Chlorine Dioxide Feed System for Pre-Oxidation at an 8 MGD WTP

Results from 1 Year of Full Scale Demonstration Testing

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Outline

- Bristol WTP and Distribution System Background
- Purpose of Demonstration Testing
- Testing Objectives and Performance Goals
- Description of the Demonstration Unit
- Testing Protocol
- Analysis of Data and Results
- Conclusions
- Future Improvements

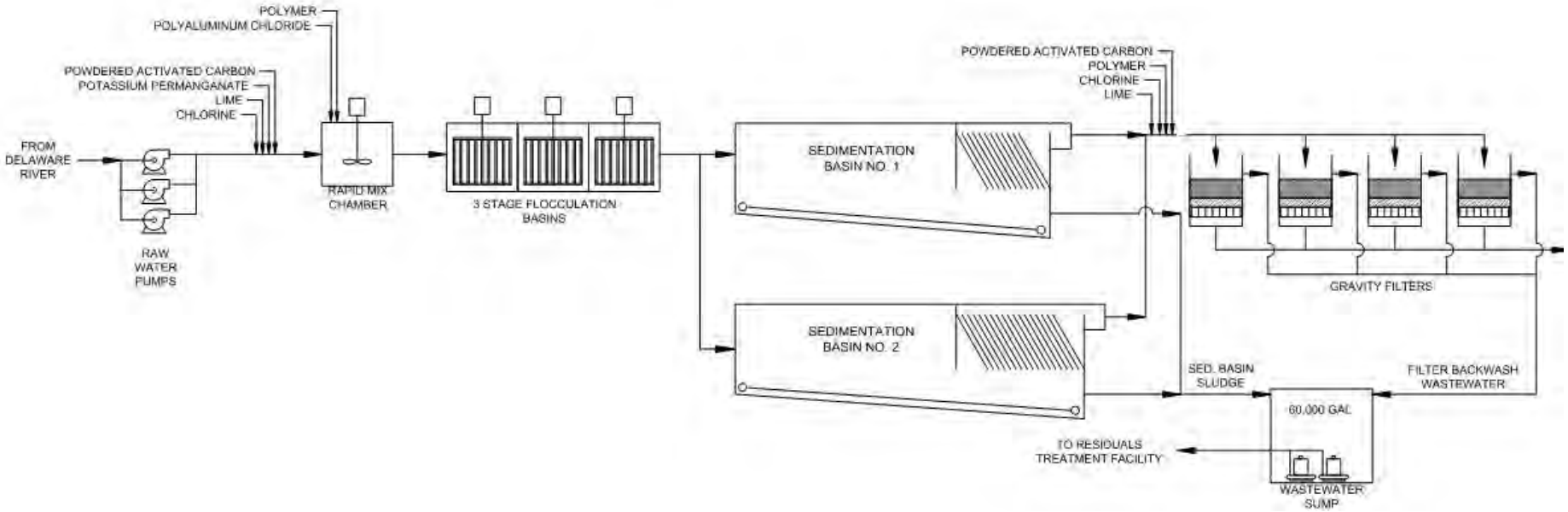
Bristol Water Treatment Plant

Background

- Owned and operated by Aqua, PA
- Located in Bucks County, PA
- Serves approx. 125,000 customers from Bristol Borough, Bristol Twp., and Bensalem Twp.
- Max. Capacity – 8.0 MGD
- Avg. Operating Flowrate – 5.0 MGD

