Everett DAF Conceptual Design

Reasons for Pilot Testing

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Sam Hartley
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Lowell Lorenz
WTP Superintendent

Discussion Topics

- Clarification and DAF Background
  - Water quality criteria
  - Variations in process design
  - Brief project examples
- Everett Water Filtration Plant & Zooplankton
  - Issues analysis
  - Preliminary design assessment
  - Results and Conclusions
- Everett's Next Steps

Clarification Background

- Primary Solid/Liquid Separation at WTP
- Primary Functions
  - Reduce filter solids loading
  - Improve filter performance, net production
  - Produce solids for disposal or processing
- Function of Density (Water @ 1 g/cc)
  - Minerals: 2-3 g/cc (low detention time needed)
  - Organics: ≤1.1 g/cc (increased detention time)

Dissolved Air Flotation: Need?

- Algae/Organics: Not WTP Operator’s Friend
  - – Algaltoxins (from oxidation, cell lysis)
  - – Off-tastes, malodors, color
  - – Filter clogging organisms (particles & organics)
- Algae/Organics Removal
  - – Reservoir treatment difficulty & cost
    - ***Environmental issues, copper use***
    - ***Organics and color may remain after treatment***

Dissolved Air Flotation: Theory

- DAF
  - Solid/liquid separation
  - Gas supersaturation
  - Bubble size from 20 - 100 µm
  - Floats material to water surface
- Key Performance Criteria
  - Attraction between floc and dissolved gas
    - ***Electrostatic attraction***
    - ***Entrapment within gas bubbles***
    - ***Minimize detatchment***
  - Minimize turbulence
  - Gentle, slow rise rate (1 cm/sec)

View of DAF surface showing a "milky" bubble cloud

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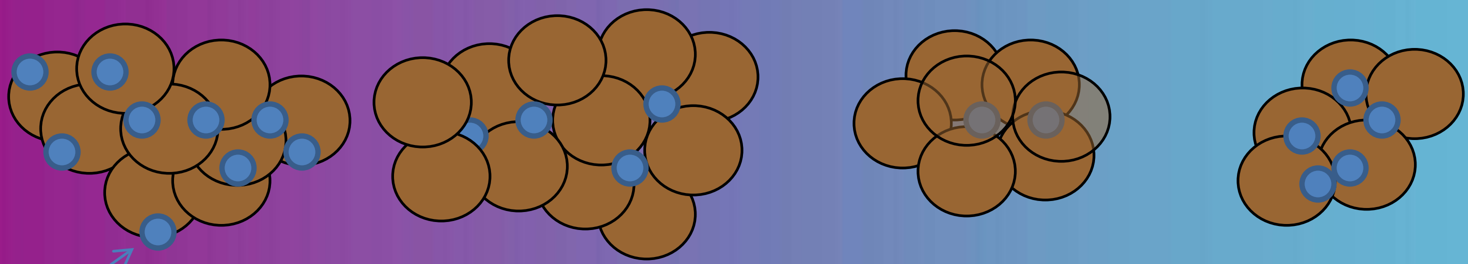
Dissolved Air Flotation: Application

- Water Quality
  - Presence of seasonal or persistent algae & organics
  - Likely greater than 95% removal
  - Toxin release minimized
  - Low to Moderate Turbidity (<100 NTU)
  - High Color
- Process Efficiency
  - Excellent removal of Natural Organic Matter
  - Excellent color removal
  - Excellent algae removal (typically >95%)
- Designs
  - Retrofit of poorly performing sedimentation basins
  - Add-on

DAF Design

Bubbles Attach To Floc

Bubbles Absorbed Into the Floc



Bubbles Adhere

Bubbles Trapped as Floc Forms

Bubbles Form on Floc and grow in size

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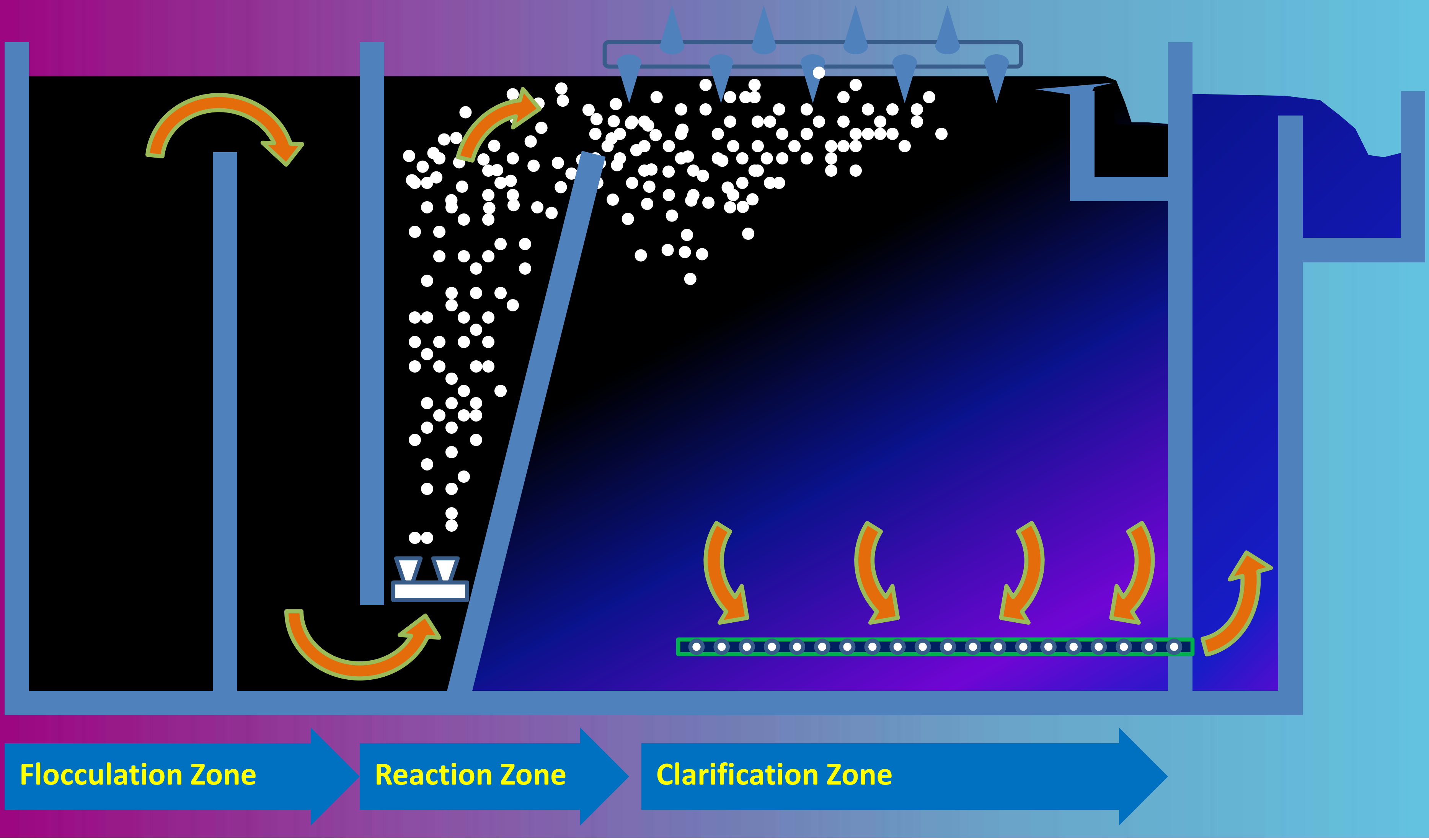
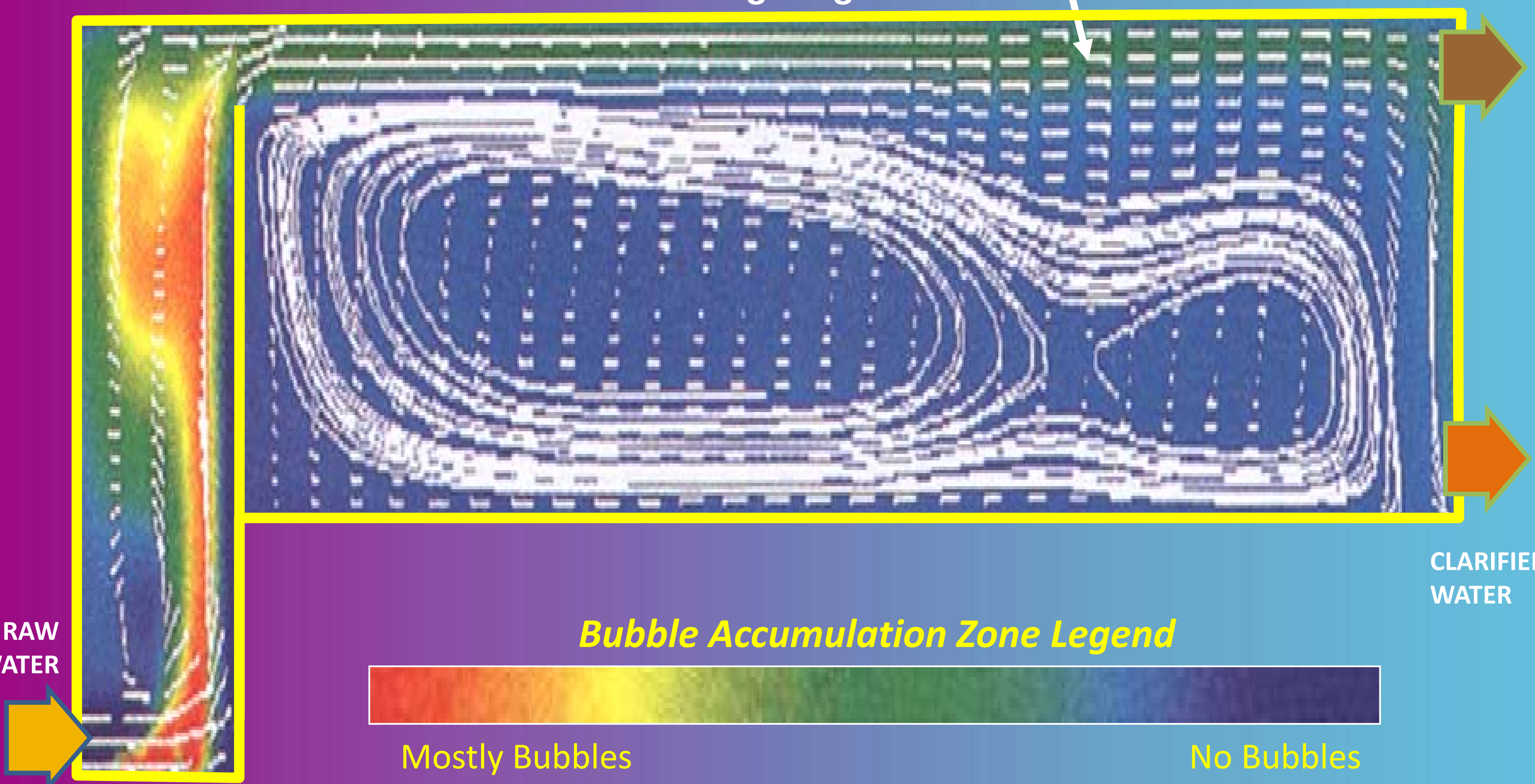
DAF Design

