ~ Chemistry of Lime Addition

Chemical precipitation is one of the more common methods used to soften water. Chemicals normally used are lime (calcium hydroxide, Ca(OH)_2) and soda ash (sodium carbonate, Na_2CO_3). Lime is used to remove chemicals that cause carbonate hardness. Soda ash is used to remove chemicals that cause non-carbonate hardness. When lime and soda ash are added, hardness-causing minerals form nearly insoluble precipitates. Calcium hardness is precipitated as calcium carbonate (CaCO_3). Magnesium hardness is precipitated as magnesium hydroxide (Mg(OH)_2). These precipitates are then removed by conventional processes of coagulation/flocculation, sedimentation, and filtration. Because precipitates are very slightly soluble, some hardness remains in the water--usually about 50 to 85 mg/L (as CaCO_3). This hardness level is desirable to prevent corrosion problems associated with water being too soft and having little or no hardness.

Lime Addition

Hardness		Lime		Precipitate
CO_2	+	Ca(OH)_2	→	$\text{CaCO}_3 + \text{H}_2\text{O}$
$\text{Ca(HCO}_3)_2$	+	Ca(OH)_2	→	$2\text{CaCO}_3 + 2\text{H}_2\text{O}$
$\text{Mg(HCO}_3)_2$	+	Ca(OH)_2	→	$\text{CaCO}_3 + \text{MgCO}_3 + 2\text{H}_2\text{O}$
MgCO_3	+	Ca(OH)_2	→	$\text{CaCO}_3 + \text{Mg(OH)}_2$

5.2 ~ Lime & Caustic Chemistries

For each molecule removed	Number of molecules used
One molecule calcium bicarbonate hardness	one molecule of lime
One molecule magnesium bicarbonate hardness	two (2) molecules of lime
One molecule non-carbonate calcium hardness	one molecule of soda ash
One molecule non-carbonate magnesium hardness	one molecule of lime + one molecule of soda ash

5.3 ~ Coagulation, Flocculation, and Sedimentation

Flocculation allows flocs to contact other flocs and grow large enough to settle in the sedimentation stage. Water is mixed gently with a small amount of energy. Most flocculators are compartmentalized, allowing for a tapered mix, so less energy must be applied as the flocs grow in size.

Detention time in the flocculator is important to allow particles to come in contact with each other. The minimum time recommended is 30 minutes for conventional water softening. Sludge returned to the head of the flocculator reduces the amount of chemical needed and provides seed flocs for the precipitation. The estimated return sludge is 10 to 25 percent of the source water. Sedimentation follows flocculation. Settling rates for these tanks are a function of particle size and density. Detention times in the settling basins range from 1.5 hours to 3.0 hours, and they can be rectangular, square, or circular (some designs incorporate inclined tube

settlers). The detention time in the Port St. Joe reactive clarifier is 8.2 hours at average day flow and 4.1 hours at max day flow.

Sedimentation can also occur in the solids-contact unit, in which the water is mixed with chemicals and flocculated in the center of the basin, then forced down and trapped for removal in a sludge blanket in the bottom of the tank.

5.4 ~ Sludge Removal

Residue created from lime-soda ash softening is normally very high in calcium carbonate or a mixture of calcium carbonate, and magnesium hydroxide. Calcium carbonate sludges are normally dense, stable inert, and dewater readily. Solids content in the sludge range from 5 to 30 total solids with a pH greater than 10.5. Lime-soda ash sludges may be treated with lagooning, vacuum filtration, centrifugation, pressure filtration, recalcination, or land application. Port St. Joe send its sludge to the wastewater treatment plant.

5.5 ~ Alkalinity

Alkalinity (mg/L as CaCO_3) is the capacity of water to neutralize acids. This is determined by the content of carbonate, bicarbonate and hydroxide. Alkalinity is a measure of how much acid can be added to a liquid without causing any significant change in pH.

When pH is less than 8.3, all alkalinity is in the bicarbonate form and is commonly referred to as natural alkalinity. When pH is above 8.3, alkalinity may consist of bicarbonate, carbonate, and hydroxide. As pH increases the alkalinity progressively shifts to carbonate and hydroxide forms. Total alkalinity is the sum of bicarbonate, carbonate, and hydroxide alkalinity. Various chemicals effect water differently:

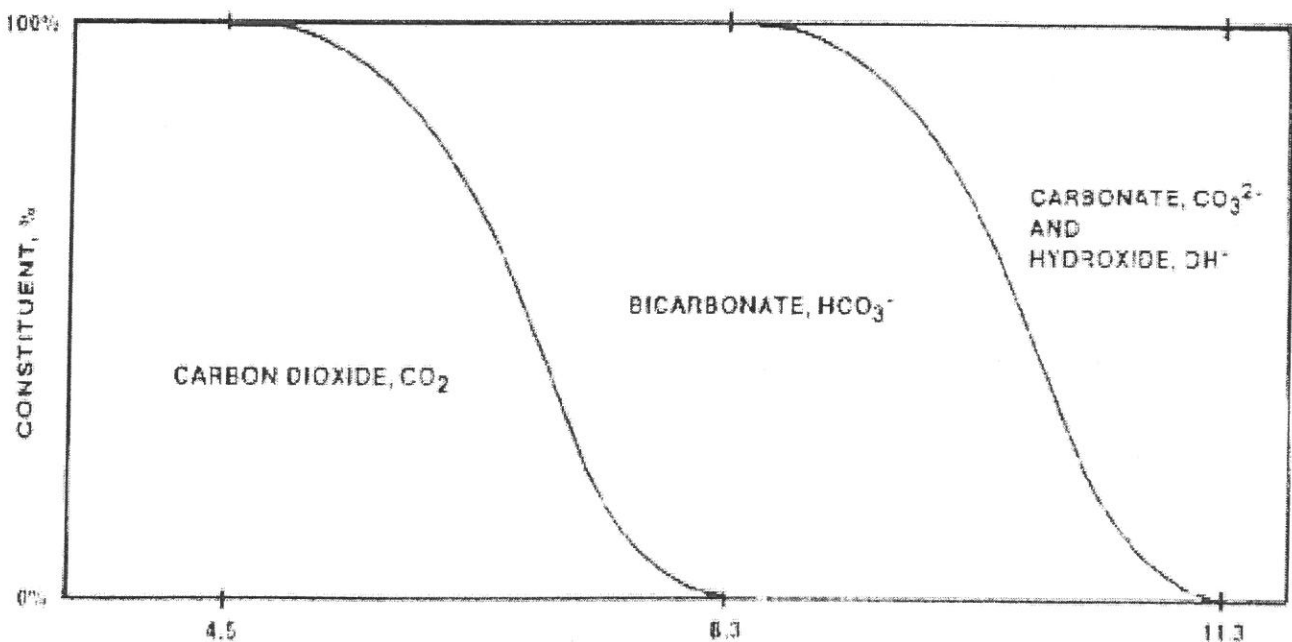


Figure 4 ~ Relationship between pH and alkalinity (HCO_3^- , CO_3^{2-} and OH^-)

Chemicals and Alkalinity Results

Lowers Alkalinity:	Increases Alkalinity:
Aluminum sulfate	Calcium hypochlorite
Carbon dioxide	Caustic soda
Chlorine gas	Hydrated lime
Ferric	Soda ash
Ferric Sulfate	Sodium Aluminate
Sulfuric acid	

Molecular Weights for Common Chemicals

Chemicals	Molecular Weights
Quicklime (CaO)	56
Hydrate Lime (CaOH)	74
Magnesium (Mg)	24.3
Carbon Dioxide (CO ₂)	44
Magnesium Hydroxide (Mg(OH) ₂)	58.3
Soda Ash (NaCO ₃)	106
Alkalinity (as CaCO ₃)	100
Hardness (as CaCO ₃)	100

5.6 ~ Treatability

Primary coagulants are always used in the coagulation / flocculation process. Alum and ferric sulfate are most commonly used. The function of the coagulant is to encourage particulates in the water to clump together. In choosing the ferric sulfate it is effective over a wider pH range and is effective within all temperature ranges. The use of ferric sulfate will help eliminate odors from and existing hydrogen sulfide.

