UNIVERSITY AREA JOINT AUTHORITY

Advanced Oxidation Processes for Control of Biofouling of RO Membranes

SEPTEMBER 2014

RETTEW℠
We answer to you.

Presentation Overview

- University Area Joint Authority (UAJA)
- Water Reuse
- Advanced Wastewater Treatment
- Biofouling
- Advanced Oxidation Process
- Alternative Evaluation
- AWT Ozone Installation

University Area Joint Authority

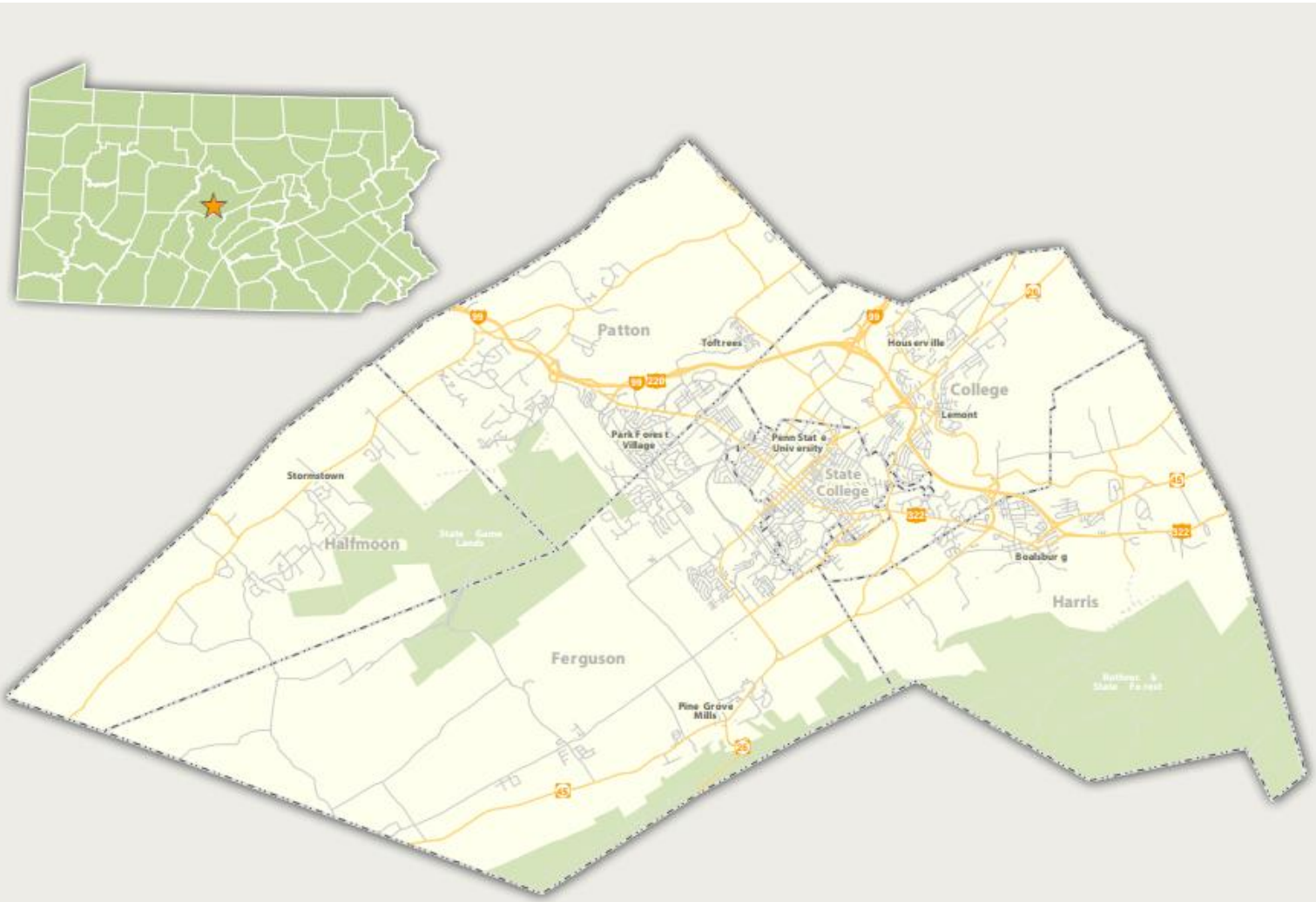
UAJA

- Pennsylvania municipal authority providing wastewater collection, treatment, and reuse in central PA
- Serves the greater State College area
  - (home to Penn State University)
- Total population served approximately 92,000

