Chlorine Dioxide Feed System for Pre-Oxidation

Results from Full Scale Demonstration Testing

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Outline and Index

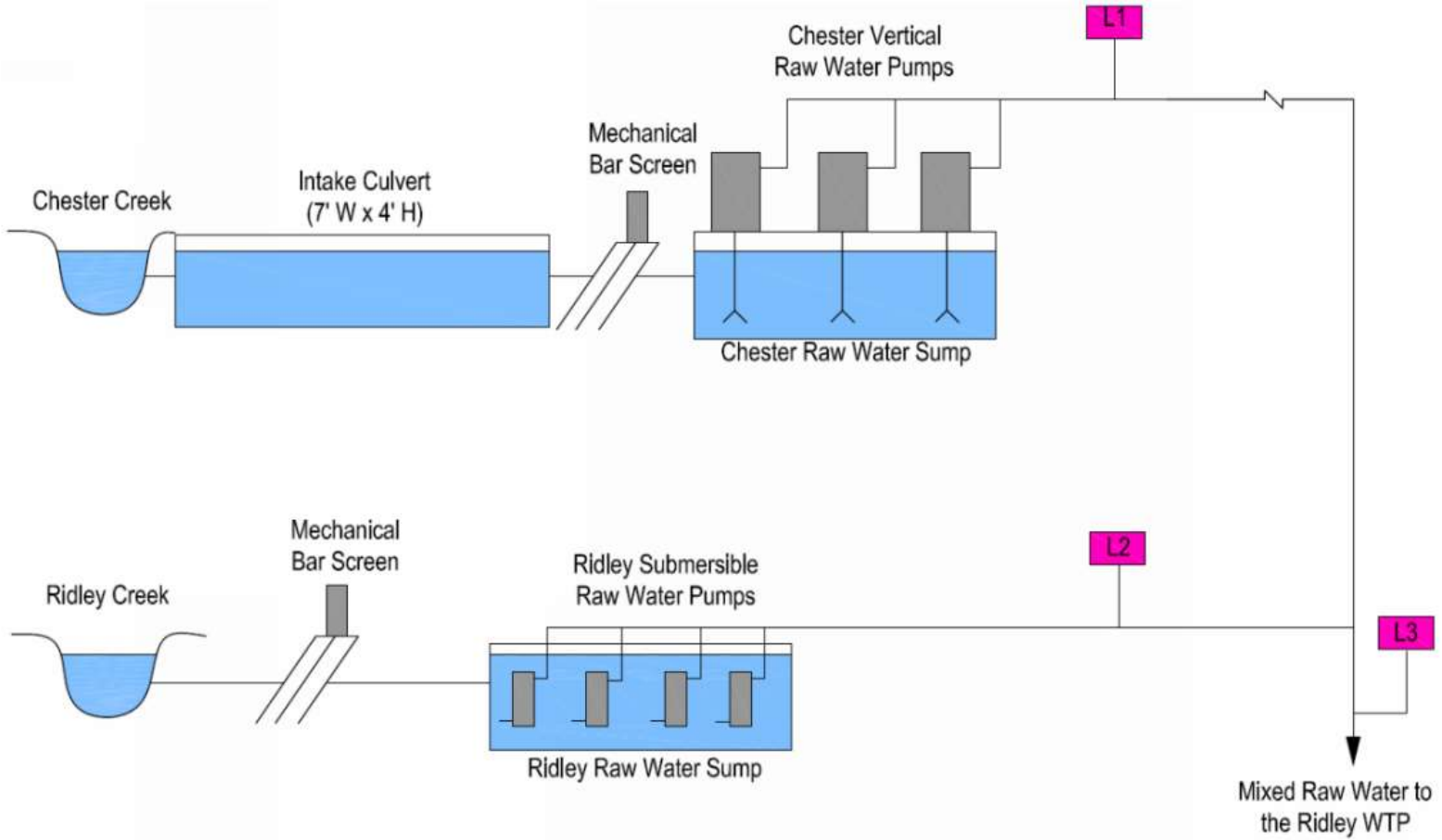
System Description

Ridley WTP
Owned and operated by Aqua PA

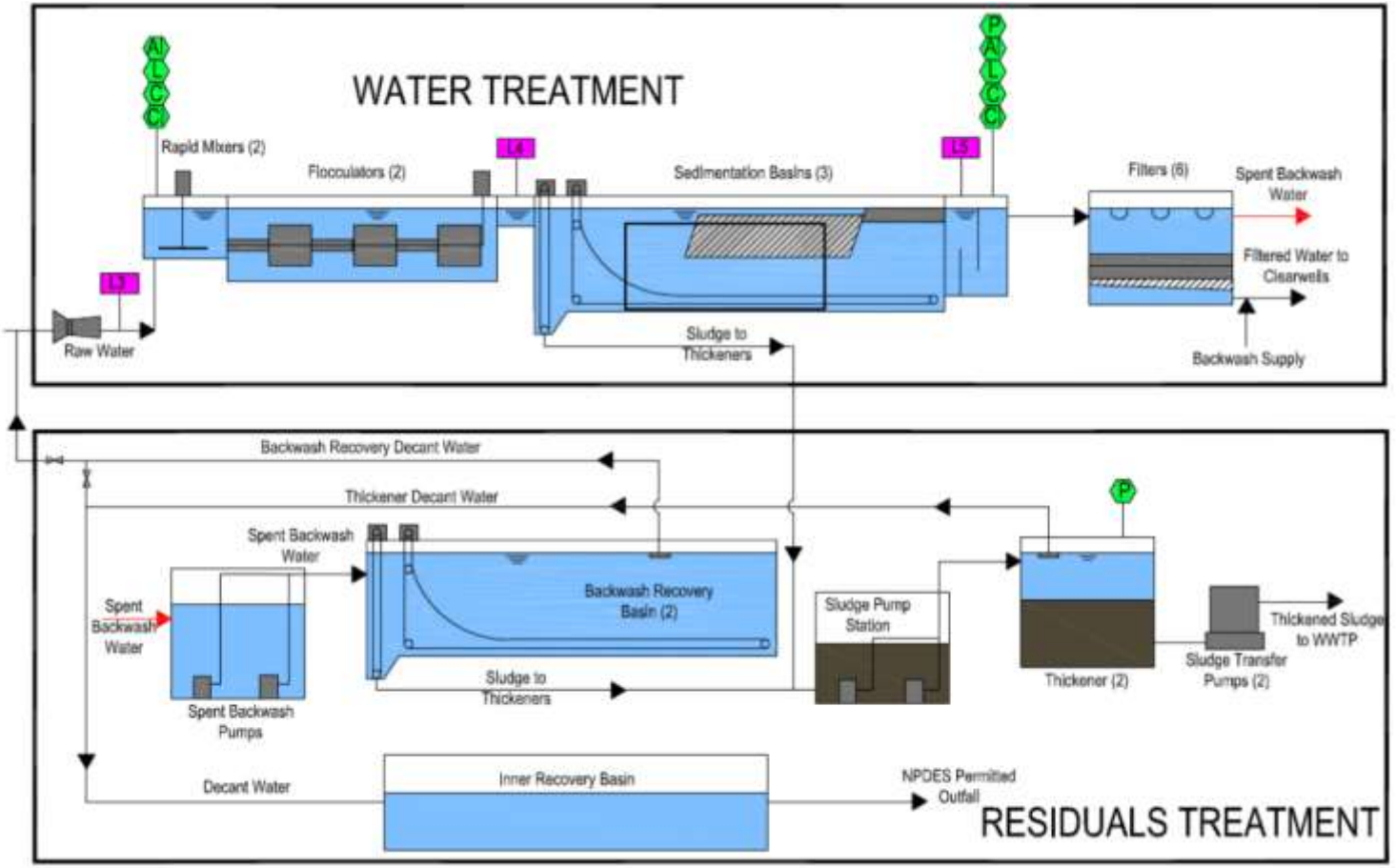
Location
Delaware County
Media, PA

Customers
in (Location)