In surface waters, color cannot be removed at high pHs so extra chemical processes must be used up front. Ferric Sulfate (Fe₂(SO₄)₃) is an acidic compound with pH less than 1, that lowers the treated water's pH. Will react with alkalinity and cause a lime demand. Used to remove turbidity and cloudiness in the water through coagulation.

When alkalinity is low the water can be corrosive. A chemical titration with methyl orange (T) and phenolphthalein (P) should be preformed and the type of alkalinity calculated. With a pH of 7.3 – 7.5 only bicarbonate alkalinity is present and the amount for CO₂ is low. The form or forms of alkalinity is entirely dependent in the pH of the water. The forms of alkalinity are bicarbonate, carbonate, and hydroxide. Their totals make up total alkalinity of the water. Natural alkalinity is the bicarbonate alkalinity because at the typical pH's found in nature only bicarbonate alkalinity will exist.

Based on your lab results raw and finished water hardness is between 24 and 30 mg/L as CaCO₃ – categorized as extremely soft. Since the forms of alkalinity present are controlled by the water's pH the stability of the water should be checked. A water is considered stable when

it is saturated with calcium carbonate – which calls for hydrated lime to be used as the primary coagulant.

In this condition the water will neither dissolve nor deposit calcium carbonate. There are two approaches to determine carbonate saturation levels – the marble test and LSI.

Water with a high alkalinity for coagulation is preferred since it tends to have a more positively charged ions to interact with the negatively charged colloids. In order for the coagulants to work effectively alkalinity must be present. It is customary to provide enough alkalinity by chemical addition – to produce at least 30 mg/L minimum alkalinity residual at the end of the coagulation process.

During the jar tests floc was formed but not settled and removed. In order for floc to form you need alkalinity. The raw water has an alkalinity of 15 mg/L (as CaCO_3). We should try to raise the alkalinity to about 75 mg/L. By using calcium hydroxide ($\text{Ca}(\text{OH})_2$) as a primary coagulant the resulting alkalinity will be about 135 mg/L – more than ample to support the treatment process.

Section 6 ~ Pilot Study

6.1 ~ Next Step – Pilot Study

The next step is to perform the pilot study to switch chemicals and to obtain written approval from the FDEP prior to the change. Per FDEP Rule 62-555.520(1)(b)2, FAC no construction permit is required to change drinking water treatment chemicals. The written request shall include the following components:

- scope, purpose, and location of the work or alterations;
- assurance that the work or alterations will comply with applicable requirements of FDEP, Safe Drinking Water Act, applicable industry standards;
- assurance of continuing compliance with applicable primary or secondary drinking water standards;
- technical and reliability information [safety data sheets (SDS), or product safety data sheets (PSDS)];
- third-party technology verifications or historical study data;
- jar test results to provide assurance of continuing compliance;
- a plan to monitor at least daily for applicable process control parameters
- a plan for start-up, normal operation, and emergency shutdown of the demonstration testing or pilot plant and for emergency flushing of storage and distribution facilities; and
- a plan to properly train operators and to staff the affected drinking water treatment plant with a licensed operator during all times of demonstration testing or pilot plant operation.

6.2 ~ 90-Day Pilot Study

Port St. Joe may request a 3 month pilot study to determine if hydrated lime is appropriate and determine what issues the city might face if it decides to proceed. We would suggest a step wide approach to hydrate lime feed during the study, as shown in the table below.

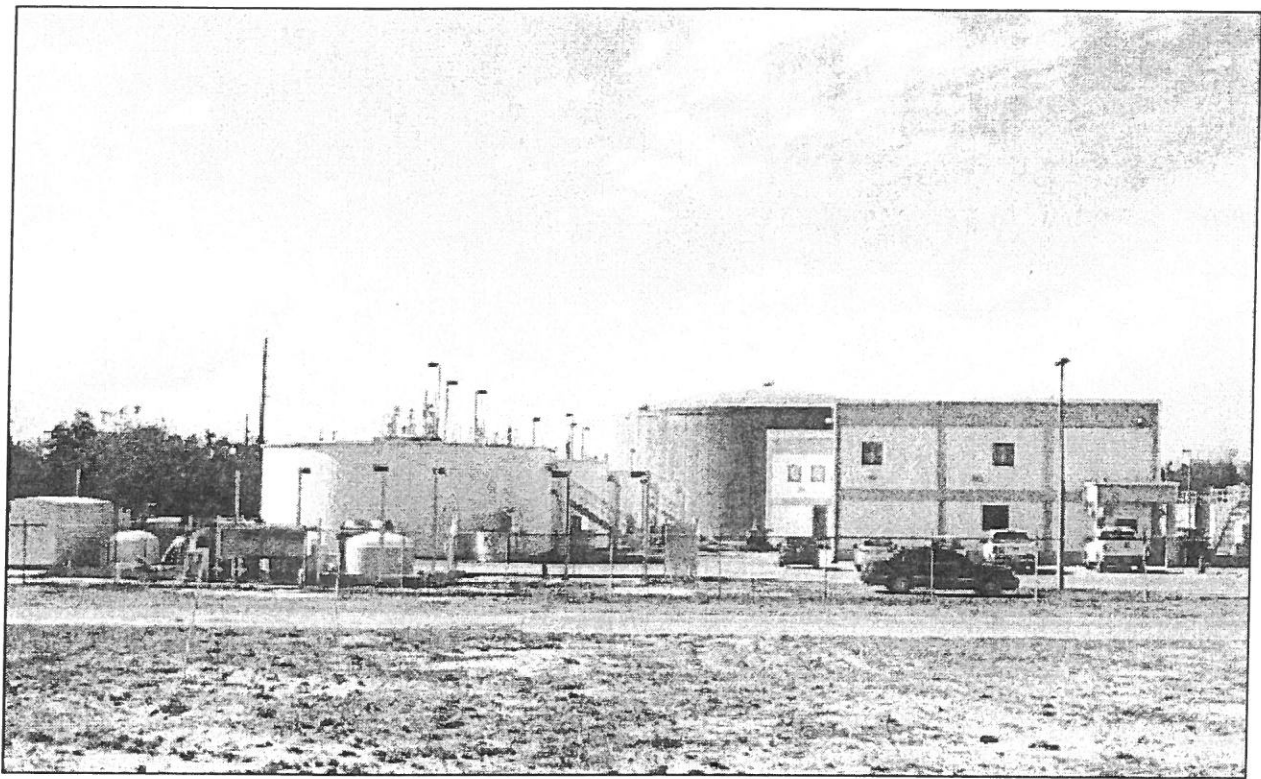
Week	Pre-Treatment Dose	Post- treatment Dose
1-3	10 ppm	0 ppm
4-6	15 ppm	5 ppm
7-9	20 ppm	10 ppm
10-13	25 ppm	15 ppm