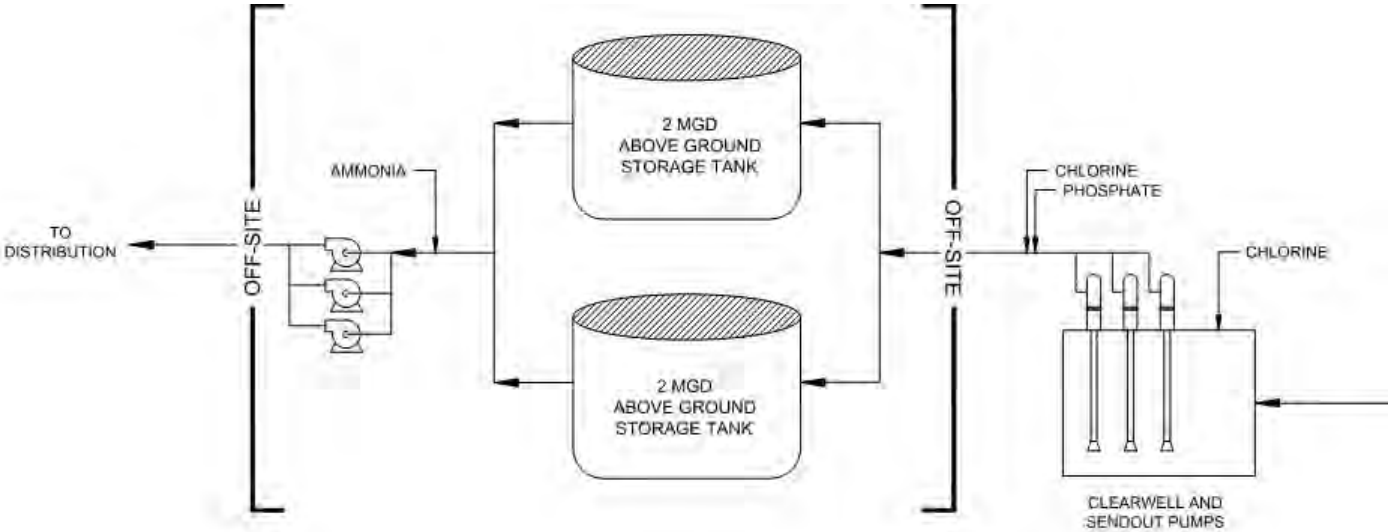
Bristol Water Treatment Plant

Background



Bristol Water Treatment Plant

Background



Distribution System

Background

- Total chlorine residual of less than 0.2 mg/L
- Chloramination practice results in occurrence of nitrification in distribution system.
- A significant amount of disinfection byproduct (DBPs) formation at the entry point rather than in the distribution system

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

Potential Benefits

Demonstration Study Hypotheses

- Oxidation of pre-cursors before the filters may allow the chlorine dosage applied to the filter influent to be reduced.
- Reduction of the chlorine dose at the filter influent may result in reductions in DBP formation in the distribution system.
- Chlorine dioxide breaks down to form the chlorite ion. Studies have shown that the presence of the chlorite ion in finished water results in better control of organisms in the distribution system, especially those which cause nitrification.
- Chlorine dioxide also may improve coagulation via microflocculation.

Testing Objectives and Performance Goals

Secondary Disinfection

PARAMETER	GOAL	BENEFIT POTENTIAL
Total Chlorine Residual	>0.2mg/L	Improve Water Quality in Distribution System
ATP* HPC**	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

*Adenosine Triphosphate (ATP)

** Heterotrophic Plate Count (HPC)

Reference :http://winnipeg.ca/waterandwaste/water/testresults/winnipeg.stm

Testing Objectives and Performance Goals

Disinfection By-Product (DBPs)

PARAMETER	GOAL	BENEFIT POTENTIAL
TTHMs*	Reduction at entry point	DBP reduction
HAAs**	Reduction at entry point	DBP reduction
TOC, DOC, UV254, Specific UV Absorbance***	n/a	Removal of DBP pre-cursors during microflocculation

*Total Trialomethanes (TTHMs)
** Haloacetic Acids (HAAs)
*** Total Organic Carbon (TOC)
Dissolved Organic Carbon (DOC)