University Area Joint Authority

UAJA

- 52 employees, managers and staff providing operations and management
- Total assets in excess of $300 million
- Average residential customer user rate +/-$400 per year for wastewater disposal



Overview Map of the Centre Region's Municipalities and location in Pennsylvania

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UAJA

- Wastewater treatment facility is called the Spring Creek Pollution Control Facility
- Advanced WWTF with tertiary effluent standards and water reclamation
- Currently rated for treatment of 10.56 MGD hydraulically and 50,000 lbs/day of BOD_5
- Only permitted to discharge 6.0 MGD

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Spring Creek

- Designated by PA DEP as a high quality, cold water fishery
- Spring fed creek with world class brown and rainbow trout population
- Decreasing baseflows in Spring Creek from growth, coupled with increasing wastewater discharge led to increases in water temperature

University Area Joint Authority

Spring Creek

- Completion of 316A temperature impact study (extremely rare for Municipal Authority)
- Results found that flows in excess of 6.0 MGD could harm aquatic environment
- Places restrictions an both quantity and quality of discharge from WWTP

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Spring Creek

- Tertiary standards with biological nutrient removal requirements:
  - Hyd capacity 10.6MGD
  - Avg flow 5.2 MGD
  - BOD/TSS 10 mg/l
  - Total nitrogen 6 mg/l
  - Total phosphorus 0.13 mg/l

University Area Joint Authority

Beneficial Reuse

- To meet regulatory restriction and provide for future, proceeded with beneficial reuse project
- Project consisted of:
  - EPA 503 Class A biosolids production facility with in-vessel composting (Since 1992)
  - Advanced water reuse facility with indirect potable reuse
  - Constructed wetlands

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Water Reuse

- Area supplied entirely with groundwater supplies for drinking water
- Reviewed options from interbasin wastewater transfer to refrigeration of effluent
- Community chose water reuse over other options as it provided sustainable, long-term approach and could balance growth and its impacts

Water Reuse

- Decreasing baseflows in Spring Creek from growth, coupled with increasing wastewater discharge led to increases in water temperature

- Groundwater recharge was ultimate goal, with community, commercial and industrial reuse occurring along pipeline corridor

- Indirect potable reuse and groundwater recharge will enter zones of contribution of community drinking water supplies

Water Reuse

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2015 Status Report

- Operational for nine (9) years
- Initial capacity of reuse = 1.0 MGD (20% of plant)
- Reused over 500 million gallons at customers

Water Reuse

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2015 Status Report

- Customers and uses
  - Hotel (irrigation/laundry/swimming pool)
  - Industrial laundry
  - Car wash
  - Governmental (HVAC)
  - Country club (irrigation/swimming pool)

- First constructed wetland for groundwater recharge under construction

Advanced Wastewater Treatment

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Existing Installation

- Microstraining (500 micron)
- Pressure microfiltration (Evoqua CMF)
- Biofouling control
- Low pressure reverse osmosis (Koch ULP)