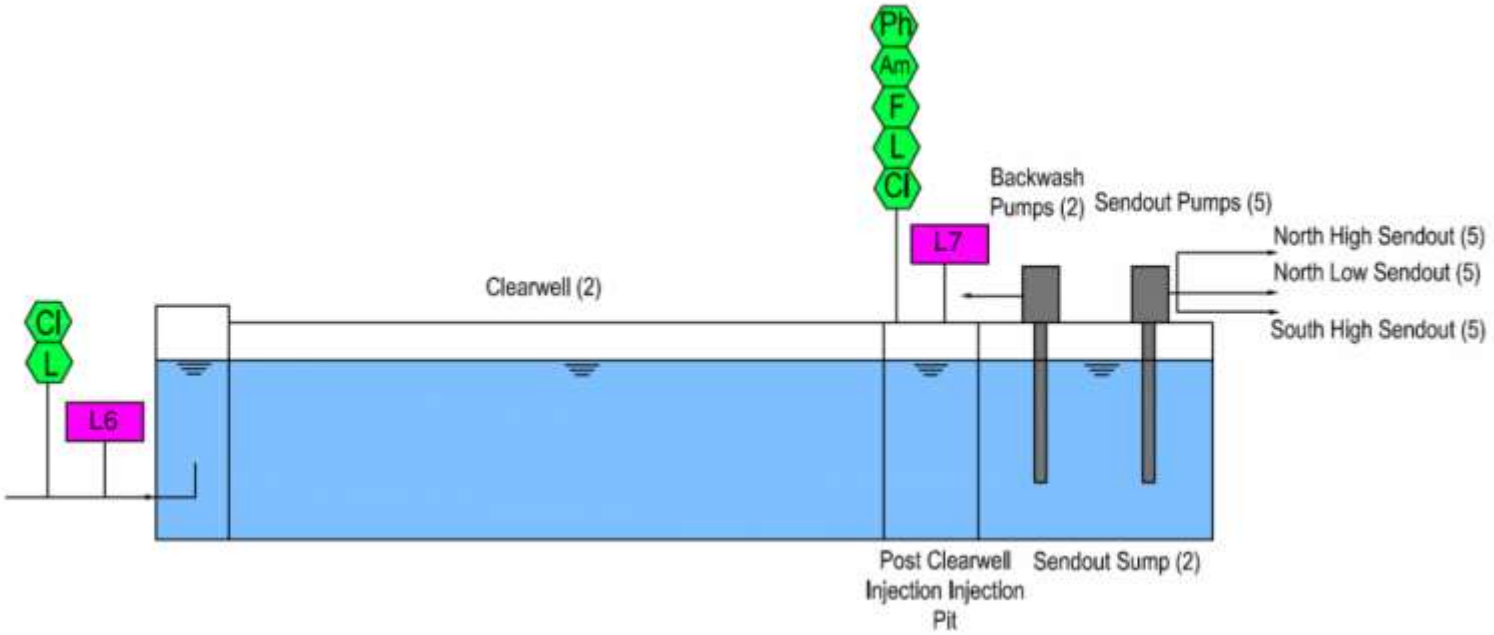
Flow Rate
Avg. Operating - 3.5 MGD
Max - 7.5 MGD
Min - 1.8 MGD



Ridley Water Treatment Plant Schematic



Ridley Water Treatment Plant Schematic



Ridley Water Treatment Plant Schematic

Evaluate the effectiveness of Chlorine Dioxide as a pre-oxidant to improve water quality in the distribution system.

Aqua PA – History with Chlorine Dioxide

Demonstration Study Successes

1

Shenango WTP

Permanent Installation in 2014.

2

Bristol WTP

Permanent Installation 2018.

3

Ridley WTP

???

Potential Benefits

- Increased Chlorine Residual in Distribution System
- PADEP proposed min. chlorine residual of 0.2 mg/L
- Disinfection Byproduct (DBP) Reduction
- Oxidation of pre-cursors before filters allow lower chlorine dosage at filter influent
- Nitrification reduction
- Chlorine dioxide reduces to form the chlorite ion which has been shown to result in better microbial control in finished water
- Improved coagulation
- Chlorine Dioxide aids in microflocculation

Testing Objectives and Performance Goals

PARAMETER	GOAL	BENEFIT POTENTIAL
Total Chlorine Residual	> 0.2 mg/L	Improve Water Quality in Distribution System
ATP [1] HPC [2]	5 pg/mL n/a	Reduce Nitrification
Chlorite	MCL = 1 mg/L > 0.1 mg/L	Reduce Nitrification
Chlorate	< 840 ug/L	Improve Water Quality in Distribution System
TTHMs [3]	Reduction at entry point	DBP reduction
HAAs [4]	Reduction at entry point	DBP reduction
TOC, DOC, UV254, Specific UV Absorbance [5]	n/a	Removal of DBP pre-cursors during microflocculation

[1]Adenosine Triphosphate (ATP)
[2]Heterotrophic Plate Count (HPC)
[3]Total Trialomethanes (TTHMs)
[4] Haloacetic Acids (HAAs)
[5] Total Organic Carbon (TOC)
Dissolved Organic Carbon (DOC)