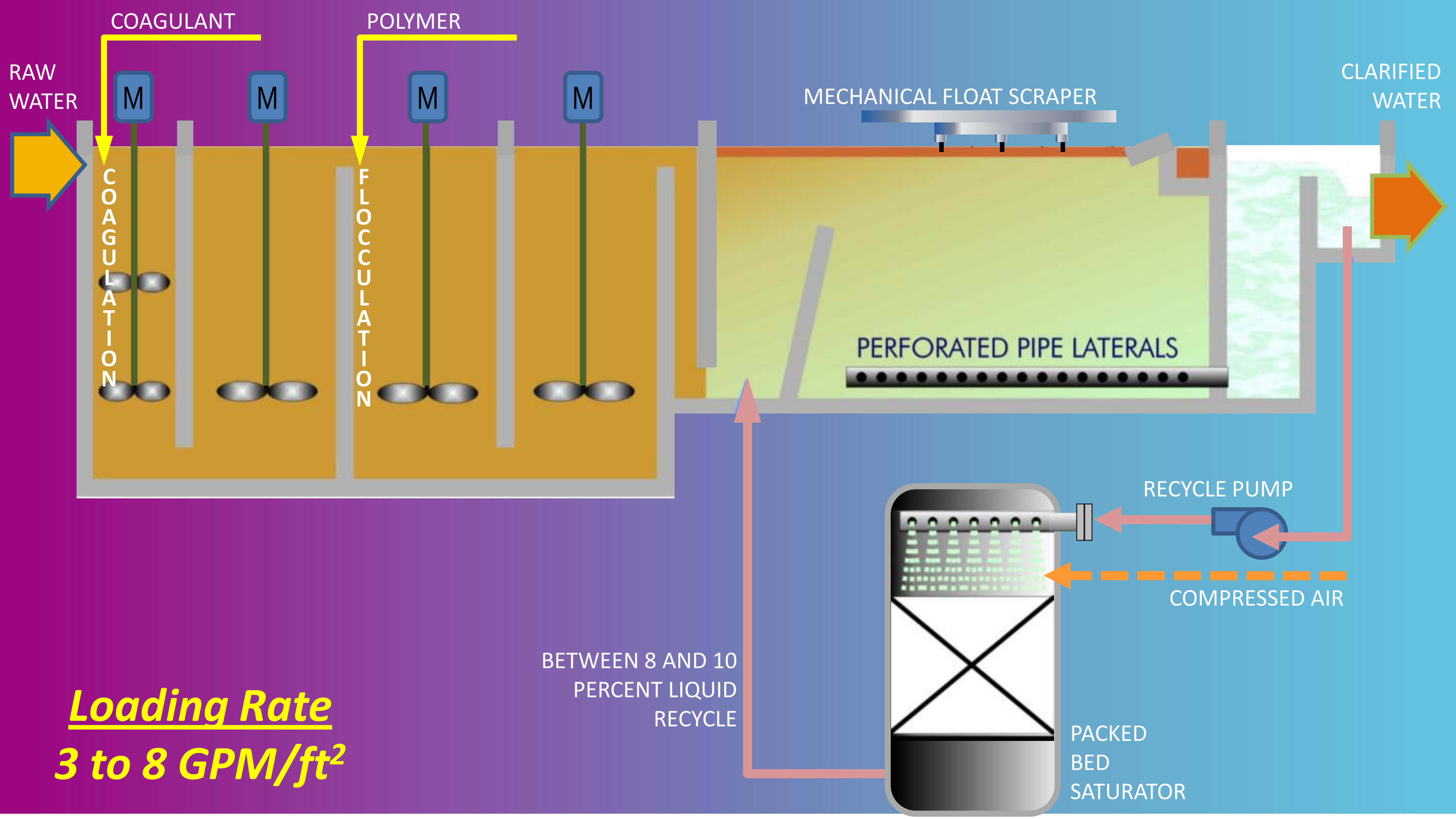


DAF Design



Bubble cloud thins out along length of basin
THICKENED SOLIDS REMOVED
CLARIFIED WATER
RAW WATER
Bubble Accumulation Zone Legend
Mostly Bubbles
No Bubbles

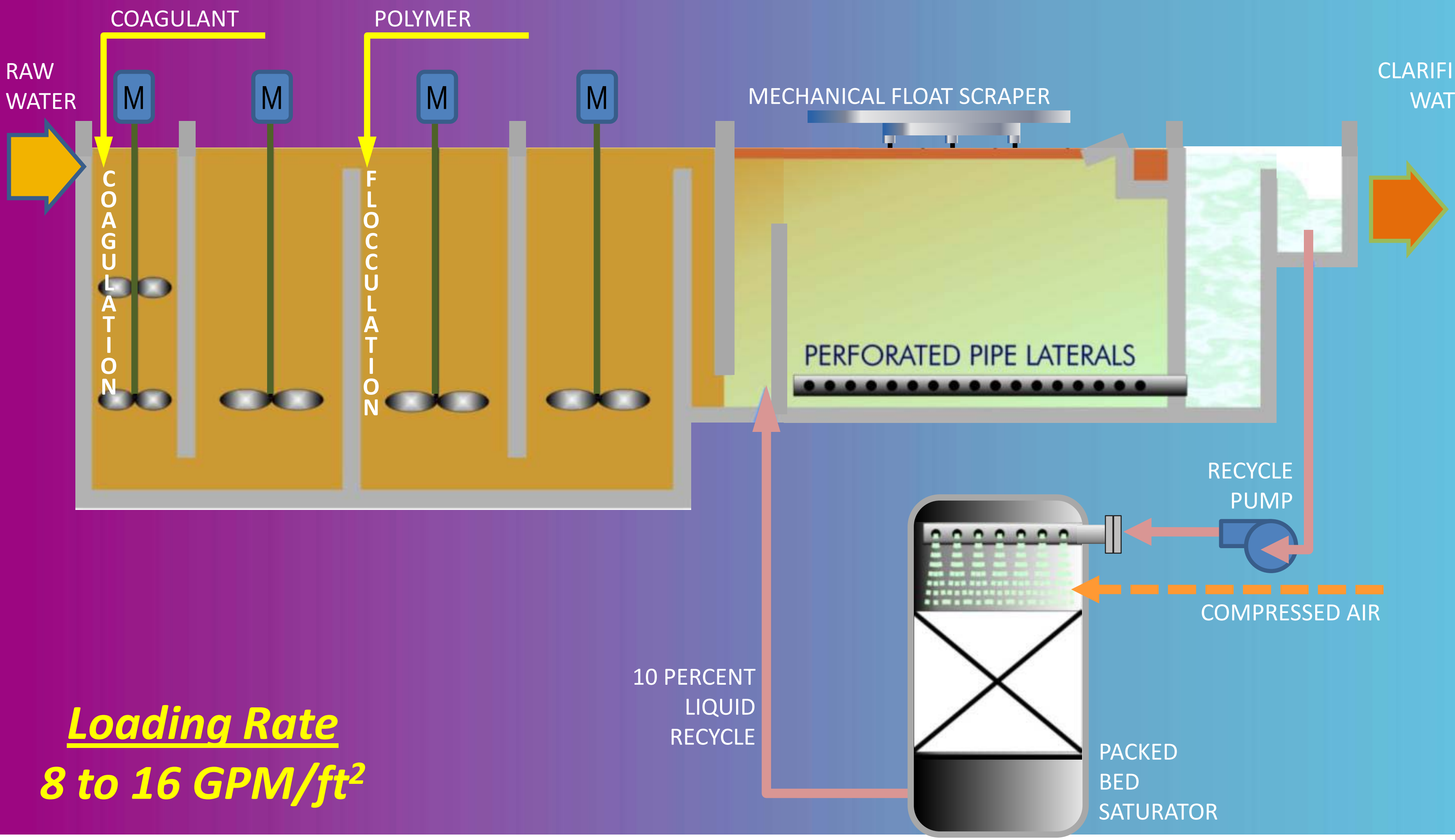
DAF Design: Standard



Loading Rate

3 to 8 GPM/ft²

DAF Design: High Rate



Loading Rate

8 to 16 GPM/ft²

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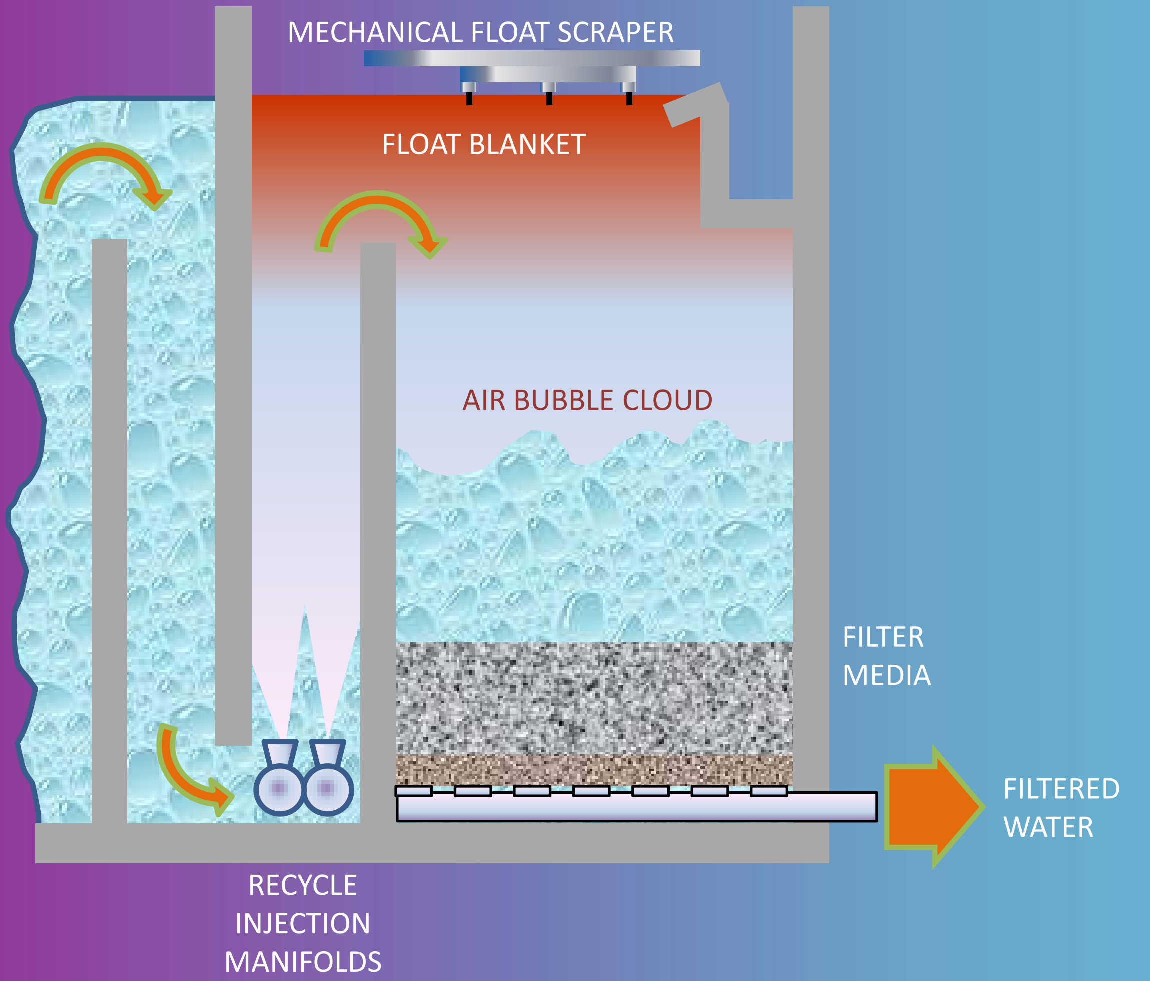
DAF Design: In-Filter