Advanced Wastewater Treatment

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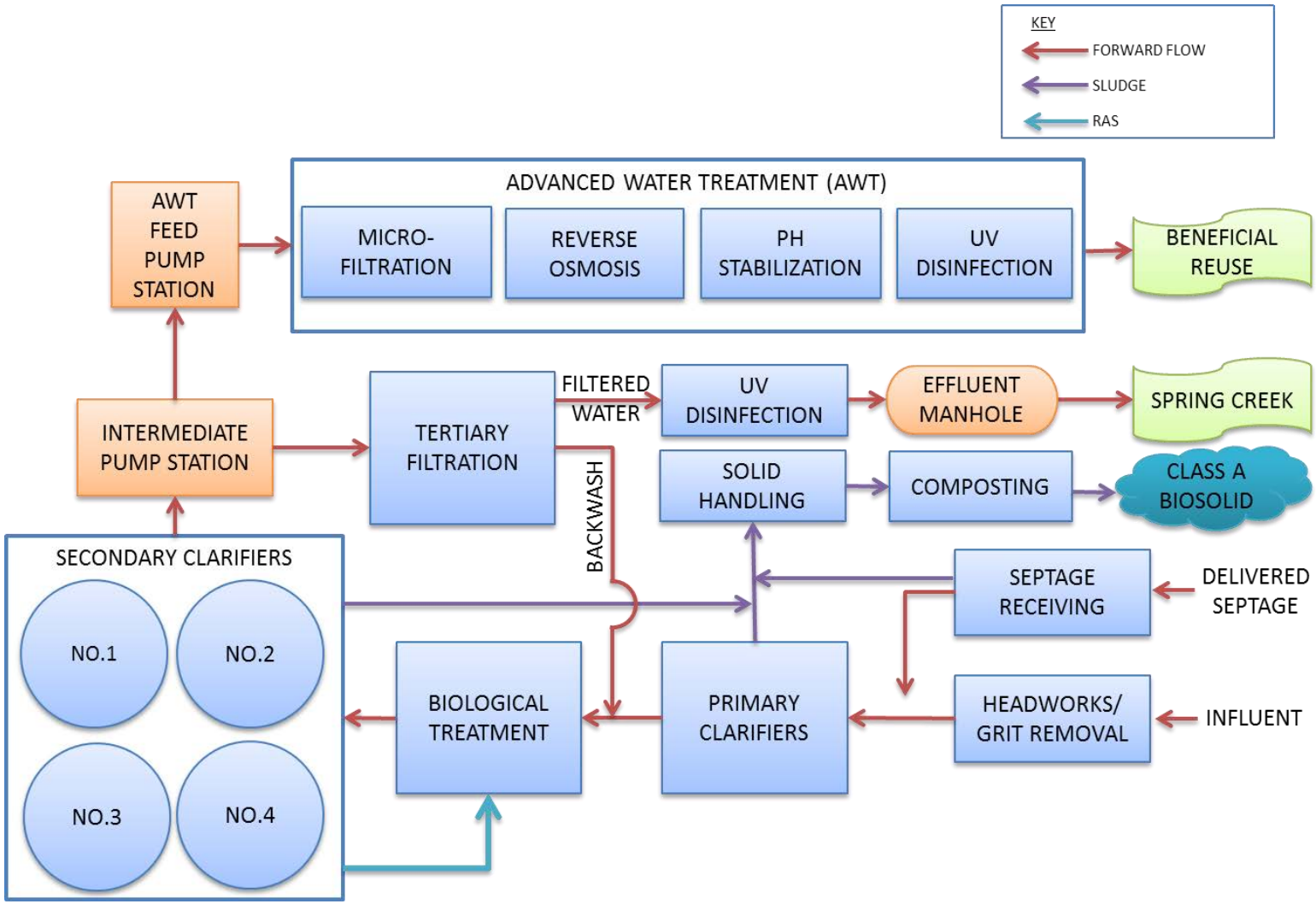
Existing Installation

- UV disinfection
- Mixed oxidant disinfection (sodium hypochlorite)
- Storage
- High service pumping and distribution

Advanced Wastewater Treatment



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Biofouling

- The efficiency of membrane treatment can be diminished by plugging, scaling, and or biofouling
- Plugging occurs when colloidal particles are absorbed into the membrane and physically clog the small openings in the membranes
- Scaling occurs when particles are deposited, usually from precipitation, onto a membrane, also causing it to plug
- Biofouling occurs when microbacteria colonize on membranes. This bacteria then grows into and on the membrane
    - Biofilm (a.k.a. slime) can also result from extracellular secretions by the bacteria. The biofilm can not only plug the membranes but it can also form protective layer over the bacteria so that treatment chemicals do not come into contact with the bacteria

Biofouling

- The prevention of biofouling is difficult and its effectiveness can vary with the feed water quality and membrane construction
  - Potential prevention techniques include killing of the bacteria before it reaches the membrane
  - Removal of the bacteria after it collects on the membrane
- Killing of the bacteria could involve disinfection, use of a biocide, and/or rupturing of the cells

Biofouling

- UAJA provides biofouling control to prevent colonization of the RO membranes with slime forming bacteria that require increasing cleaning frequency

- UAJA utilizes several chemicals for biofouling control on the RO Unit
  - Sodium hypochlorite (200#/d)
  - Sodium bisulfite (+-100#/d)
  - Proprietary biocide (chemtreat)

Biofouling

- While effective, the total costs of these chemicals has increased over the years dramatically

2012 costs for chemicals associated with the RO processes

Chemical	Use	Approximate Costs for Year
Sodium Hydroxide	For pH Adjustment	$34,000.00
Salt	For Sodium Hypochlorite Production	$14,000.00
RO Chemicals	For Clean in Place	$10,000.00
Biological Control	(Chlorination/Dechlorination and Biocide)	$262,000.00

Biofouling

- UAJA provides sodium hypochlorite by on-site generation
- Economics are favorable, but equipment has been problematic and has had a number of failures (1st generation)
- MIOX unit is no longer supported by manufacturer.
- Recent component failures lead to $300,000 equipment replacement or alternative technology