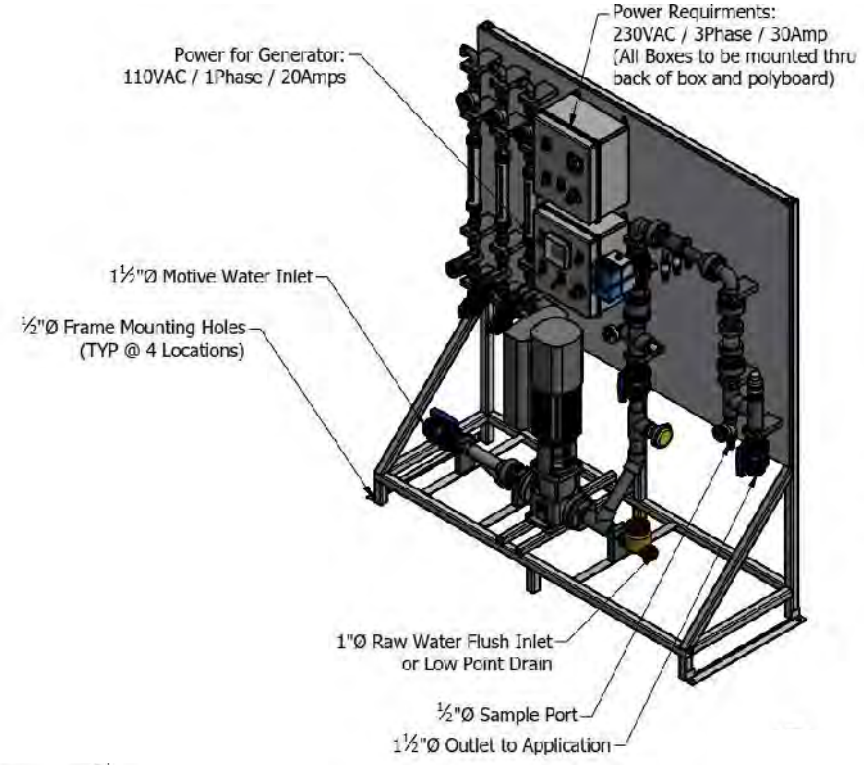
Description of the Demonstration Unit

Chlorine Dioxide System

- Chlorine gas ($Cl_{(g)}$): supplied using existing system
- Sodium Chlorite ($NaClO_2$) (25% strength): delivered and stored on site in 330 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