6.3 ~ FRWA Offer of Pilot Study Assistance

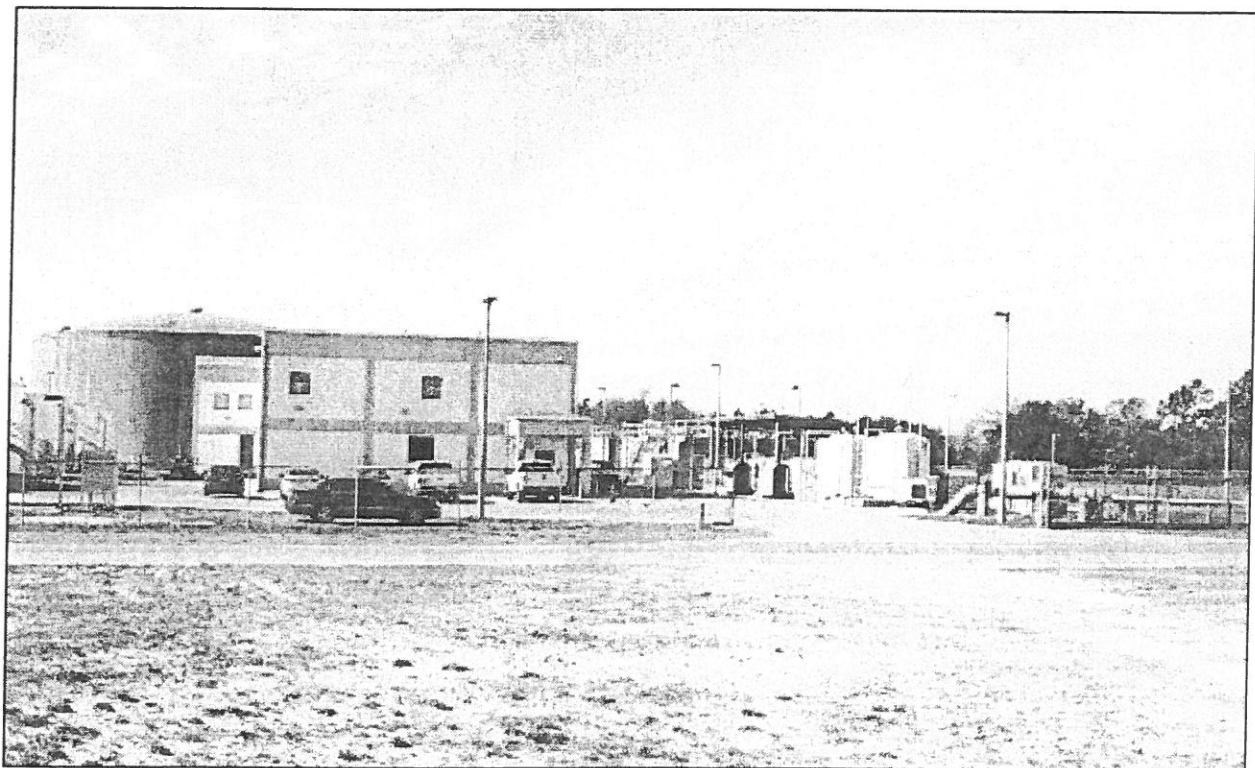
Florida Rural Water Association was pleased to assist the City of Port St. Joe with the jar testing and this report as a free membership benefit. We would be happy to assist with written request to FDEP for the pilot study, support during the pilot test, startup, assistance throughout the pilot test, shutdown, and report of findings should you wish. If this is acceptable, FRWA would ask that you provide a \$2,500 contribution to FRWA in aid of engineering assistance to help support our salaries. Engineering consultants often charge anywhere from \$15,000 to \$35,000 for this type of report and engineering assistance.

6.4 ~ Hydrate Lime Installation Engineering and Permitting

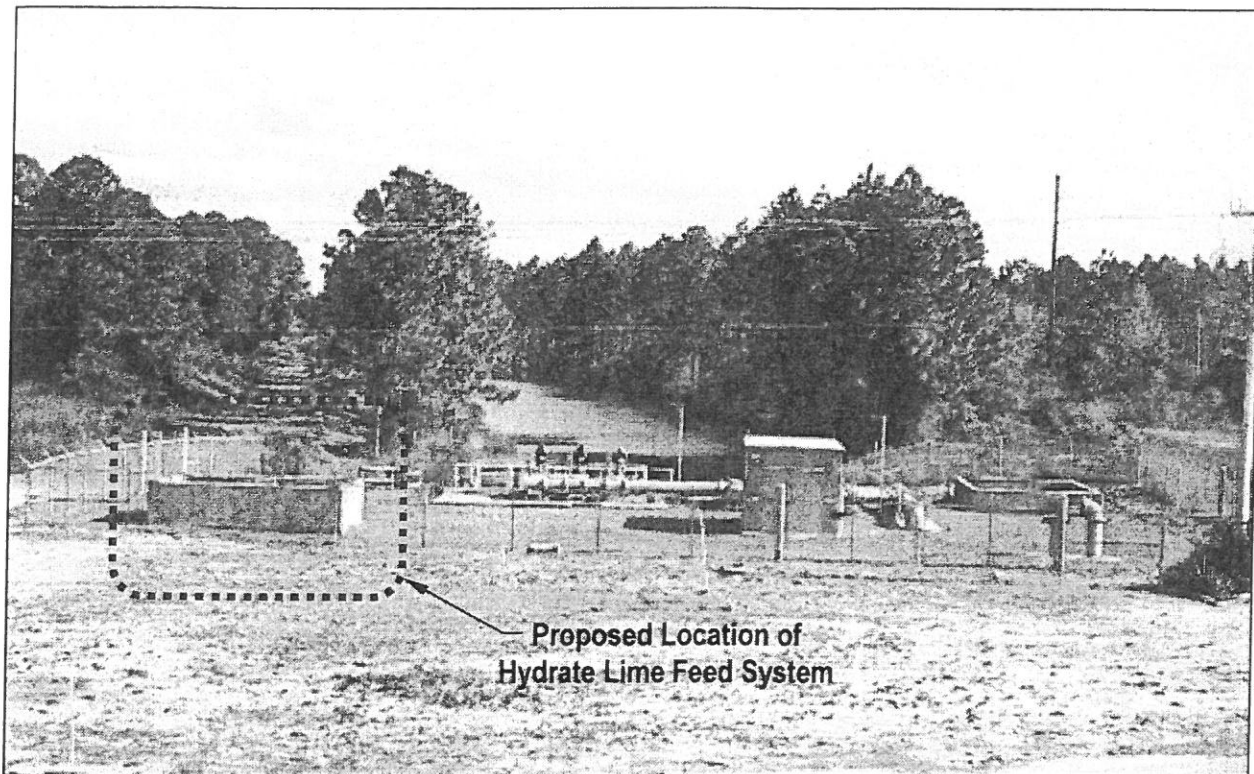
FRWA would be happy and available to assist Port St. Joe with its hydrated lime installation, engineering, and permitting as a membership benefit, should you wish to proceed. You are free to use any of your consulting engineering firms for the installation – we only wish for Port St. Joe to have the best water quality possible for its customers.