Advanced Oxidation Process

- Advanced Oxidation Processes (AOP)
  - Method of treatment that generate hydroxyl radicals to destroy contaminants
- The hydroxyl radical is 200% more effective in oxidation than sodium hypochlorite
  - Destroy contaminants, including organic compounds, trichloroethylene (TCE), endocrine disrupting compounds (EDCs), N-Nitrosodimethylamine (NDMA), pesticides, and pharmaceuticals
- The AOP process has proven to be an effective method for additional contaminant removal and disinfection to both wastewaters and “clean” water, such as the effluent to an RO system

Advanced Oxidation Process

- AOP often refers to the combination of chemical processes that employ ozone (O3) or hydrogen peroxide (H2O2) with ultraviolet (UV) light to produce highly reactive hydroxyl radicals
- It has been determined that, when applied to secondary effluent, O3 alone can provide AOP treatment
- The ozone reacts with the organic matter in the secondary effluent, resulting in hydroxyl radicals
- This reaction effectively eliminates the need for the additional energy from UV light typically required to produce the hydroxyl radicals

Alternative Evaluation

Evaluation of Technologies

- UAJA and RETTEW evaluated a number of technologies to replace existing biofouling application
  - Status Quo – Replace MIOX and continue chemical application
  - UV Disinfection
  - Ozone Disinfection
  - UV + Hydrogen Peroxide

Alternative Evaluation

Evaluation of Technologies

- Project team consulted with existing RO installations and equipment vendors for latest technologies and implementations for pre-RO biofouling control

Alternative Evaluation

Benchscale Testing

- Based on similar projects and applications, benchscale testing was completed on UAJA's Microfiltration Effluent
- Utilize Heterotrophic Plate Count as Indicator of Biofouling Control

Alternative Evaluation

Benchscale Testing

- Benchscale Testing
  - UV disinfection (WEDECO)
  - Ozone disinfection (WEDECO)
  - Ozone disinfection (Ozonia)
  - Chlorine dioxide (GE W&PT)
- Traditional hydrogen peroxide + UV not interested in pre-RO application

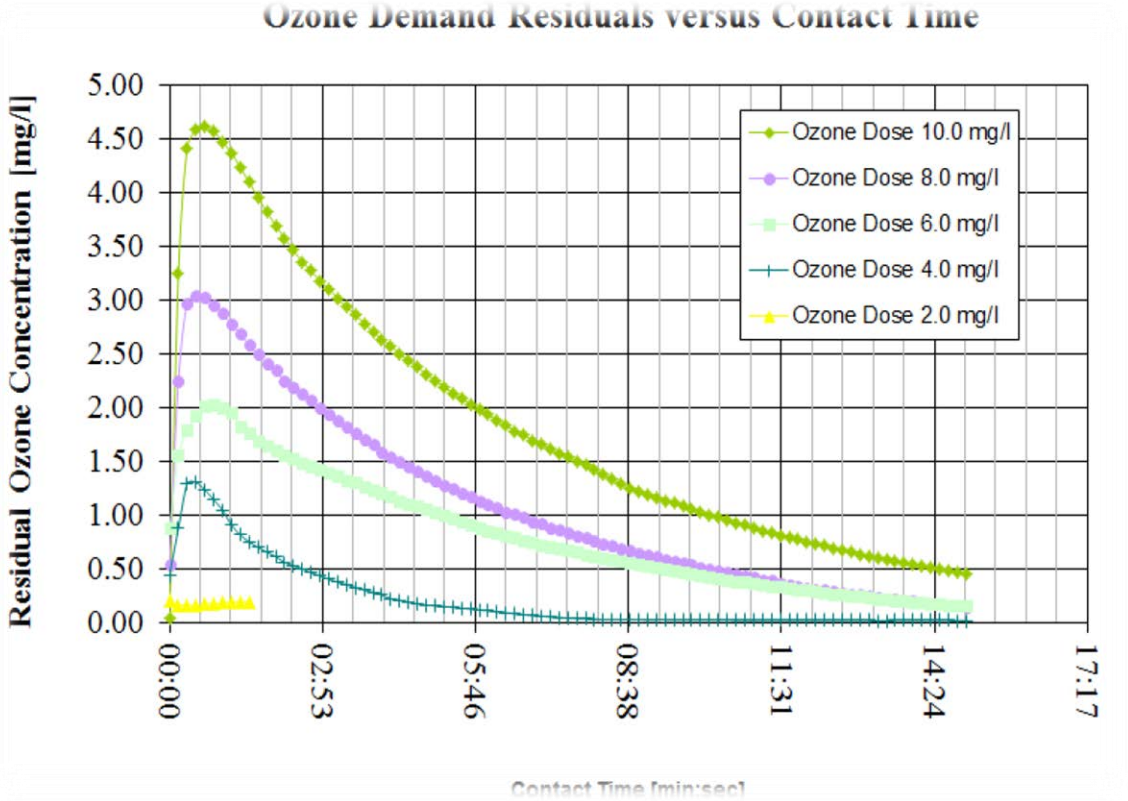
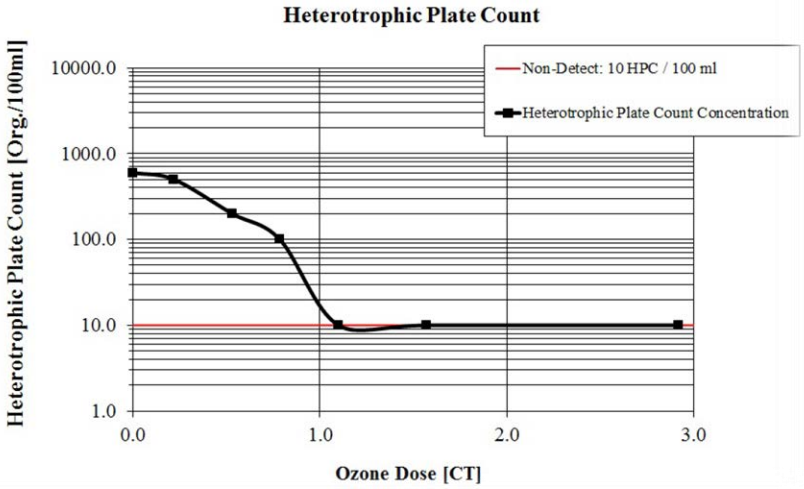