Description of the Demonstration Unit

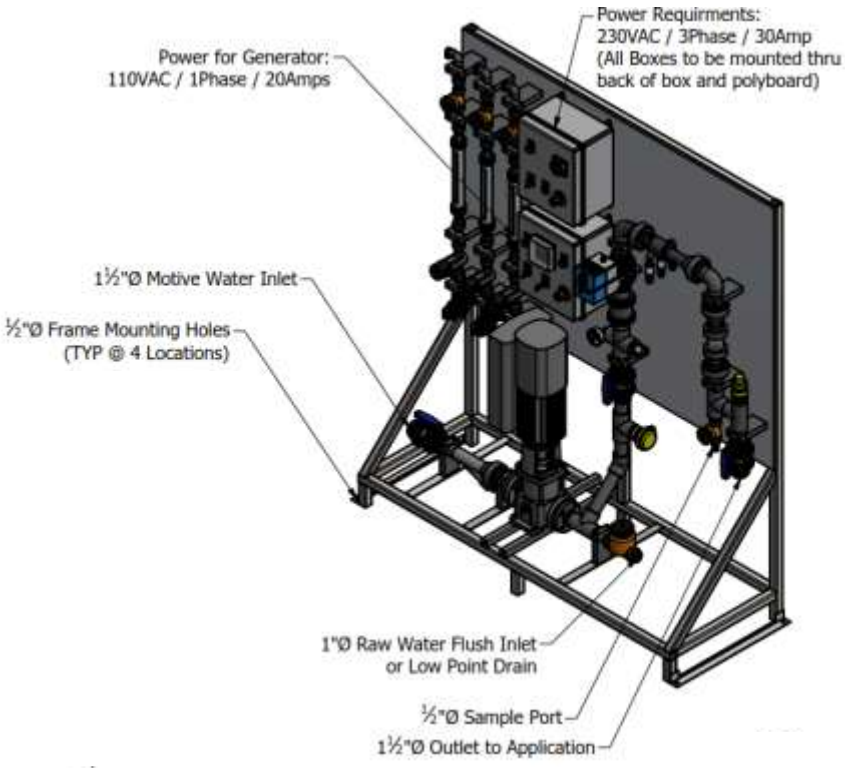
Chlorine Dioxide System

$$2NaClO_2 + Cl_2 \longrightarrow 2ClO_2 + 2NaCl$$

- Chlorine gas ($Cl_{2(g)}$): supplied using existing system
- Sodium Chlorite ($NaClO_2$) (25% strength): delivered and stored on site in 275 gallon totes (2)
- Unit operates manually based on desired chlorine dioxide feed rate (ppd)
    - Rotameters for each chemical are adjusted by operators