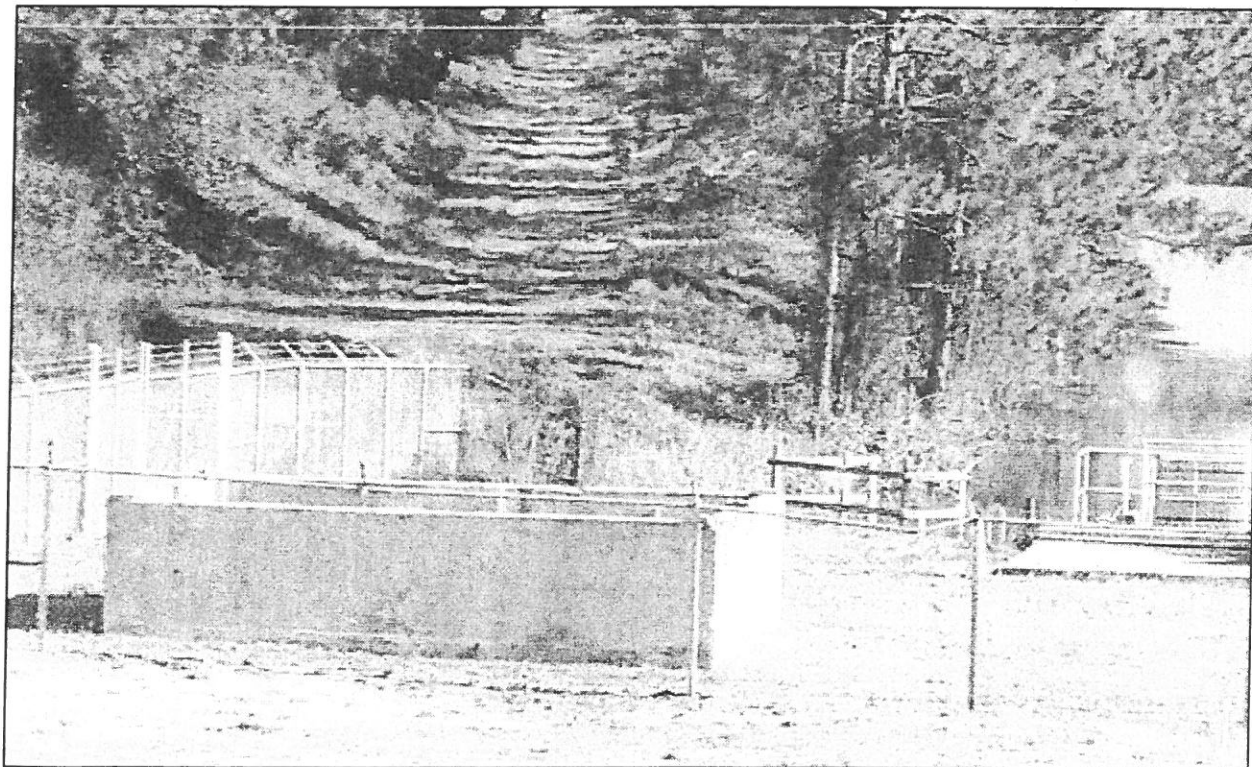
Water Treatment Plant looking eastward



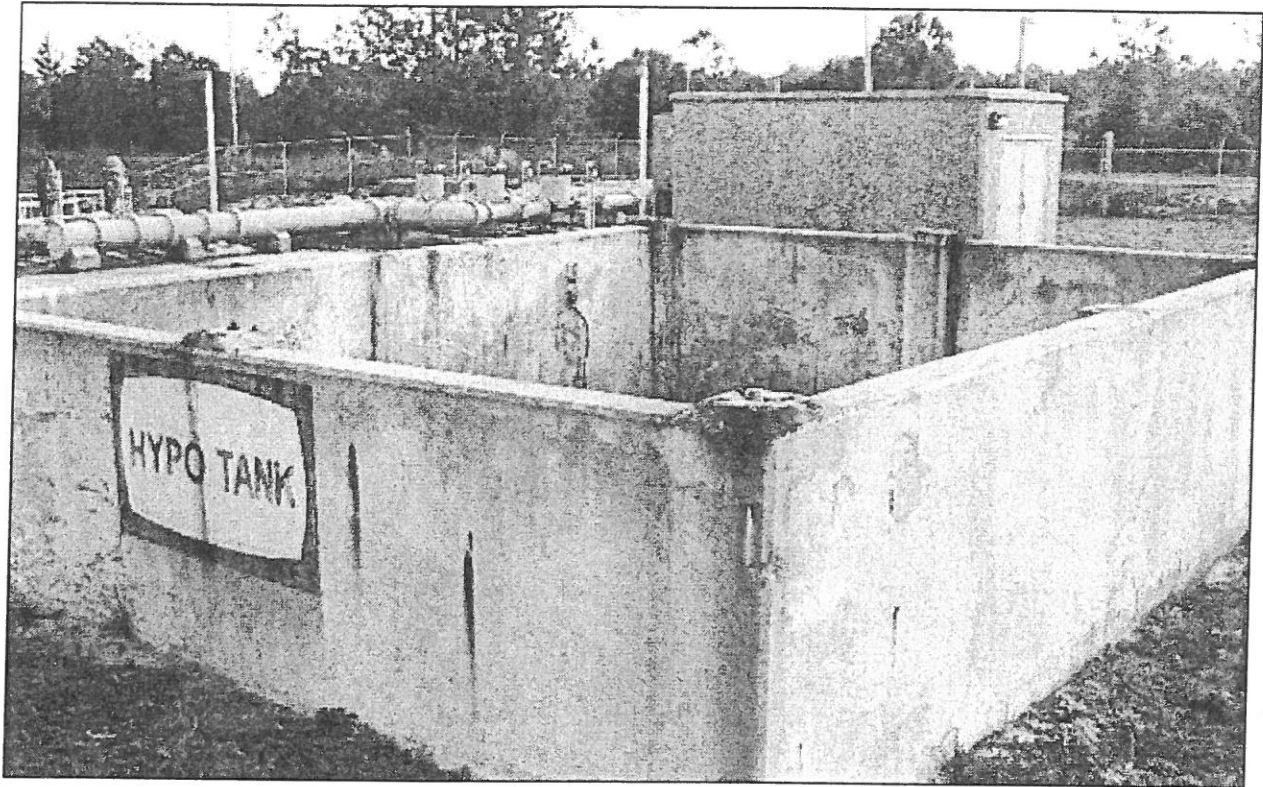
Water Treatment Plant looking eastward



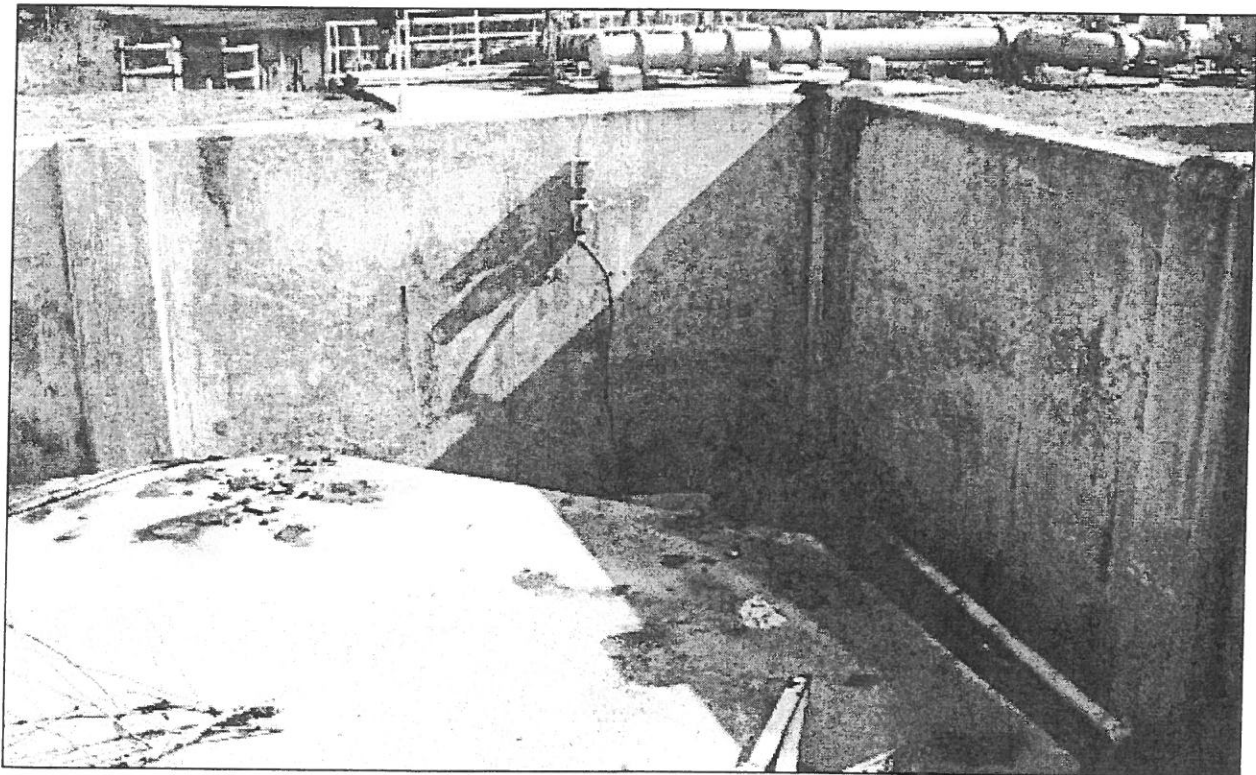