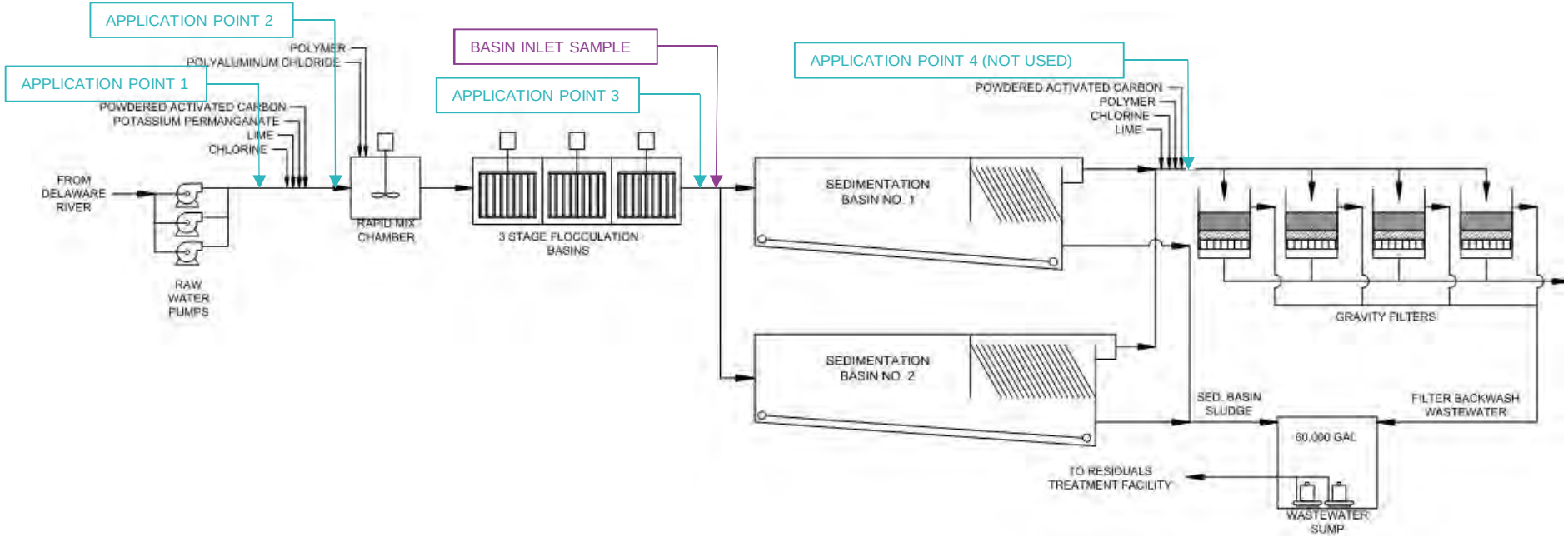
Description of the Demonstration Unit

Capabilities

	CHLORINE DIOXIDE SYSTEM	BWTP	MAXIMUM UTILIZATION	AVERAGE UTILIZATION	
PRODUCTION (ppd)	15-150	134	67	42	25
DOSE (mg/L)	2.0	2.0	1.0	1.0	0.6