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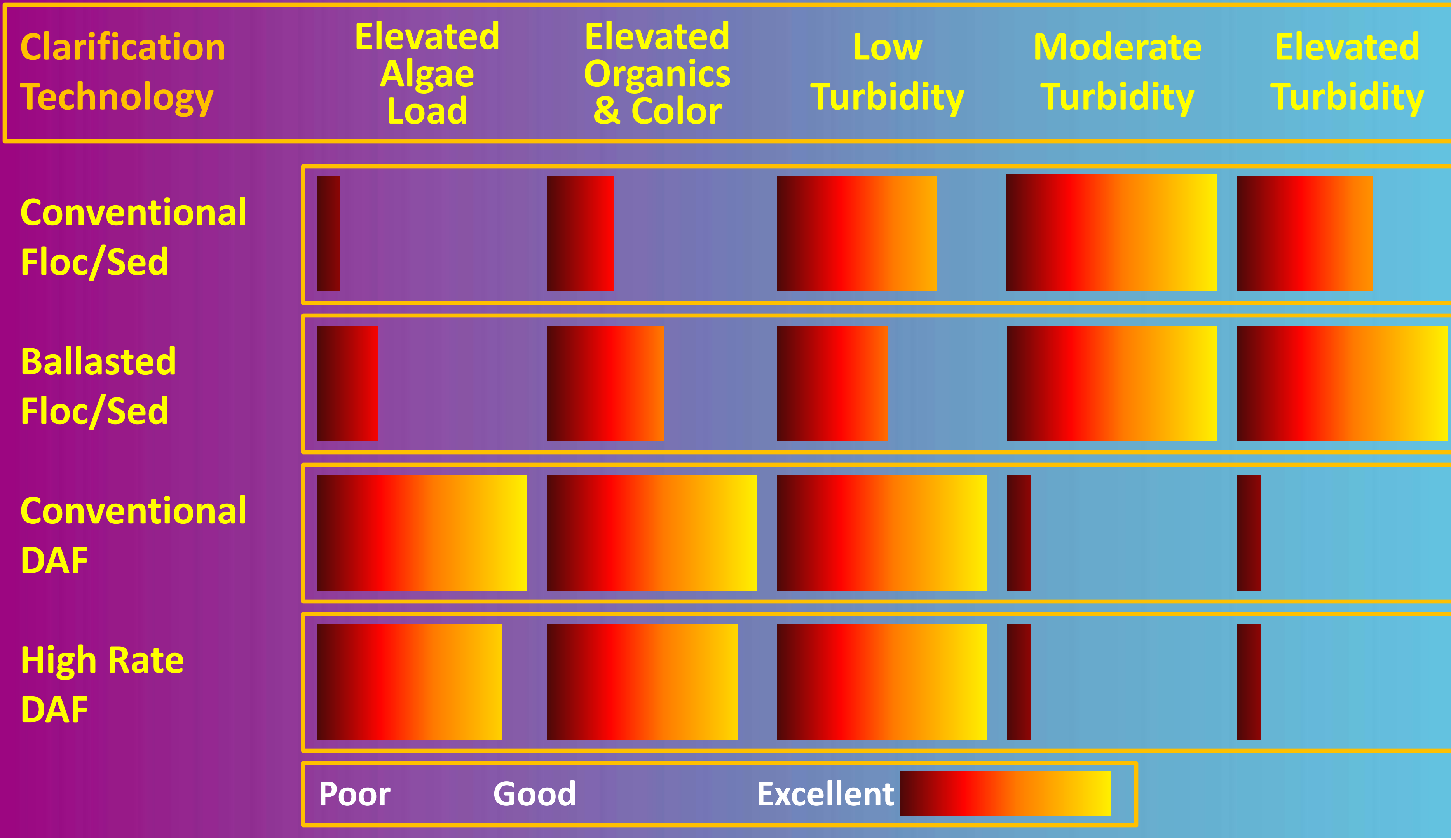
Clarification Technology Selection



Selected DAF Projects

WTP Flow (MGD)	Facility	AECOM Involvement	Project Information
290 MGD	NYDEP, NY, NY	D, CM	In-filter DAF
130 MGD	Tianjin, China	D, CM	DAF, ozone, biofiltration
100 MGD	Winnipeg, MT, CAN	P, D, CM	10^6 cells/mL, 3 yr pilot DAF, ozone, biofiltration
75 MGD	Greenville, SC	D	Conventional DAF
40 MGD	Zone 7 Water, CA	D	Northern California
30 MGD	Penticton, BC, CAN	P, D, CM	High Rate DAF, 60% TOC rem. 60% increase in filter loading

P: Piloting, D: Design, CM: Construction management

Discussion Topics

- Everett Water Filtration Plant & Zooplankton
  - Issues analysis
  - Preliminary design assessment
  - Results and Conclusions
- Everett's Next Steps

Everett: Background & Issues

- Everett WFP
  - Alum and Cat-T Poly
  - Three-stage flocculation

Everett: Background & Issues

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  - Monomedia filtration (52” anthracite, air scour)

Everett: Background & Issues

- Everett WFP
  - Alum and Cat-T Poly
  - Three-stage flocculation
  - Monomedia filtration (52” anthracite, air scour)
  - 120 MGD, 8 filters, 8 GPM/ft^2

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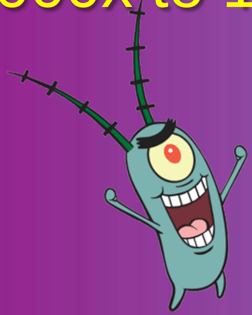
Everett: Background & Issues

- Everett WFP
- Water Quality Issues
  - Lake Chaplain
  - Spring and Fall 'Event'
  - 'Event' = Algae & zooplankton 'bloom'
  - 'Bloom' = Filter operations impairment

Everett: Background & Issues

- Everett WFP
- Water Quality Issues
- Who Is To Blame?
  - Algae: 3,000/mL, 0.0005mm
  - Zooplankton: 8,000/m^3, 0.5-2.0mm (1,000x to 10,000x larger!)



Planktonus Maniachalus

Everett: Background & Issues

- Everett WFP
- Water Quality Issues
- Who Is To Blame?
- Operations Challenges
  - Increase filters from 8 to 10 GPM/ft^2?
  - Solve filter impairment issues?
  - Can these issues be fully characterized?

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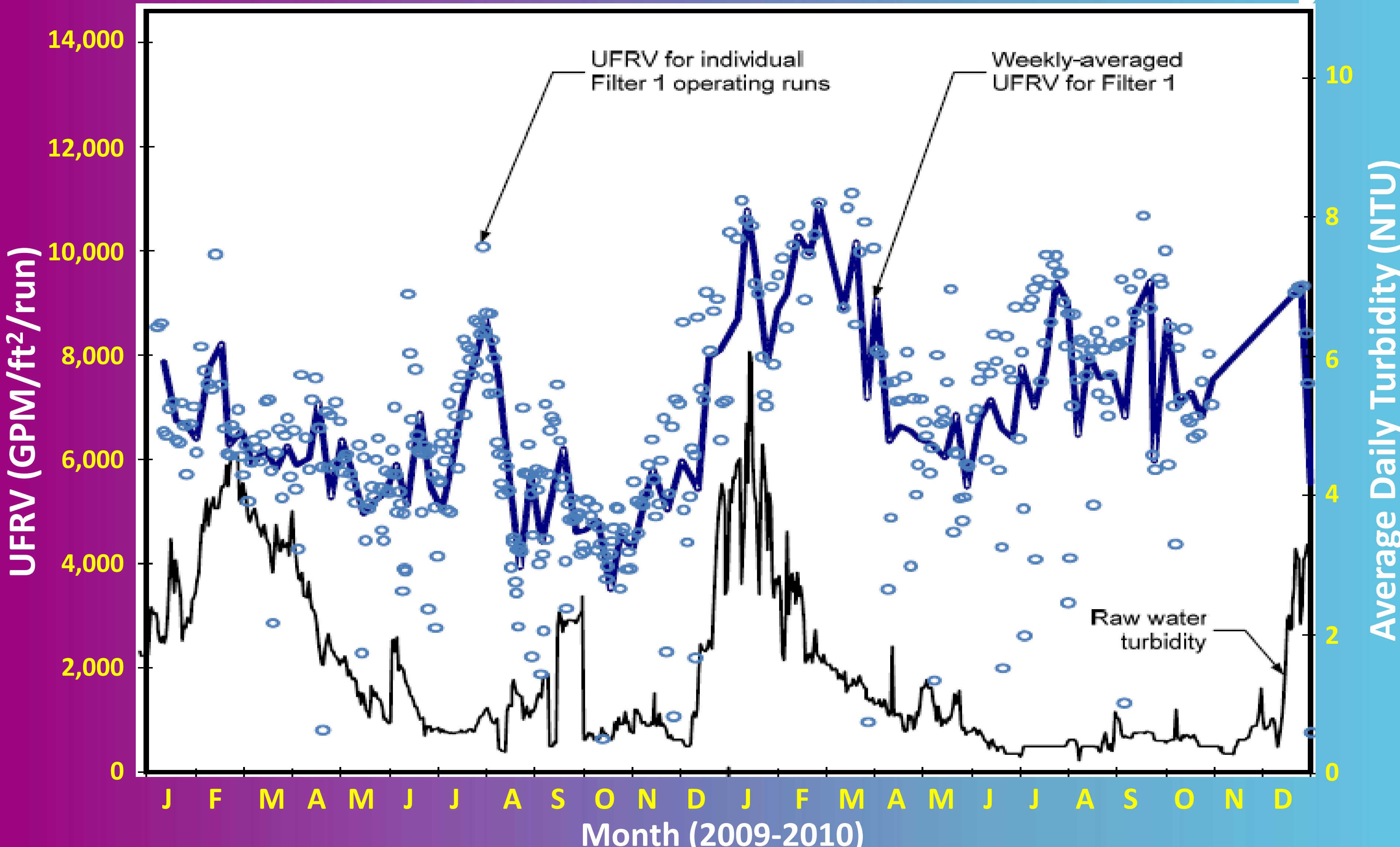
Filter Performance and Raw Turbidity