**Raw Water Intake and Proposed Location of Hydrate Lime Feed System
East of Water Treatment Plant**



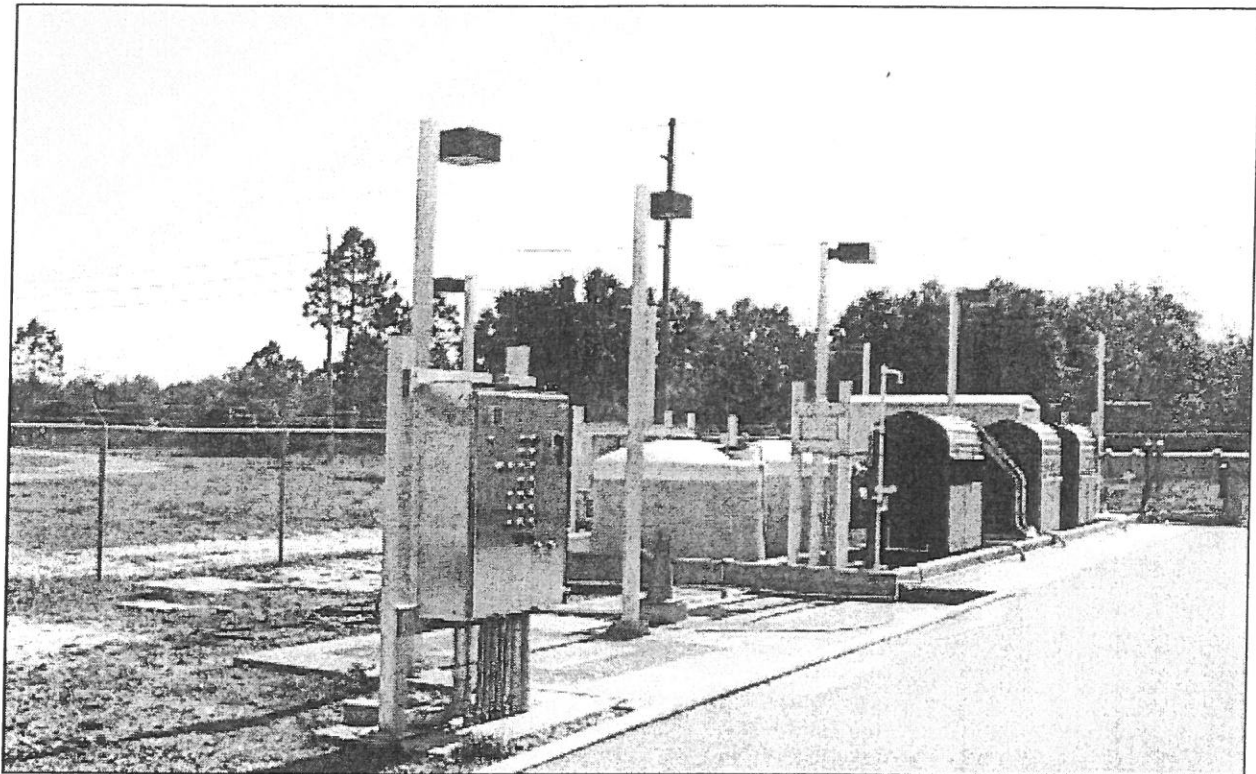
**Proposed Location of Hydrate Lime Feed System
East of Water Treatment Plant**