Description of the Demonstration Unit

Chlorine Dioxide Generator System



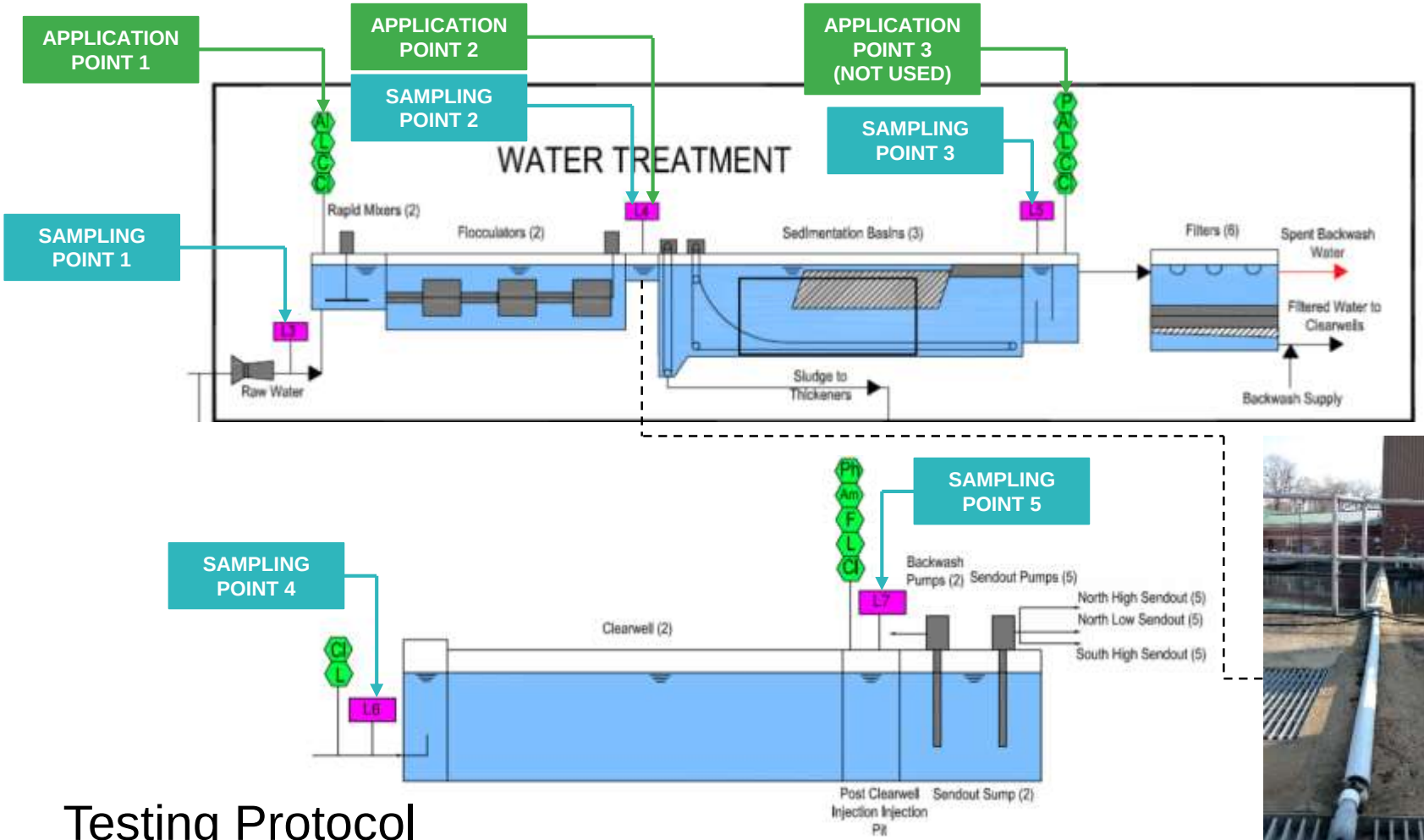
Description of the Demonstration Unit

Capabilities

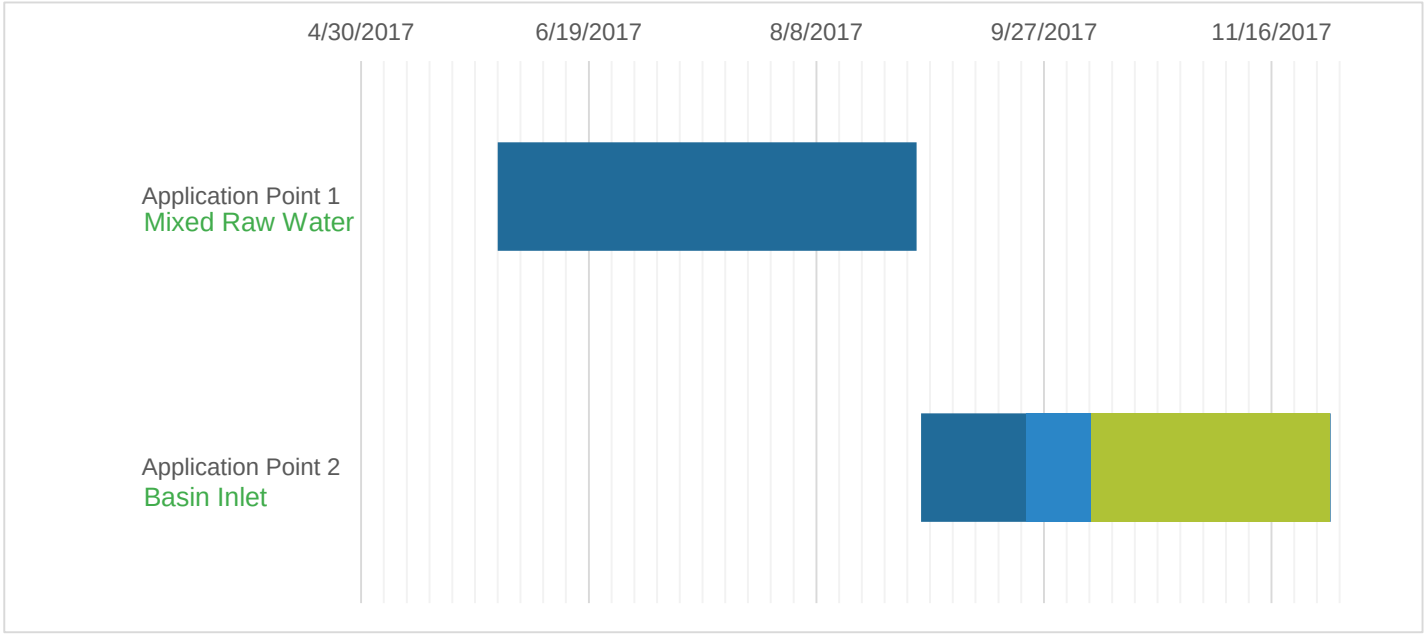
	CHLORINE DIOXIDE SYSTEM	RIDLEY WTP MAX EXPECTED CAPACITY	MAXIMUM UTILIZATION	AVERAGE UTILIZATION		MINIMUM UTILIZATION
FLOW RATE (MGD)	-	7.5	4.82	3.5		2.47
PRODUCTION (ppd)	15-150	75	32.2	17.5	23.4	17
DOSE (mg/L)	2.0	1.0	0.8	0.6	0.8	0.8