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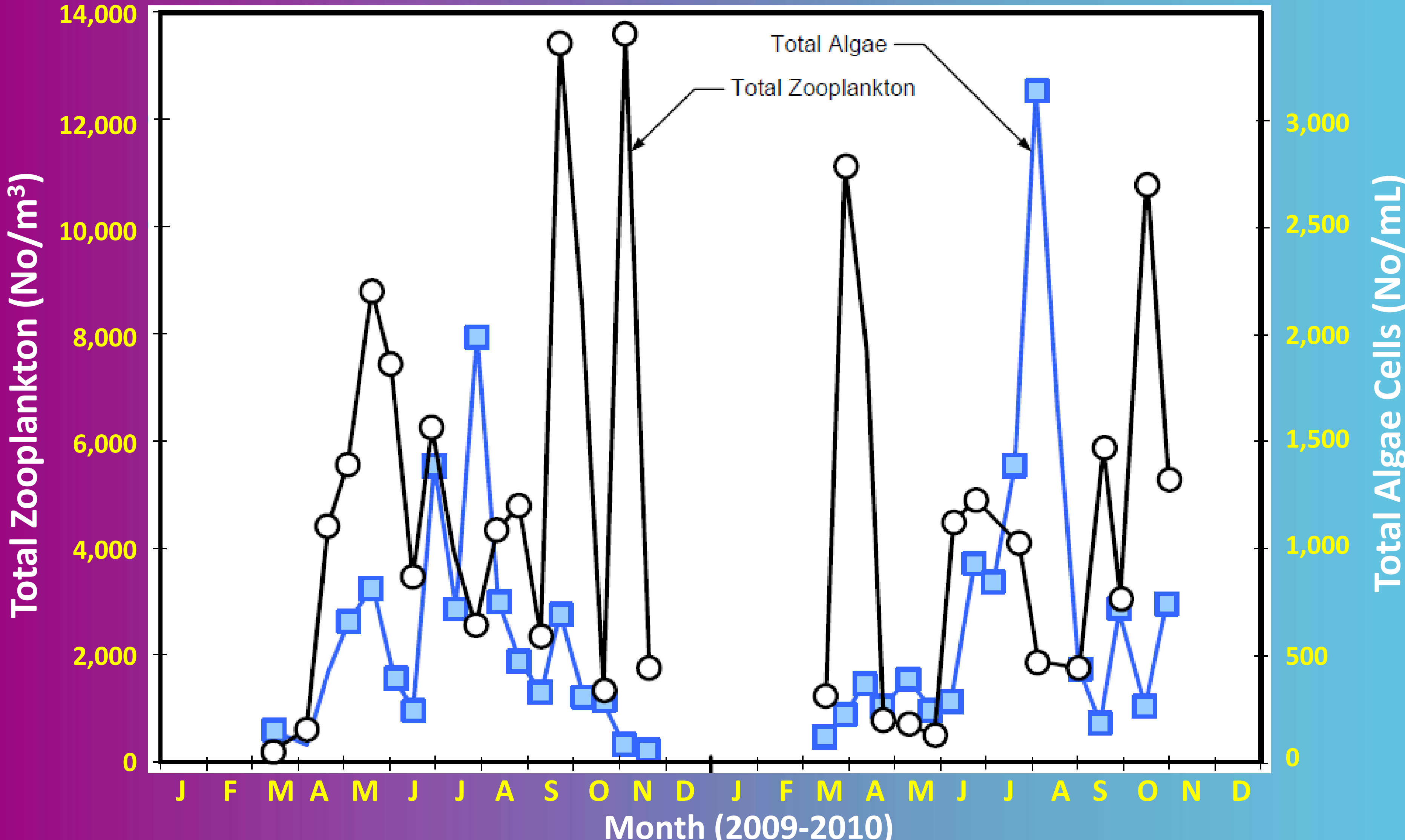
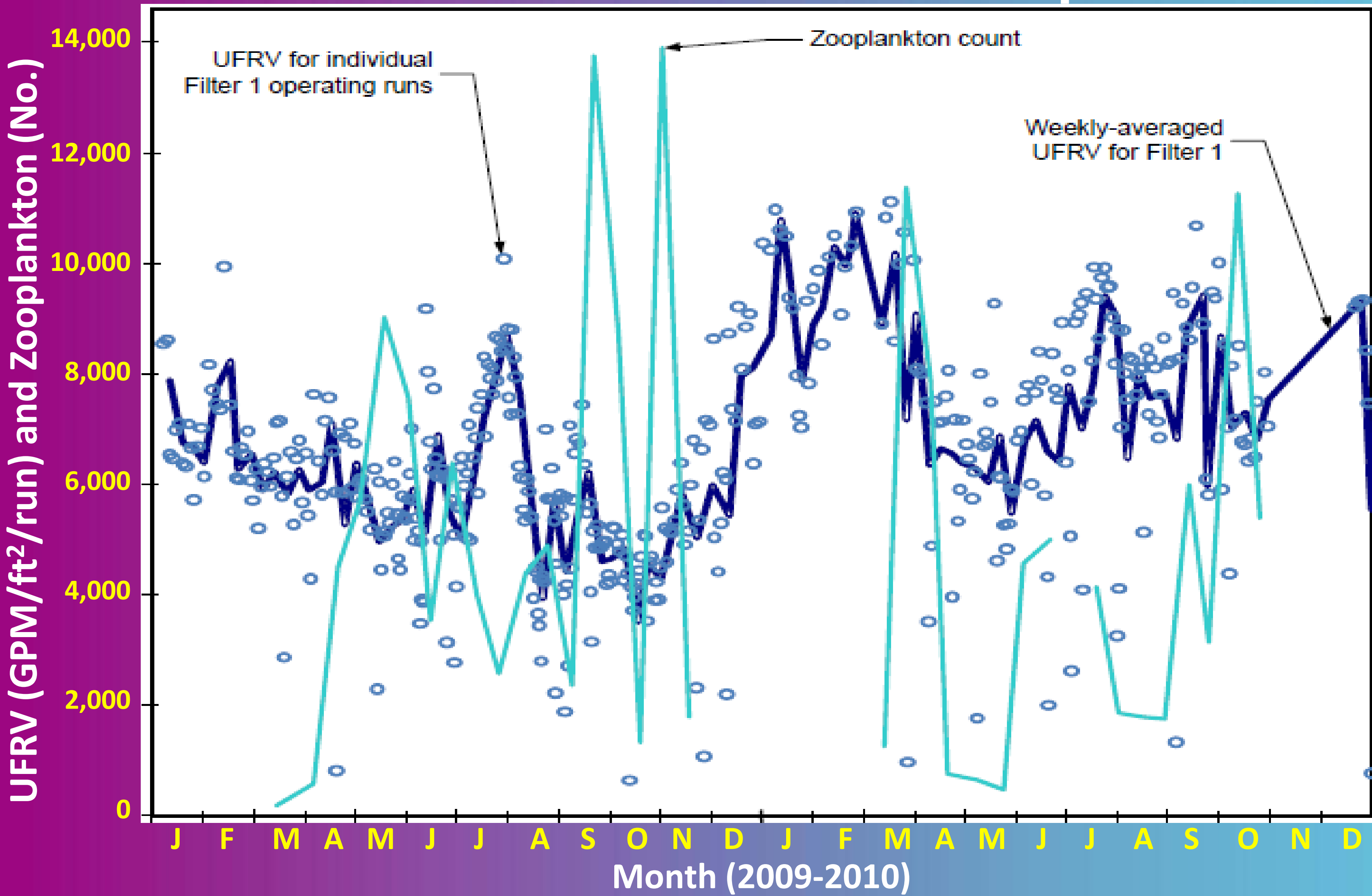
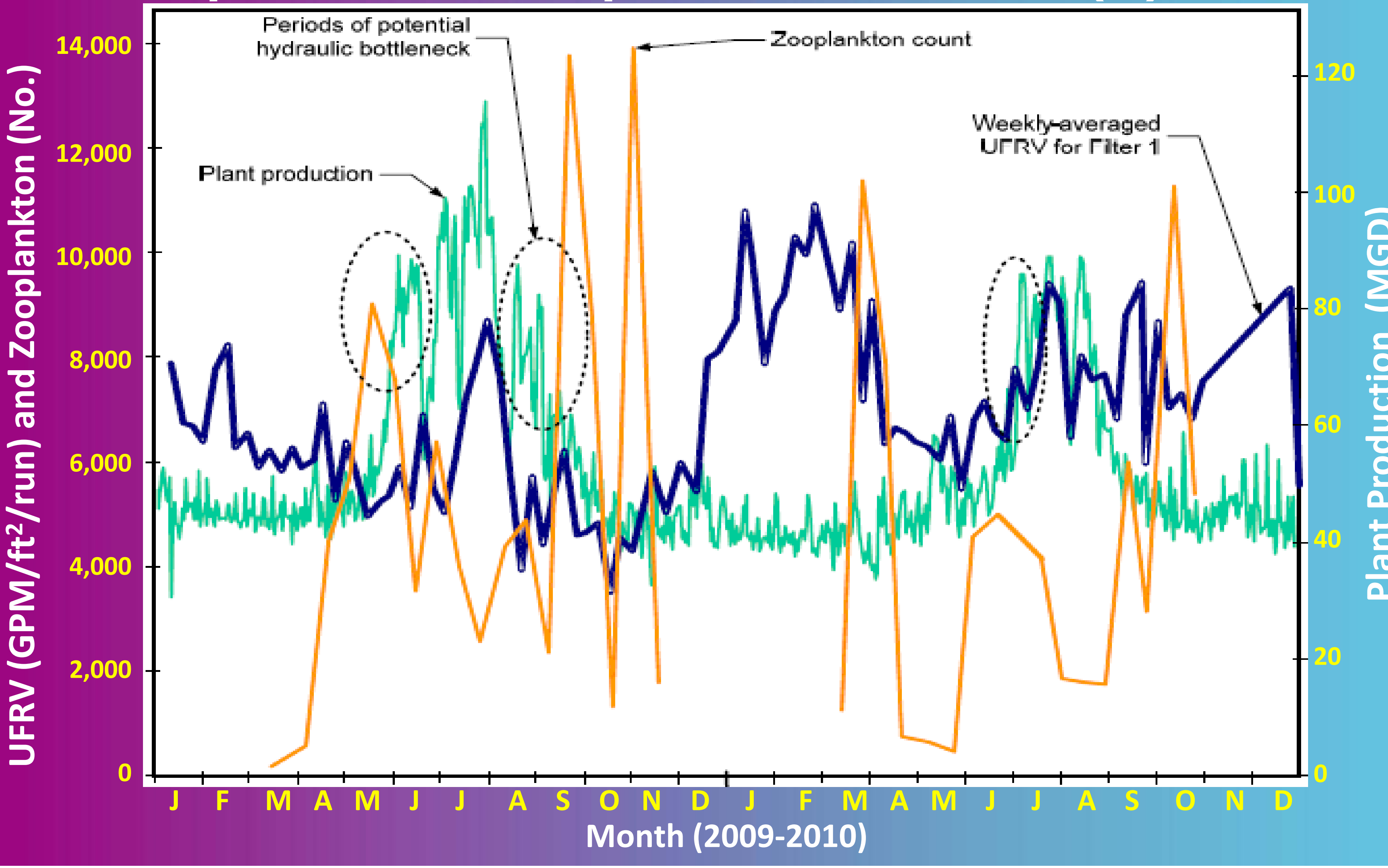
Raw Water Algae & Zooplankton