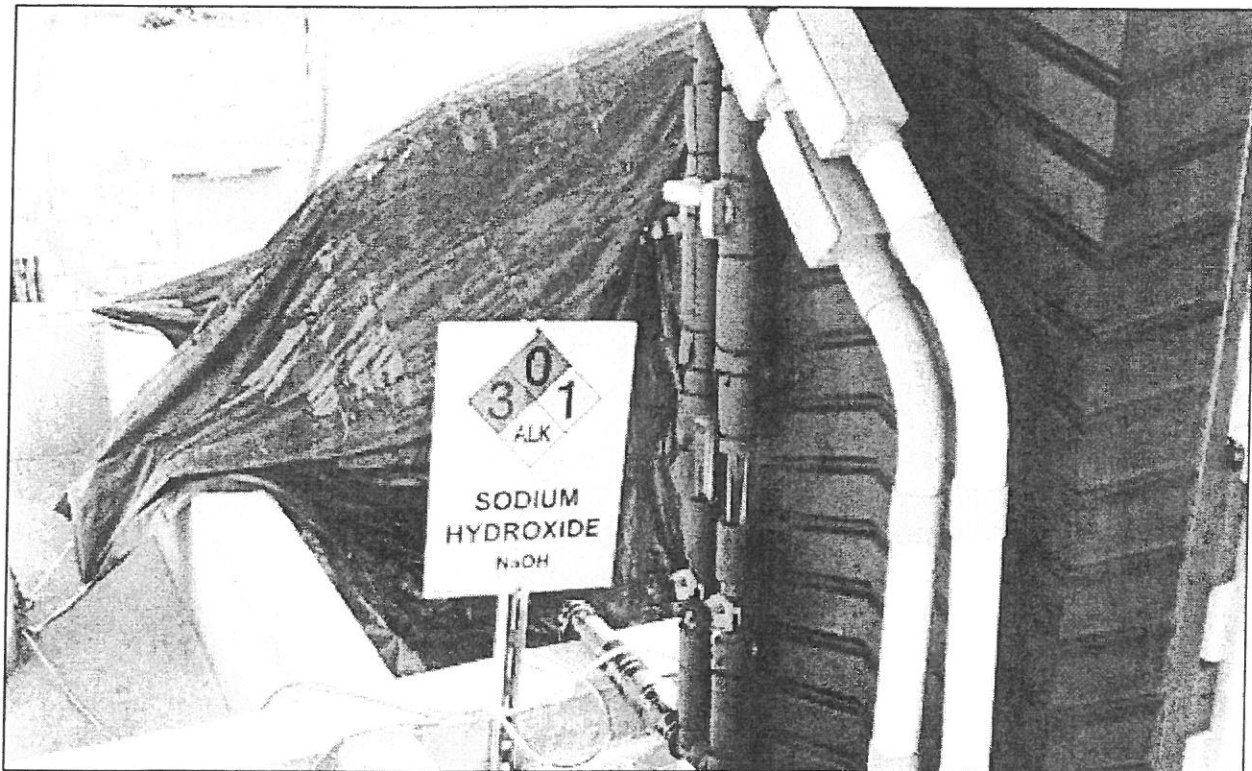
Proposed Location of Hydrate Lime Feed System



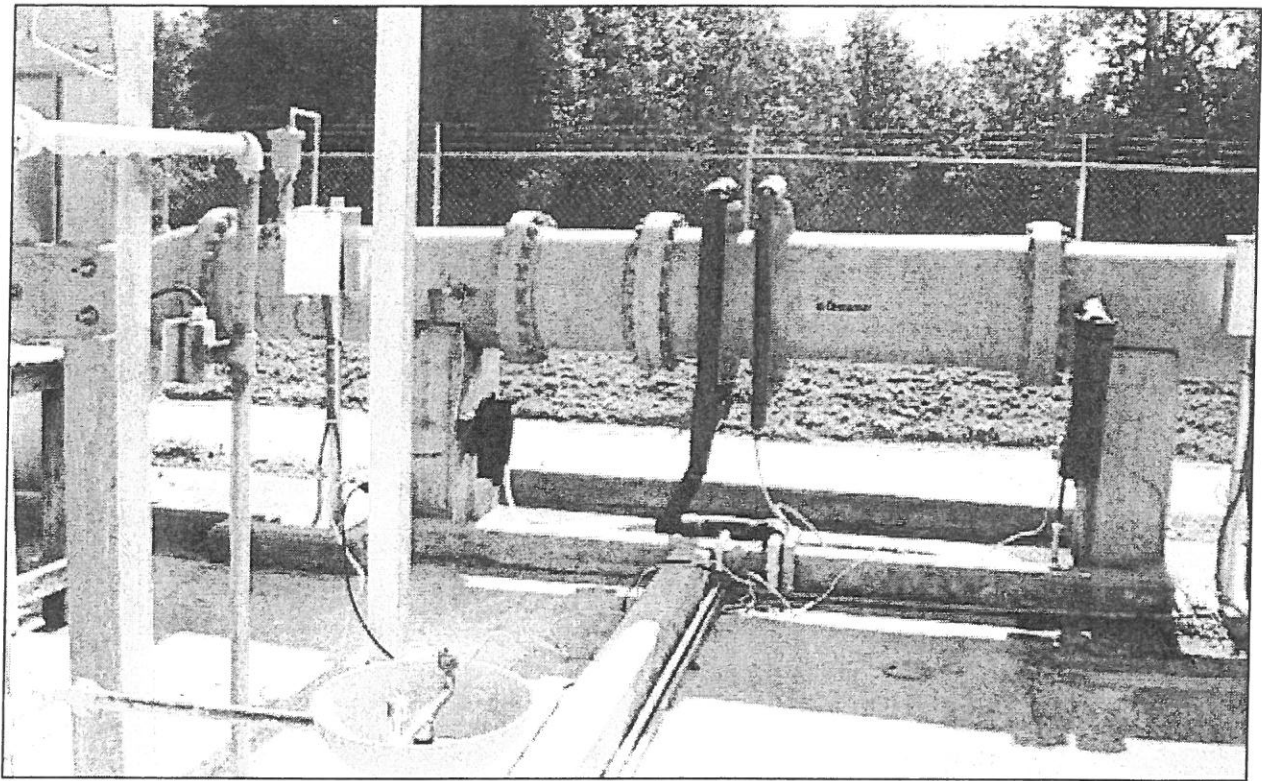
Proposed Location of Hydrate Lime Feed System