Solution for low flow & dosage:

- Use reduced sodium chlorite solution of 7.5%



Testing Protocol



Testing Protocol

Testing Protocol

WTP Data Collection

- **Daily Data**

- Date/Time
- Raw Water Flow from Ridley & Chester Creeks (MGD)
- Chlorine Dioxide Dose (mg/L) set at generator panel
- pH & Temperature (°C)
- Basin Outlet Chlorine Dioxide Residual & Chlorite Residual (mg/L)
- Entry Point Chlorine Dioxide Residual & Chlorite Residual (mg/L)

- **Additional Samples**

- Generator Efficiency (samples taken by LANXESS once/month)
- % Removal of TOC,DOC, UV254, SUVA for Ridley combined RW (once/week)

Testing Protocol

Distribution System

- 6 Sampling Locations
- Low Water Age
- High Water Age
- Average Water Age

- Weekly Data
- Free & Total Chlorine (mg/L)
- ATP
- HPC
- TTHM
- HAA5
- Nitrite
- Chlorite (mg/L)
- Chlorate (mg/L)

Simultaneous Compliance

Corrosion Monitoring

- Pipe Loop System
- Six Pipes
  - 2 Lead (New)
  - 2 Copper (New)
  - 2 PVC (future)
- Operational in March 2017
  - Conditioning Phase ~ 6 months

- WRF, *State of Chlorine Dioxide in Drinking Water*
- No information that corrosion would increase with the addition of chlorine dioxide (Gates, Ziglio, Ozekin 2009)

- *AWWA Journal: Research and Technology*
- Chlorine dioxide, at levels used for drinking water treatment, did not impact corrosion, as the rates were similar to those observed in the control loop, with an average rate of 2.2 mpy. The average corrosion rate in the control loop was 2.1 mpy (Eisnor and Gagnon 2004)