Filter Performance and Zooplankton

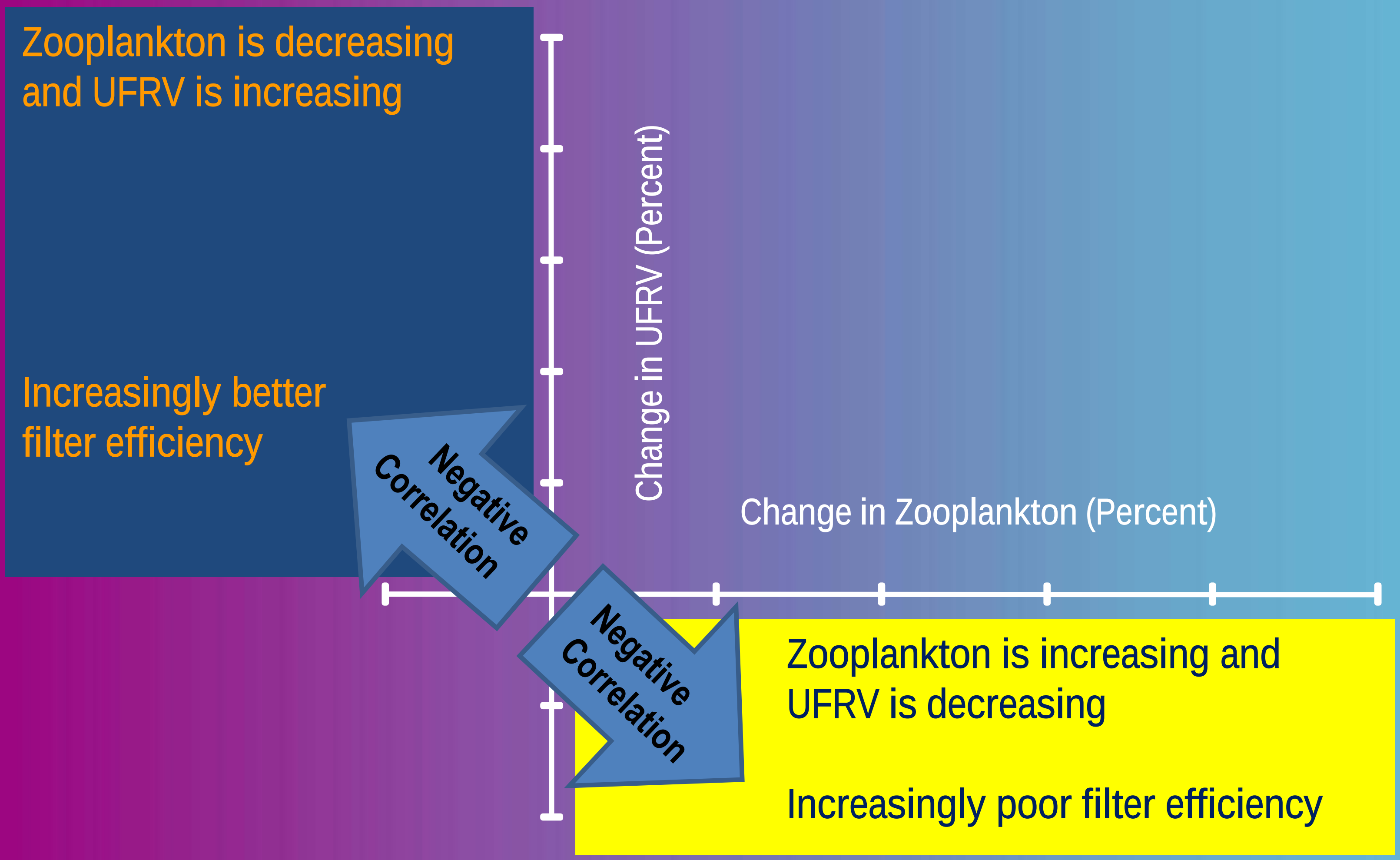


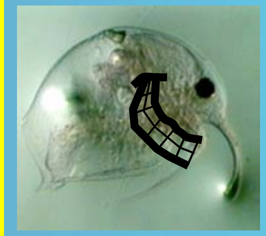
Zooplankton Impact on UFRV (?)



Zooplankton Impact on UFRV

Data represent calculated percent relative monthly change





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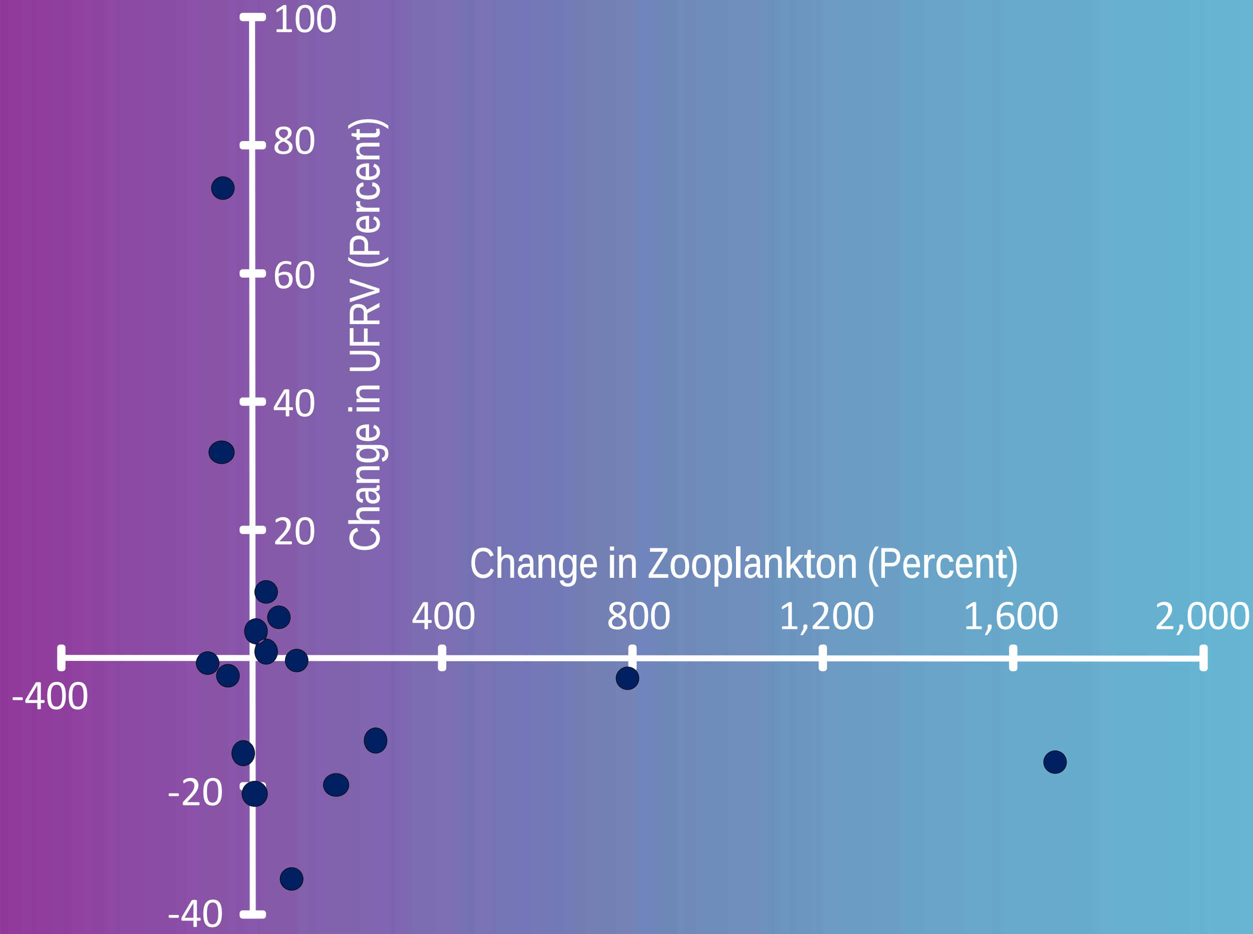

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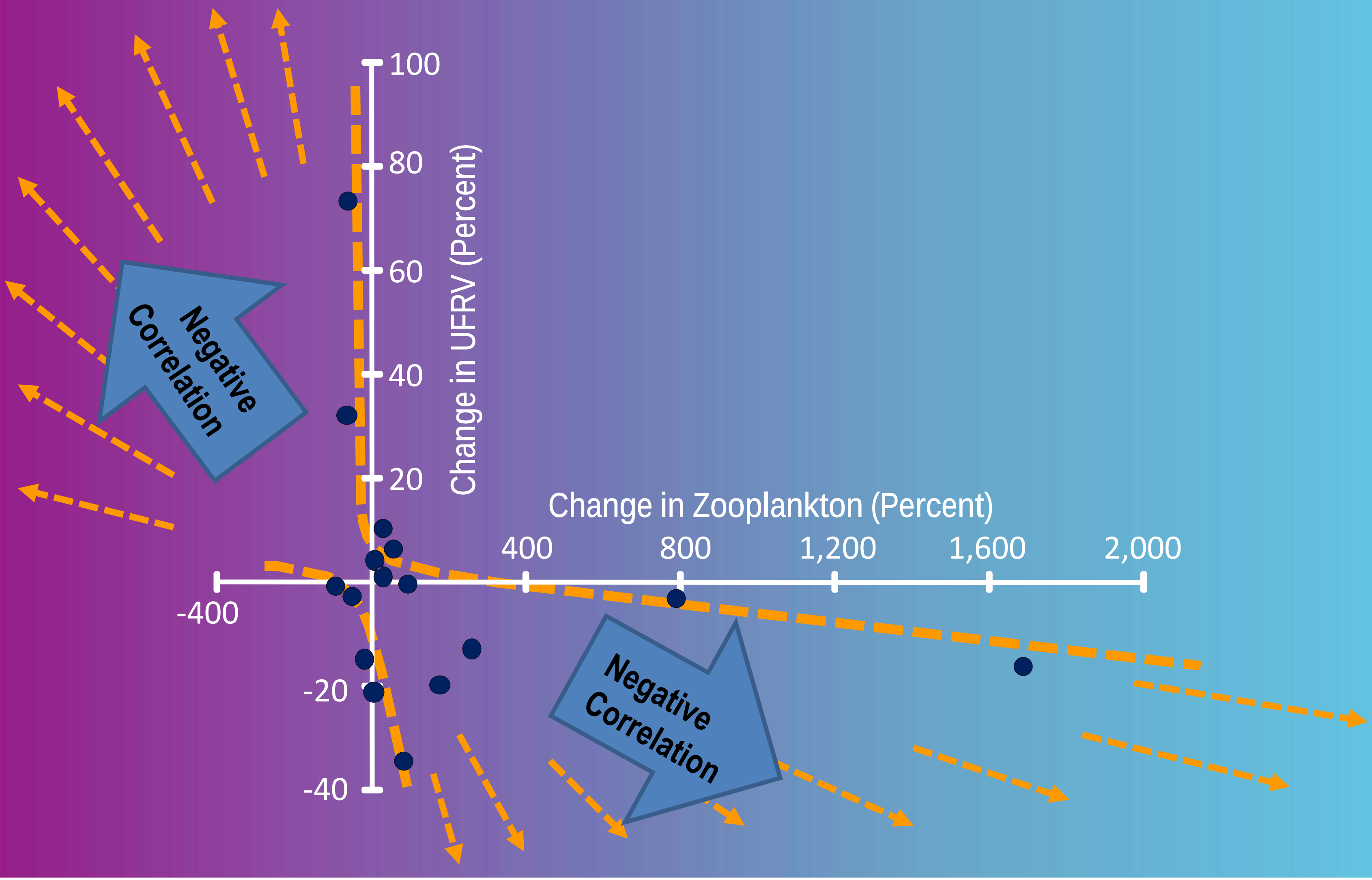