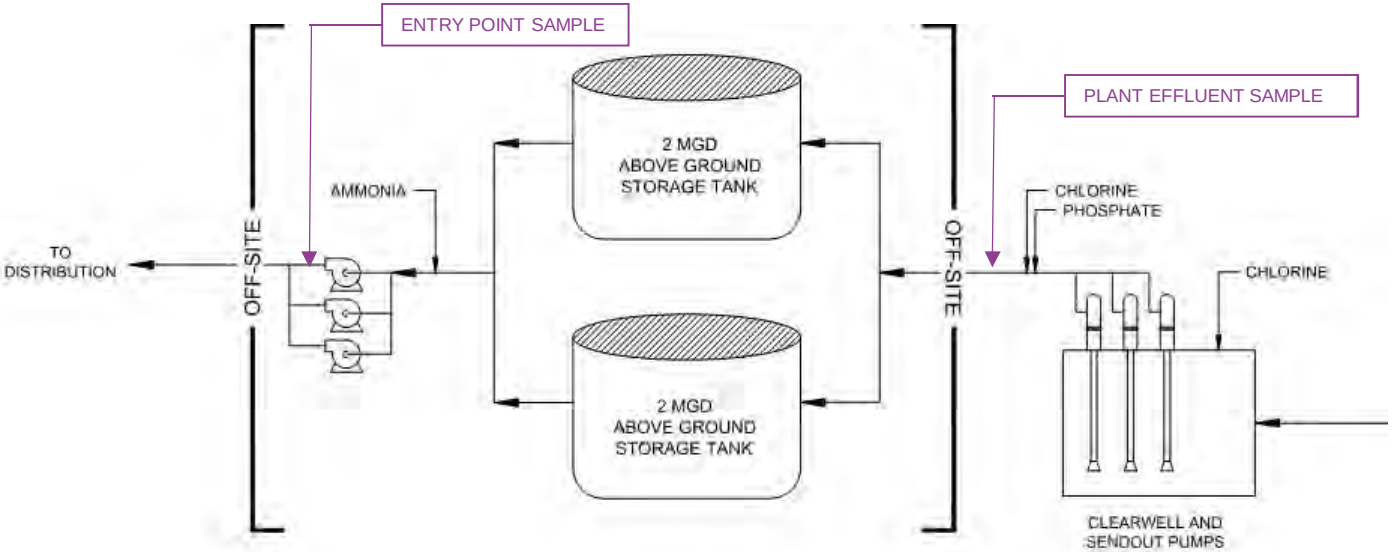
Testing Protocol

Application Points and Sampling Locations



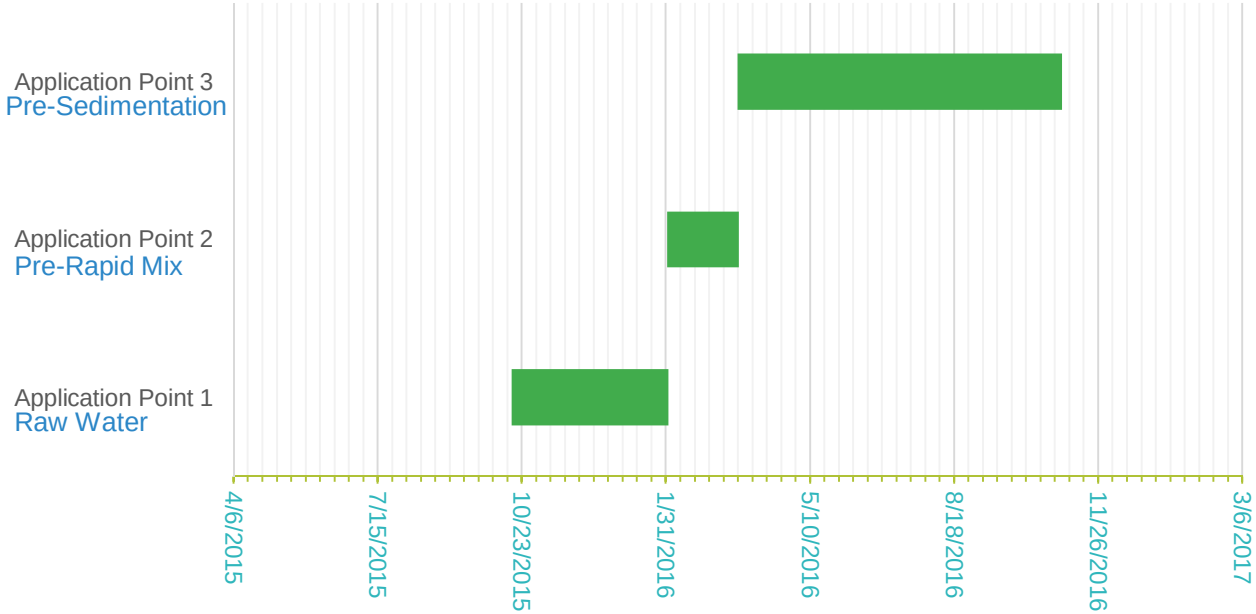
Testing Protocol

Sampling Locations



Testing Protocol

Schedule



Testing Protocol

Daily Data Measured at Plant

Daily samples taken at the BWTP include:

- Plant flow
- Chlorine (ppd) and sodium chlorite (gpd) supplied to the chlorine dioxide generator
- Chlorine dioxide dose (mg/L)
- Chlorine dioxide and chlorite residuals at the basin inlet, plant effluent, and entry point

Other samples taken at the BWTP include:

- Generator efficiency (samples beginning in November 2015, taken at least once a month)
- % removal of TOC, DOC, UV254 based on values for the raw water and combined filter effluent (samples taken at least once a week)