Corrosion Monitoring

Pipe Loop System

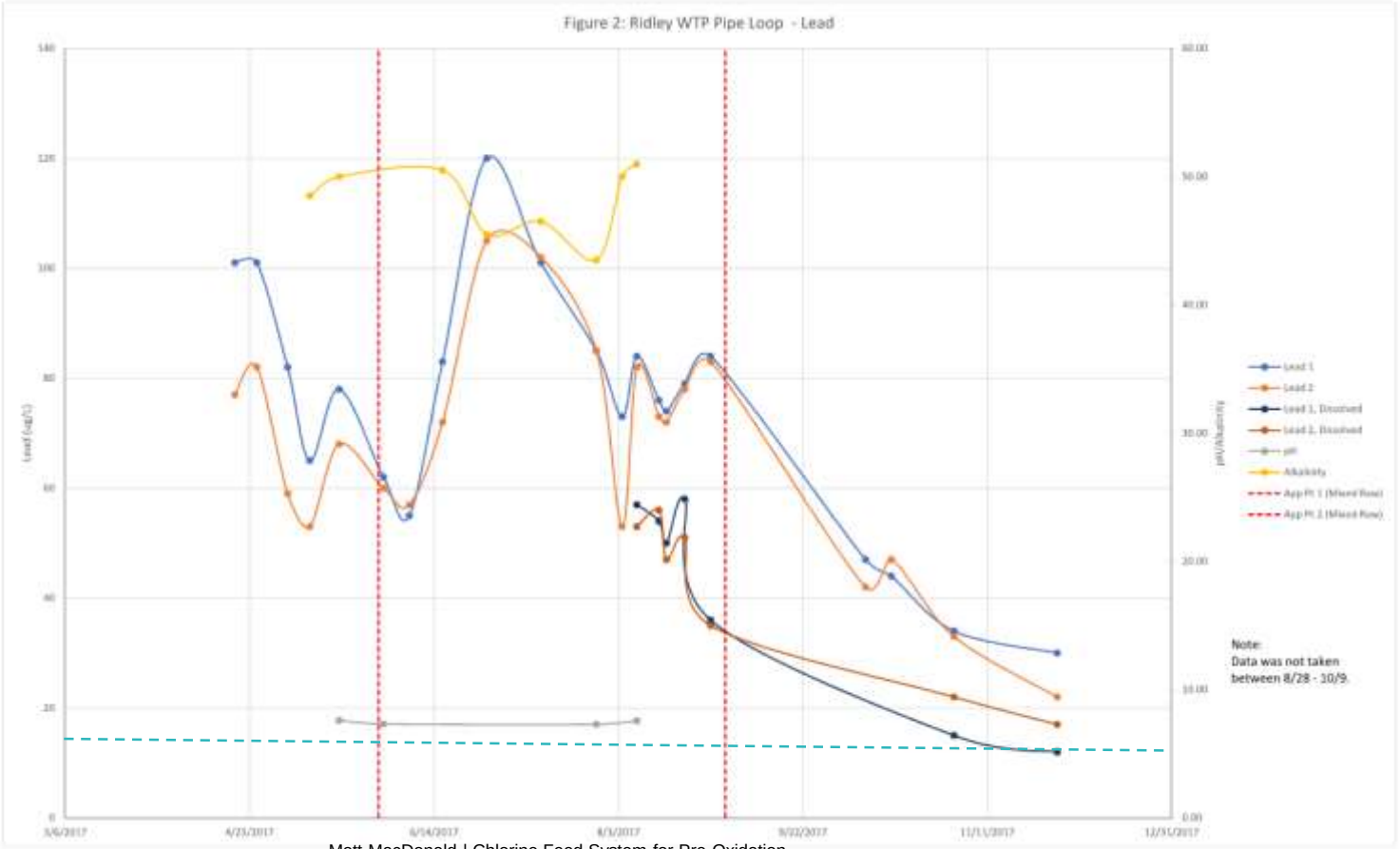
- Weekly Data

- Total Lead (ug/L)
- Total Copper (mg/L)
- Alkalinity (mg $CaCO_3$/L)
- pH

- Additional Data (beginning in Aug.)

- Dissolved Lead (ug/L)
- Dissolved Copper (mg/L)
- Orthophosphate (as P, mg/L)