Everett WFP: Results/Conclusions

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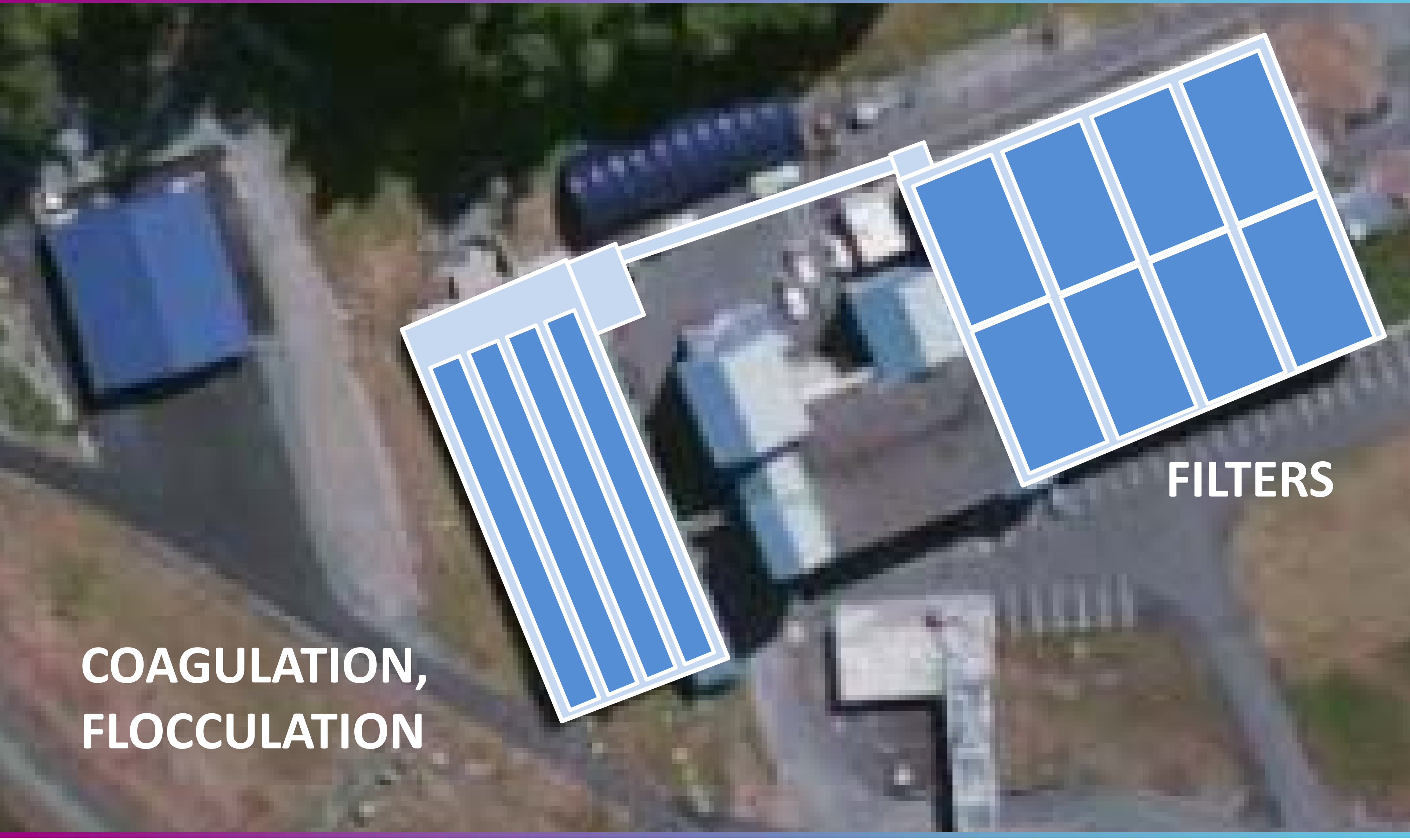
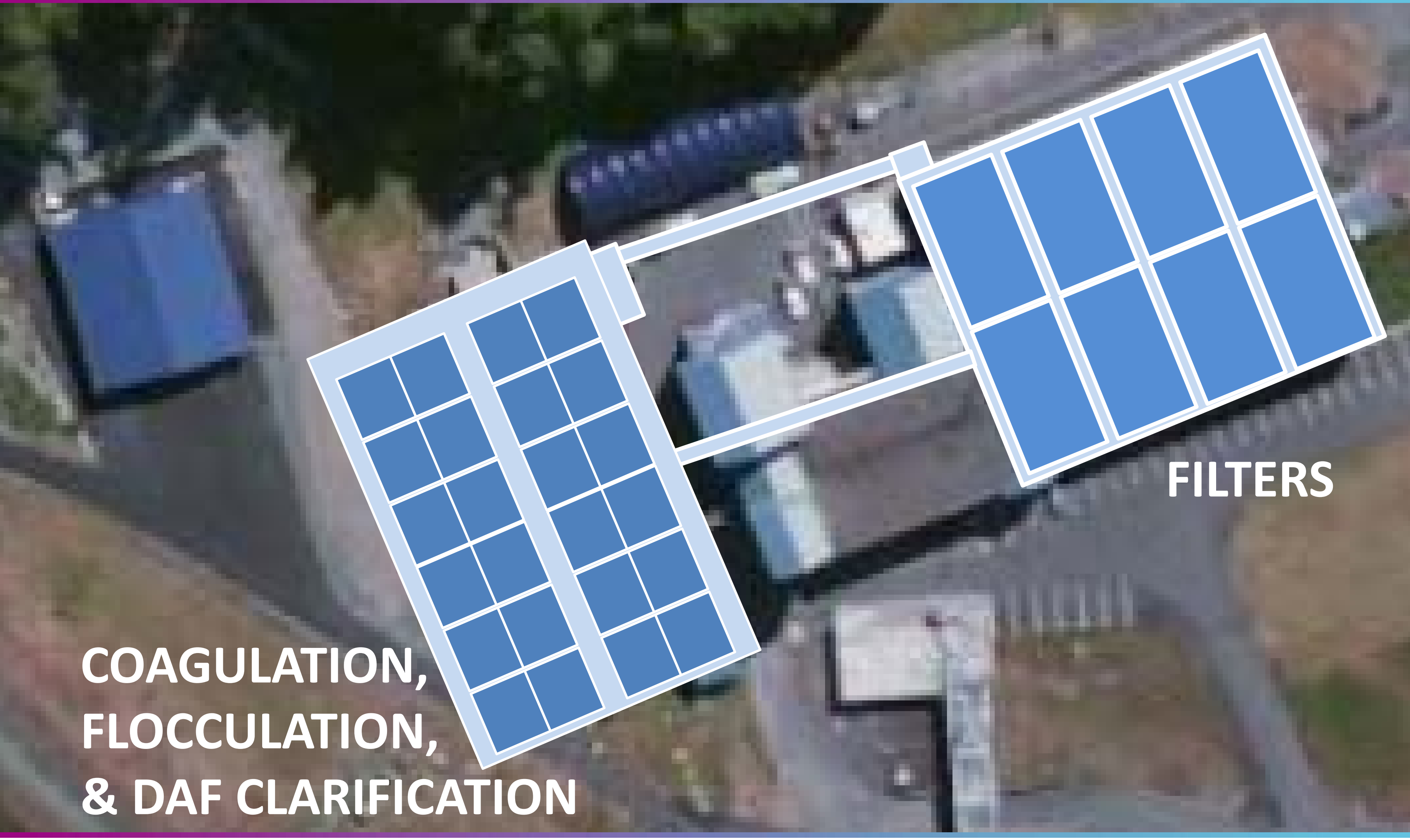


Everett WFP: Results/Conclusions

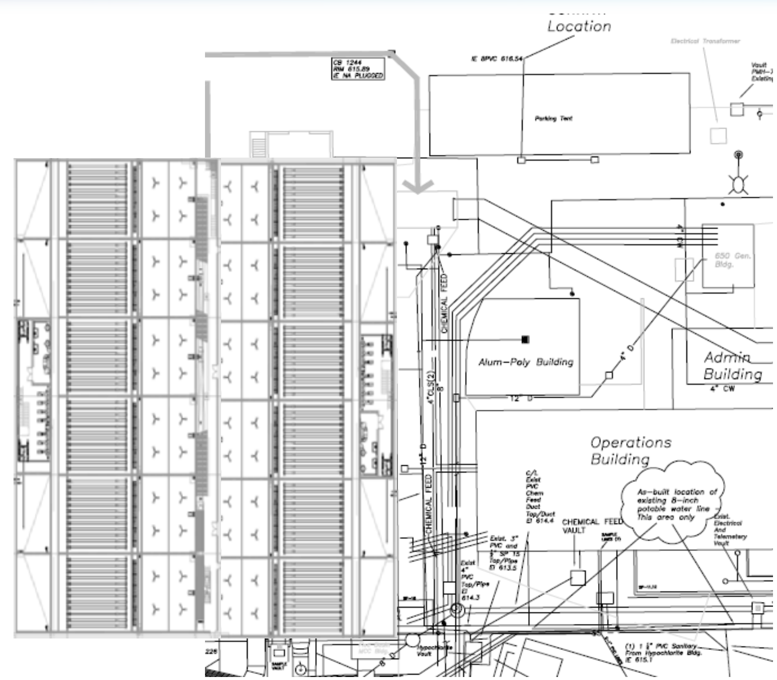


Discussion Topics

- Everett's Next Steps

Everett: Next Steps

- High Rate DAF Pilot Testing
  - Footprint minimization
  - Zooplankton removal
- Filter Piloting Optimization
  - 10 GPM/ft^2
  - Sustained UFRVs
- Overall Solids Handling Improvements
  - Characterize solids production
  - End use of pond
  - Centrifuge, solids press



Thank You

CH2MHILL

CITY OF BELLINGHAM WASHINGTON

Floating Your Algae Problems Away with High-Rate DAF

PNWS IDAHO · OREGON · WASHINGTON

GO WITH THE FLOW 2012 PNWS · YAKIMA, WA

Bob Bandarra, City of Bellingham

Joe Nattress, CH2M HILL

Acknowledgements

- City of Bellingham
  - Bill Evans
  - Martin Kjelstad
  - Peg Wendling
- Roberts Filter/Enpure
  - Don Mackay
  - Tony Amato
  - Mark Battaglia
- CH2M HILL
  - Phil Martinez
  - Lee Odell
  - Miao Miao Zhang
- Western Washington Univ.
  - Dr. Robin Matthews