Testing Protocol

Corrosion Monitoring

- Process Research Solutions (PRS) Monitoring Station

Testing Protocol

Distribution System Samples

- 5 Sampling Locations based on Water Age
  - 3 High
  - 1 Average
  - 1 Low

Testing Protocol

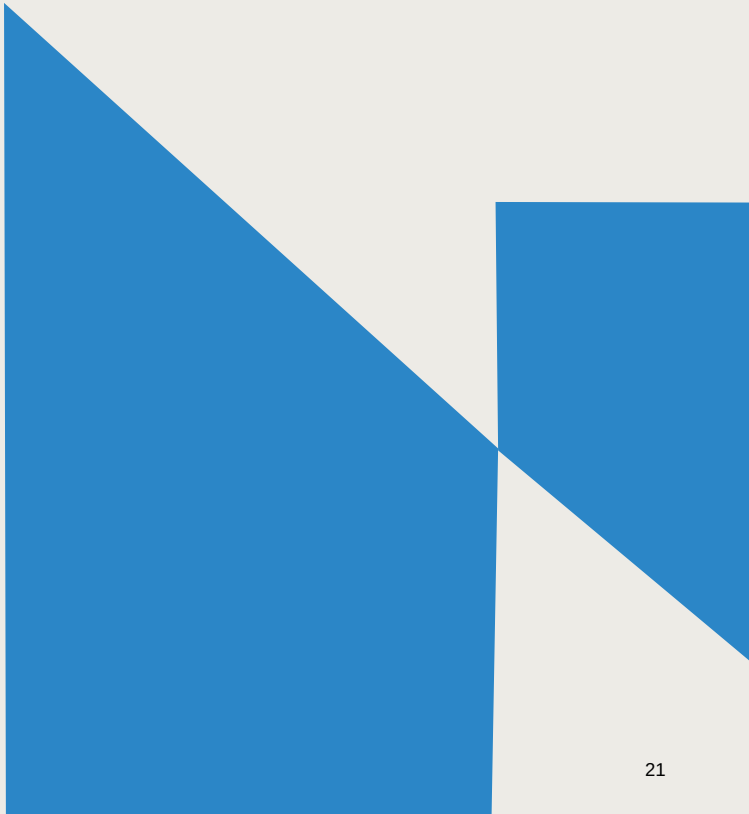
Weekly Data Measured in Distribution System

- Free and Total Chlorine (mg/L)
- pH
- Nitrite
- ATP
- HPC
- TTHM
- HAA5
- Temperature (°C)
- Chlorite (mg/L)
- Chlorate (mg/L)

Analysis of Data

Analysis

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



Analysis of Data and Results

Chlorine Residuals at Entry Point

- Challenges exist in maintaining the residual in the entry point feeding the distribution system during summer months
- Results: Chlorine residuals stabilize to a higher overall higher concentration at entry point. Most locations in the distribution system are above 0.2 mg/L.

Analysis of Data and Results

Chlorite Residuals in WTP

- Chlorite most prominent at basin inlet, but degrade at entry point
- Stabilization of chlorite levels since start of study, to overall lower level.
- Result: Average level is 0.31 mg/L – beneficial level to minimize nitrification

Analysis of Data and Results

Chlorate Residuals in WTP

- Although there are no regulations, Chlorate is a potential contaminant of concern.
- Result: Average at entry point: 100-300 ug/L

Analysis of Data and Results

TOC, DOC, UV254 Removal

- Percent (%) removal overall higher than historically.
- Result: Addition of chlorine dioxide has a positive impact on coagulation and microflocculation

Analysis of Data and Results

Generator Efficiency

- 94-100%
- Preliminary findings indicate erratic chlorine to sodium chlorite ratio.
- Stabilized once optimum dose was reached.
- Result: As study progresses, performance of the system became more efficient.

Analysis of Data and Results

DBP Reduction: Distribution System

- Reduction in TTHMs and HAAs
- Result: Reduction of DBPs

Analysis of Data and Results

Nitrification: Distribution System

- HPC and ATP generally decrease from start of study
- Result: Reduction in nitrification

Conclusions

- Effective dose: 0.6 mg/L
- Reduce nitrification
- Reduce DBPs
- Higher overall chlorine residual
- 3 application points – provide operational flexibility

Future Improvements

- In process – create more automated permanent system at BWTP (May 2017)
- Move Demonstration Study and Chlorine Dioxide Generator System to Ridley WTP
  - Raw Water Source: Ridley & Chester Creeks

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