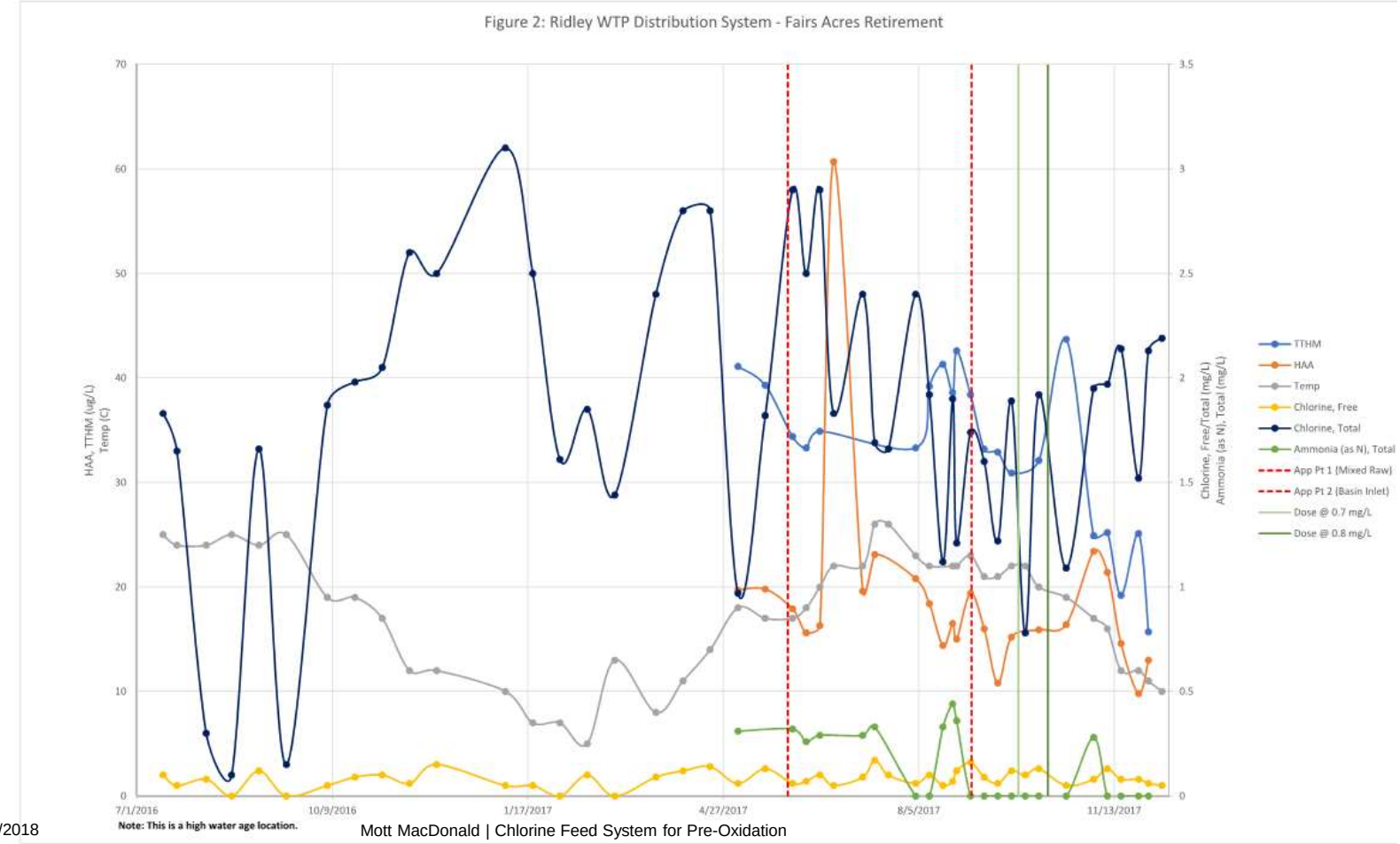
Corrosion Monitoring



Analysis of Data

- Graphical and statistical analysis to understand trends over time and assess the precision of data
- Optimum chlorine dioxide dose: 0.6 - 0.8 mg/L

Distribution System Analysis & Results: High Water Age Location



Analysis of Data and Results

Ridley WTP

1

WTP Performance

- Chlorine Dioxide residuals generally low or non-detect at entry point.
- Stable and consistent flow, pH
- 97-99% generator efficiency

2

Chlorite Residuals (WTP)

- Increased but stable at entry point.
- Average of 0.3 mg/L which is beneficial to minimize nitrification.

3

TOC, DOC, UV254

- TOC/DOC higher 95-percentile & max. % removal than previous 3 years.
- UV254/SUVA higher overall average.
- Chlorine dioxide increases microflocculation for DBP precursor removal

Analysis of Data and Results

Distribution System

1

Total Chlorine Residual

- Average total chlorine residuals well above 0.2 mg/L at all sampling locations.
- Summer months may pose challenge.

2

DBP Reduction

- Entry point TTHMs 29% decrease from previous year
- Entry point HAA5 15% decrease from previous year

3

Nitrification Reduction

- Average ATP decreased by 31% during study period from previous year.
- HPC shows similar decreasing trend.
- Increase likely in summer months.

4

Chlorate

- Goal is less than 840 ug/L in distribution system.
- Entry point averages 152 mg/L.

Conclusions

- Effective Dose: 0.6 - 0.8 mg/L
- Nitrification Reduction
- Removal of DBP Pre-cursors through microflocculation
- DBP Reduction
- Higher Overall Chlorine Residual
- 2 application points – operational flexibility

Recommendations

- Maintain Pipe Loop System
- Use Demonstration Study data as baseline
- Continue to monitor lead/copper levels with future changes in WTP chemicals & dosages
- Automated, Permanent System
- Obtain automated generator
- Design permanent system with sodium chlorite tanks
- Future WTPs
- Consider moving manual generator to another WTP for new demonstration study.

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