Presentation Outline

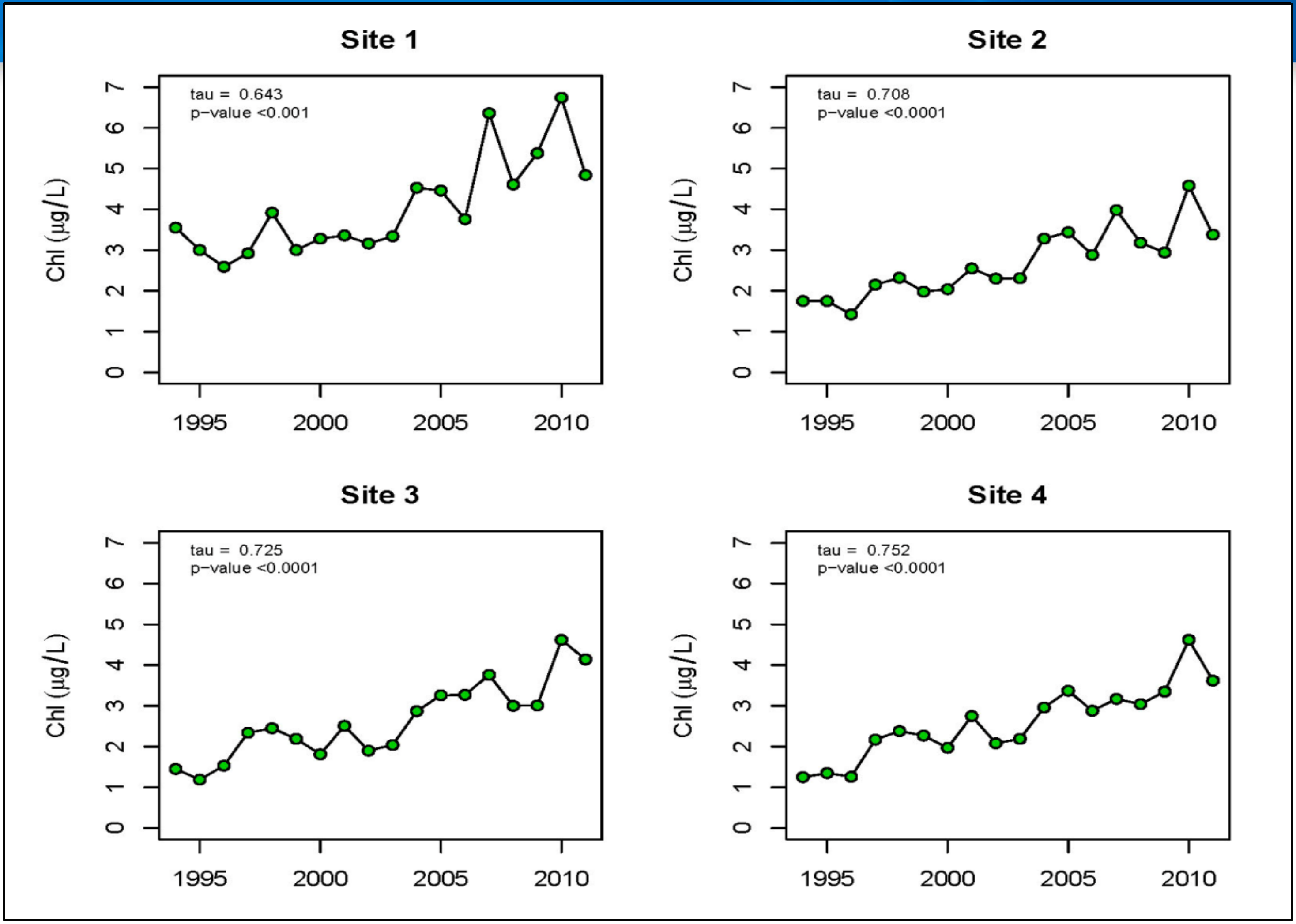
- Why is additional treatment needed?
- What is Dissolved Air Flotation (DAF) and how does it work?
- Pilot Testing Conditions
- Testing Results
- Conclusions

Why is additional treatment needed in Bellingham?

Whatcom Falls WTP

- 24 MGD in-line filtration plant
  - Rapid mix followed by 6 dual media filters
  - Free chlorine disinfection
- Raw water source- Lake Whatcom
  - Natural Lake - 6.5 BGal capacity
  - Headwaters at Mt. Baker
  - Sometimes supplemented during summer
    - Middle Fork of Nooksack River
  - Lake is divided into three basins
  - Intake is in Basin 2

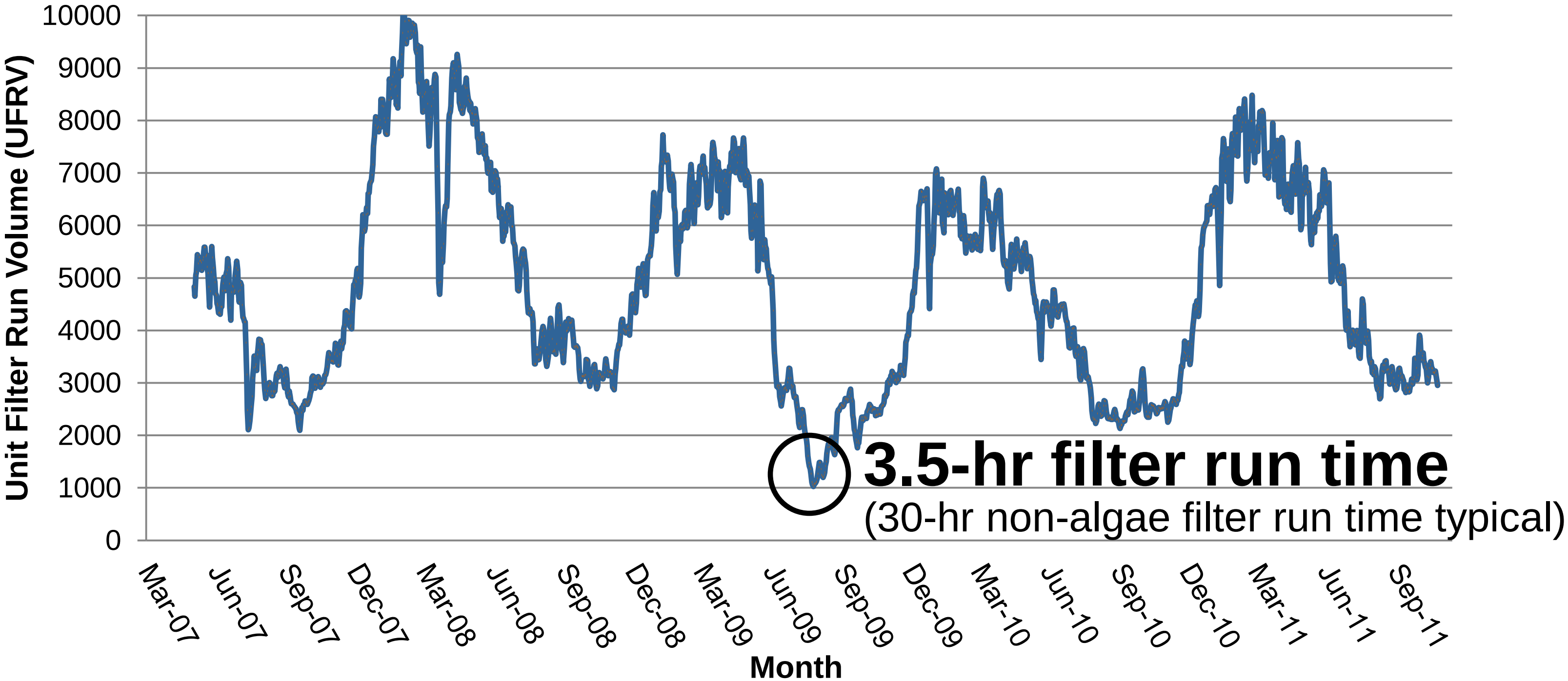
Algae Levels Are Increasing



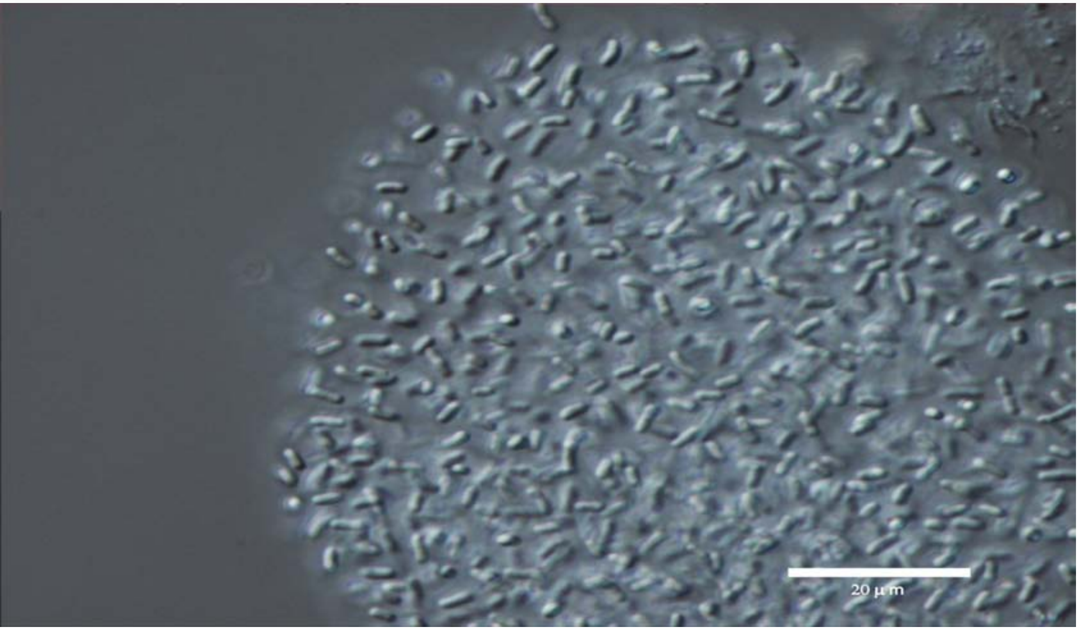
Lake Whatcom Monitoring Project 2010/2011 Report
Dr. Robin A. Matthews, February 24, 2012

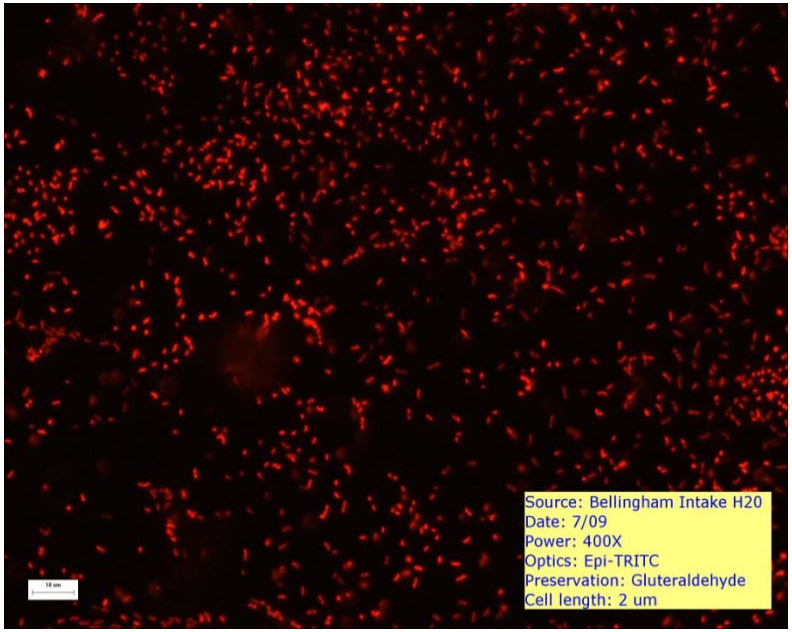
2009 Summer Algae Impacts

- Elevated blue-green algae
- Reduced filter capacity at Lake Whatcom WTP
- Mandatory water restrictions



Gazillion Aphanothece (Filter Cloggers)





What are the options available to mitigate algae?