Figure 4: Ozone Testing Results



Alternative Evaluation

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Benchscale Results

- UV, ozone and chlorine dioxide performed equivalent to UAJA existing biofouling controls and could reduce HPC to non-detect
- Ozone could provide added benefit of Advanced Oxidation Process (AOP) disinfection per EPA water reuse guidelines

Alternative Evaluation

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Benchscale Results

- PA doesn't require AOP for indirect potable reuse, but national trends indicated it could be practical requirement in future
- Economics for all alternatives were compelling over existing practices

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SUMMATION OF ALTERNATIVES

Parameter	Baseline Conditions	UV (Xylem)	Ozone (Xylem)	Ozone (Ozonia)	Chlorine Dioxide (GE)
Equipment Capital Cost	$275,000	$105,000	$405,000	$520,00	$143,000
Installation Cost	$55,000	$124,000	$162,000	$162,000	$8,200
Total Capital Cost	$330,000	$229,000	$567,000	$682,000	$152,000
Sodium Hydroxide (pH) Annual Cost	$34,000	$34,000	$34,000	$34,000	$34,000
Salt (Dis) Annual Cost	$14,000	-	-	-	-
RO CIP Annual Cost	$10,000	$10,000	$10,000	$10,000	$10,000
Biological Control Annual Cost	$262,000	$10,000	$10,000	$10,000	$10,000
Electricity Annual Cost	$19,000	$4,800	$7,800	$8,000	$4,000
Other Consumables Annual Cost	-	-	$10,500	$24,000	$6,000
Maintenance Annual Cost	$9,100	$3,000	$8,500	$8,500	$29,000
Total Annual Cost	$348,100	$61,800	$80,800	$94,500	$93,000
Total 20-yr Cost	$7,292,000	$1,465,000	$2,183,000	$2,572,000	$2,012,000
Savings over Baseline (Total)	-	$5,827,000	$5,109,000	$4,720,000	$5,280,000
Savings over Baseline (Annualized)	-	$291,350	$255,450	$236,000	$264,000

AWT Ozone Installation

Design Parameters

- LOX feed for ozone generation
- WEDECO selected as installed system based on track record and economics
  - Mass transfer efficiency — Min 95%
  - Maximum influent HPC — 5000 cfu/100 ml
  - Capacity — 42 lbs/d @ 9% (wt)
  - Design dose — 4 mg/l
  - Design CT — 1.8 mg*min/ml

AWT Ozone Installation

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Current Status

- Design completed, public bidding completed
- Economics (capital cost) slightly better than projections (-15%)
- Start-up in April 2015

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Questions

Thank you for your attention and interest. For more information:

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