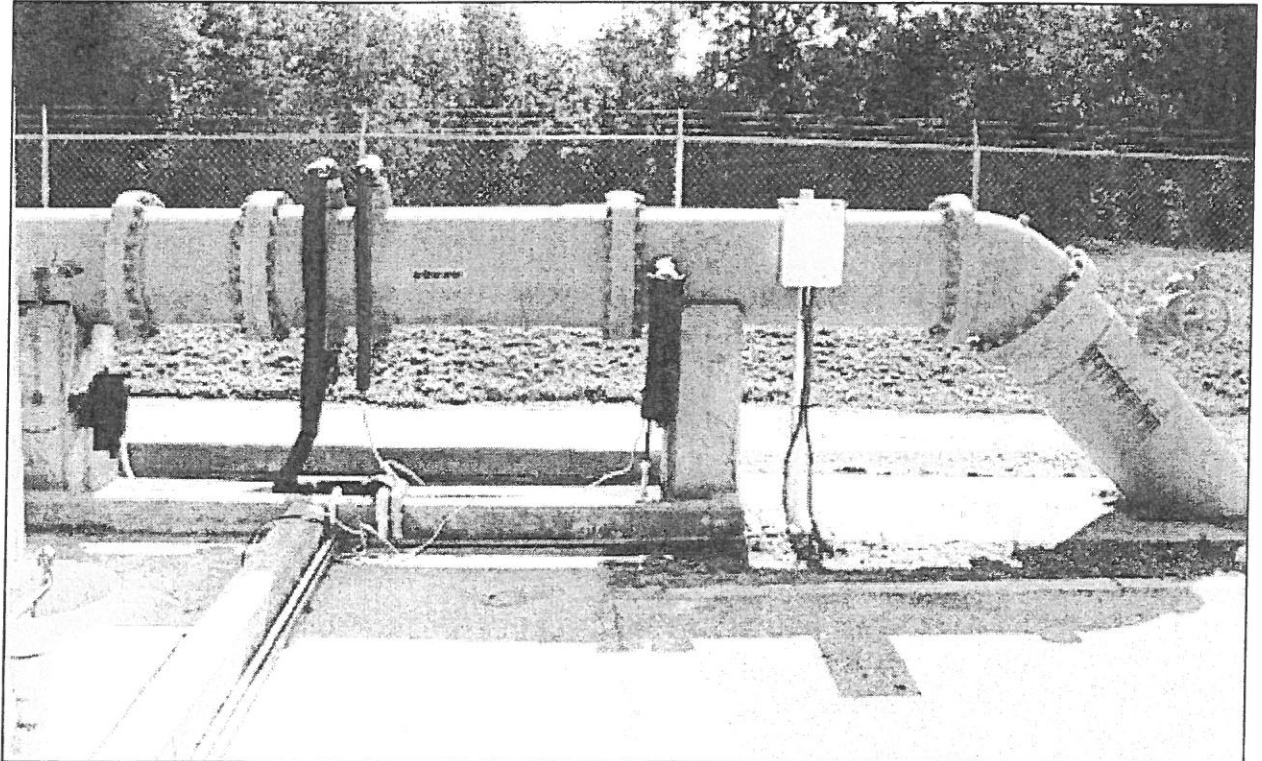
Existing Chemical Feed Equipment



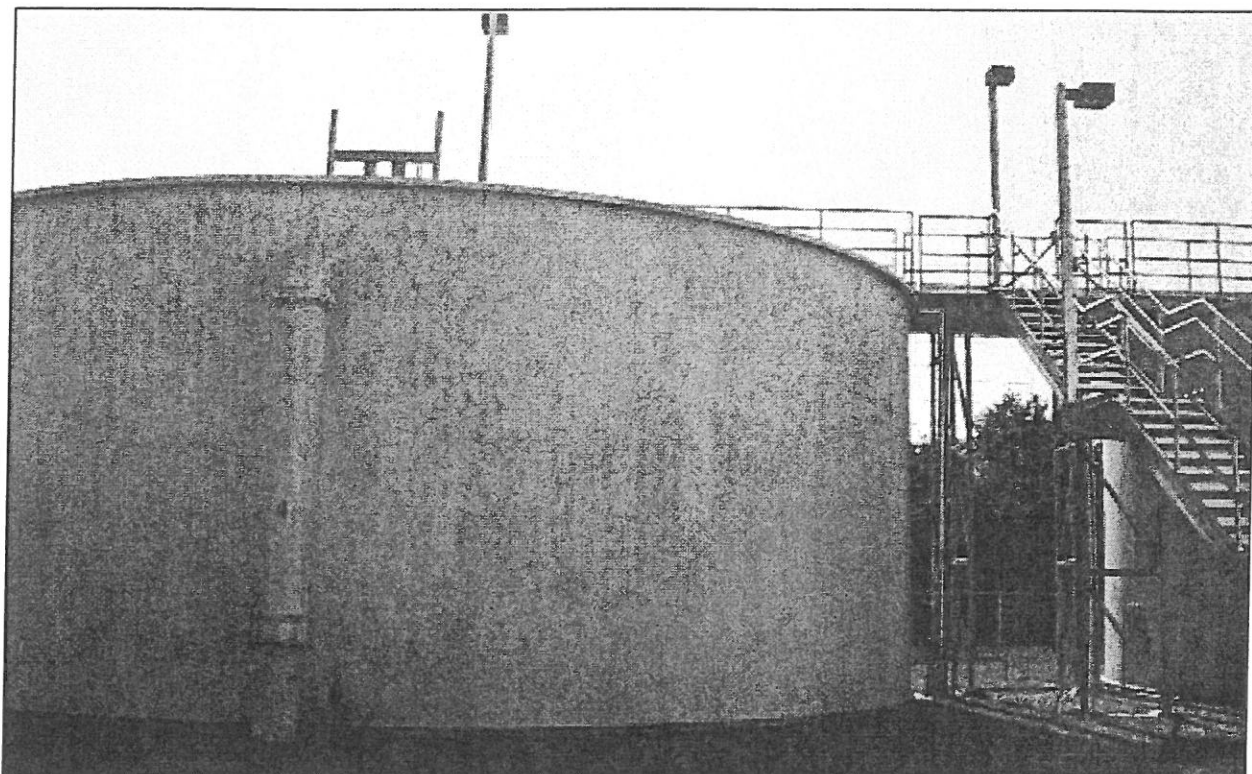
**Existing Sodium Hydroxide Feed Equipment
Covered to avoid freezing at 52° F and heated for cold weather**



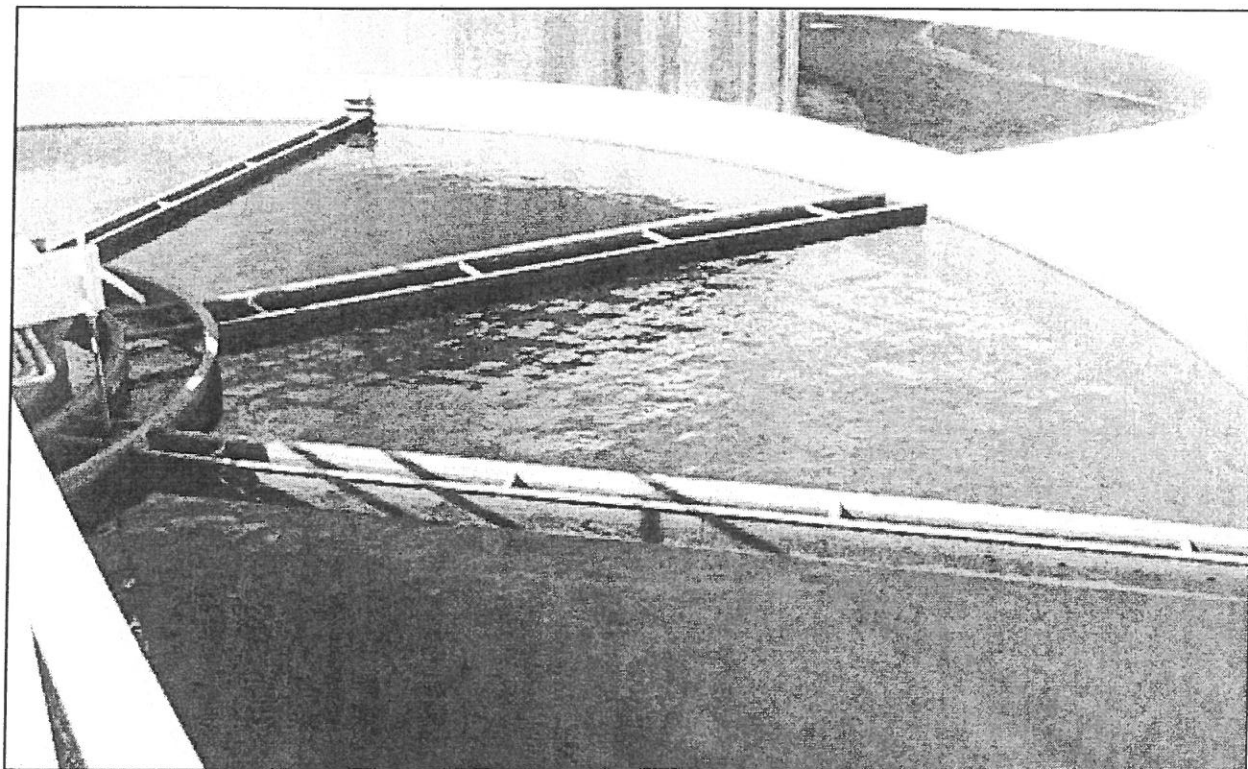
**Existing Chemical Injection Points up stream of static mixer
(very close spacing)**



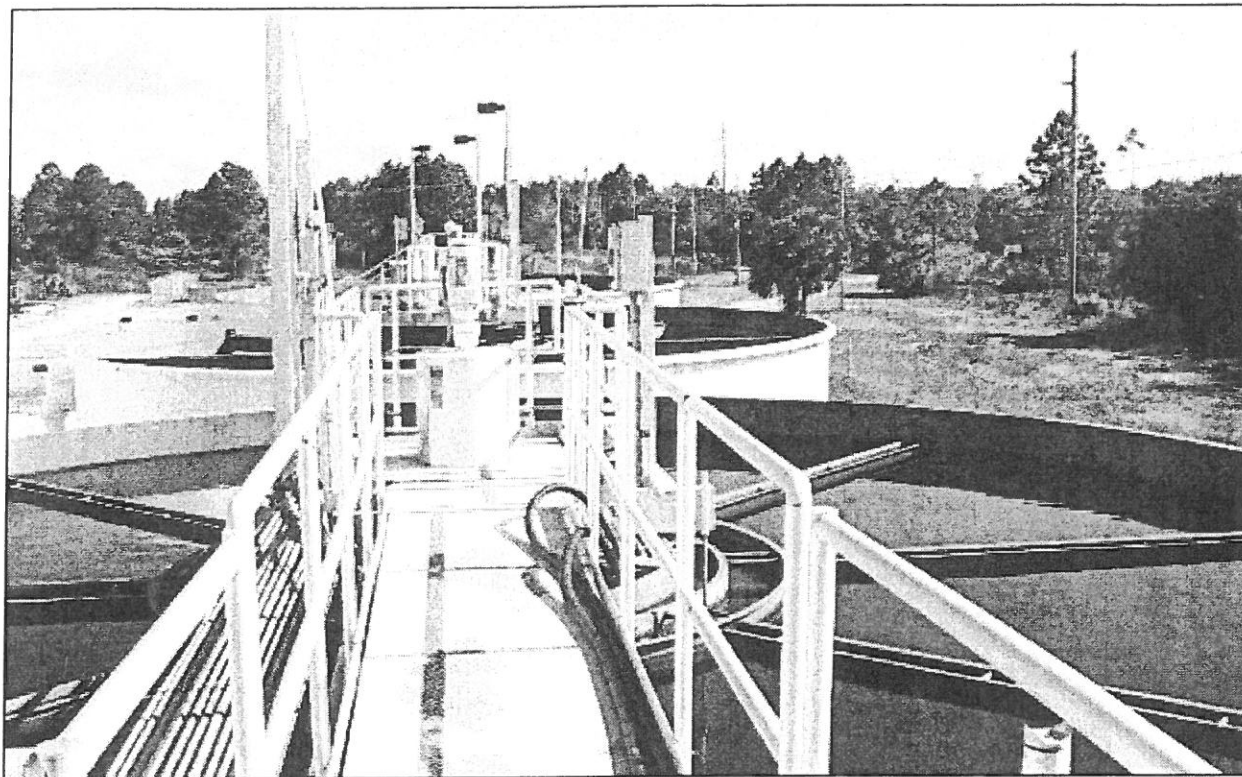
**Existing Chemical Injection Points up stream of static mixer
(very close spacing)**



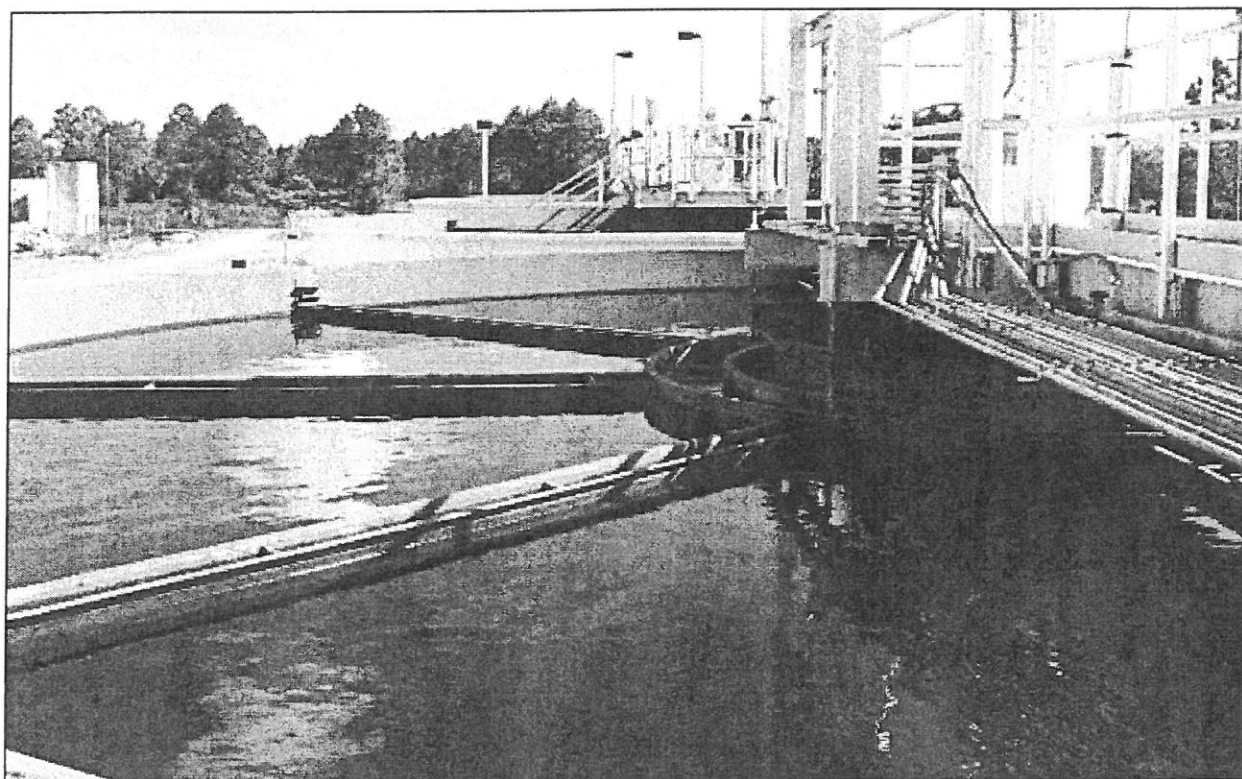
**Reactive Clarifiers – one of four
US Filter Type C Contraflo®**



**Reactive Clarifiers – one of four
US Filter Type C Contraflo®**



Reactive Clarifiers



Reactive Clarifiers