- Do nothing – and keep our fingers crossed its doesn't happen again (unlikely)
- Intensely manage the water supply and watershed
  - City currently does apply best practices in watershed where possible
  - City doesn't own very much land in the watershed, hard to control
  - No certainty of success
- Modify the raw water intake to pull from a deeper location in another part of the lake
  - High costs and disturbance to local population
  - No certainty of success – algae have been found at various depths in the Lake Whatcom water column
- Add additional treatment
  - Add additional filters to existing WTP
  - Add pretreatment to existing WTP- must fit on existing plant site

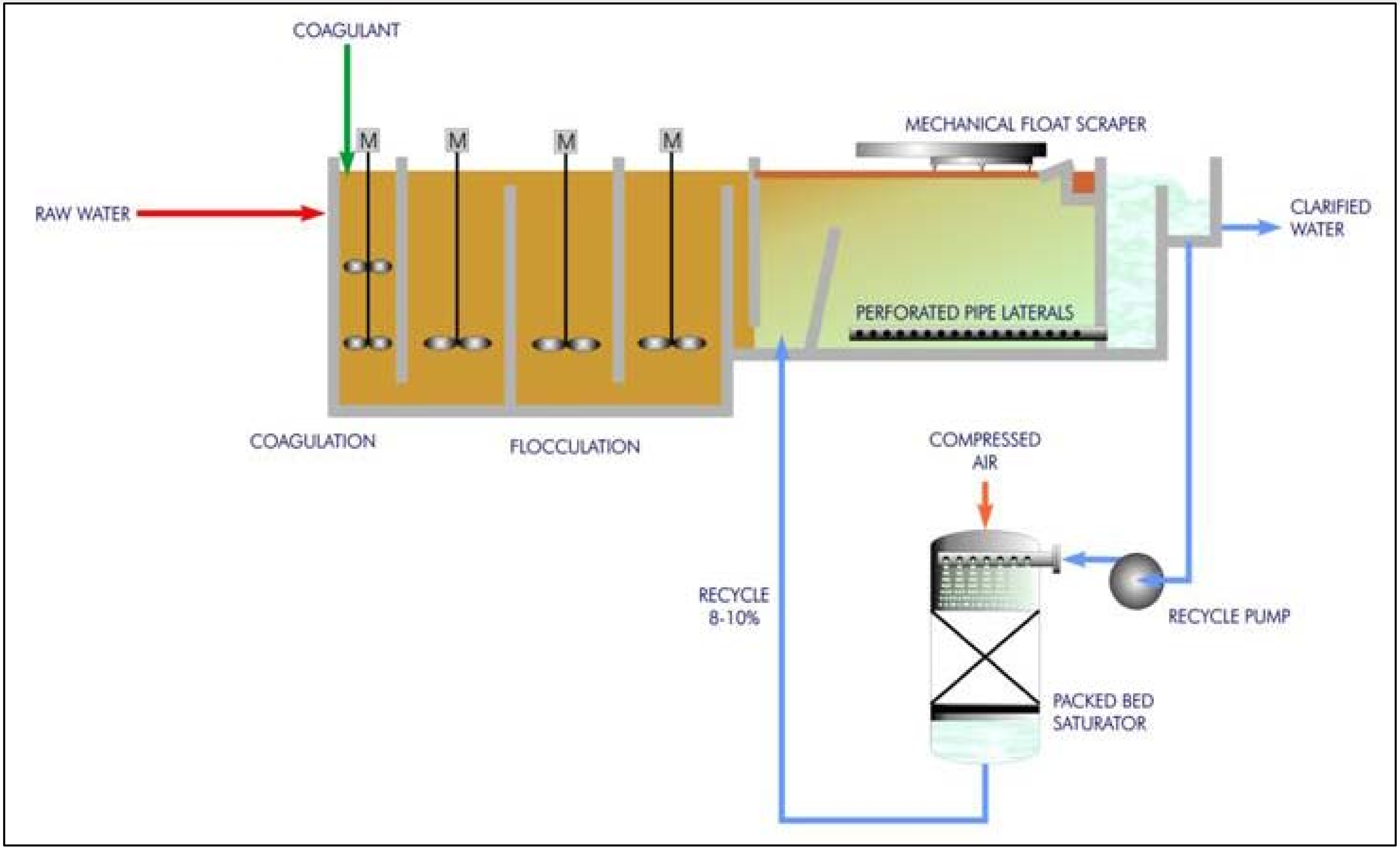
DAF is the Best Available Pretreatment Technology for Algae Removal

What is DAF and how does it work?

What Is Dissolved Air Flotation (DAF)

- Dissolved Air Flotation is a clarification/ pretreatment process
- Uses dissolved air under pressure in water that is released as it passes through nozzles
  - Produces bubbles between 10 and 100 μm
- Solids are "floated" to the top of the system
- Clarified water flows out from the bottom
- Best available technology for algae removal
  - Algae is less dense than water- "If it wants to float, let it float"

DAF Process Schematic



DAF Is A Proven Technology

- DAF first used in 1960s in Scandinavia for DW
- Started use in US in 1980s, larger scale WTPs installed in 1990s.
  - First few large plants in the Northeast
  - Largest plant with DAF – 200 mgd- New Jersey
  - Several plants larger than 50 mgd – Greenville SC, Newport News, VA, Winnipeg, MB, Waco, TX, others
  - NYC- Croton WTP – under construction – 290 mgd
- Used in other water-related work
  - Backwash wastewater treatment
  - Pretreatment for Seawater Reverse Osmosis
  - Thickening for Waste Activated Sludge (WAS)
  - Industrial Oil/Water separation
  - Stormwater separation

When to use DAF?

- Water source is a reservoir
  - Algae concerns
  - More stable turbidity
- Low turbidity water – less than 10 NTU on average
- Low to moderate TOC – less than 5 mg/L on average
- Concerns about *Giardia and Cryptosporidium*
  - Can achieve greater than 2-log removal
- Have limited land available for pretreatment
- Need to thicken clarified solids

What is this "High-Rate DAF"?

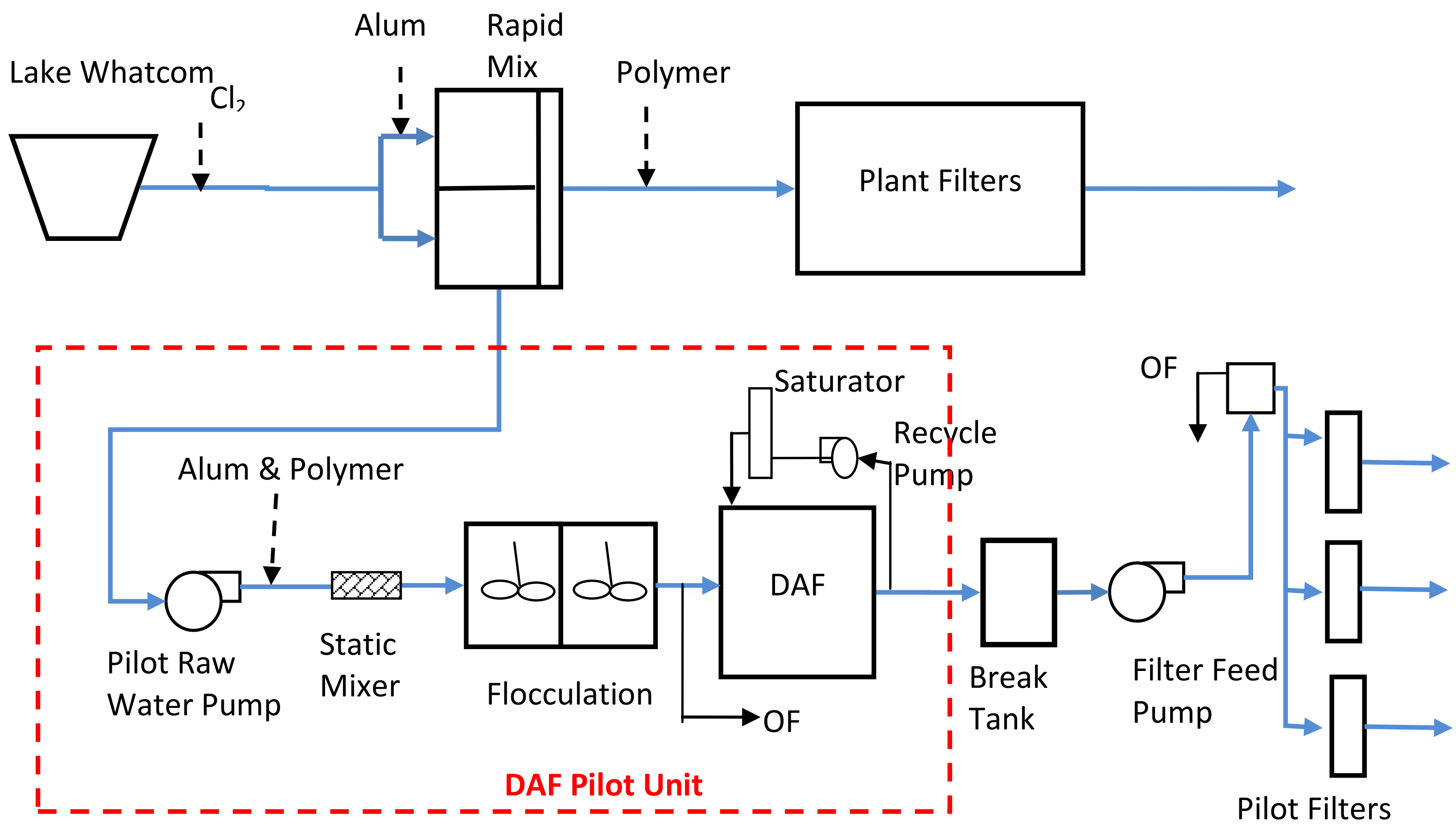
- Before 1990s, typical DAF loading rates were 8 gpm/sf or less
- Research and development has pushed loading rates higher
  - Reduce footprint of the flotation zone
  - May require modification of the float zone area
- High-rate DAF – 10 to 20 gpm/sf possible
  - Major vendors
    - ITT Water – ClariDAF ®
    - Infilco Degremont – AquaDAF ®
    - Enpure/Roberts Filter – Enflo-DAF®

Pilot Testing Conditions

Pilot Testing Conditions

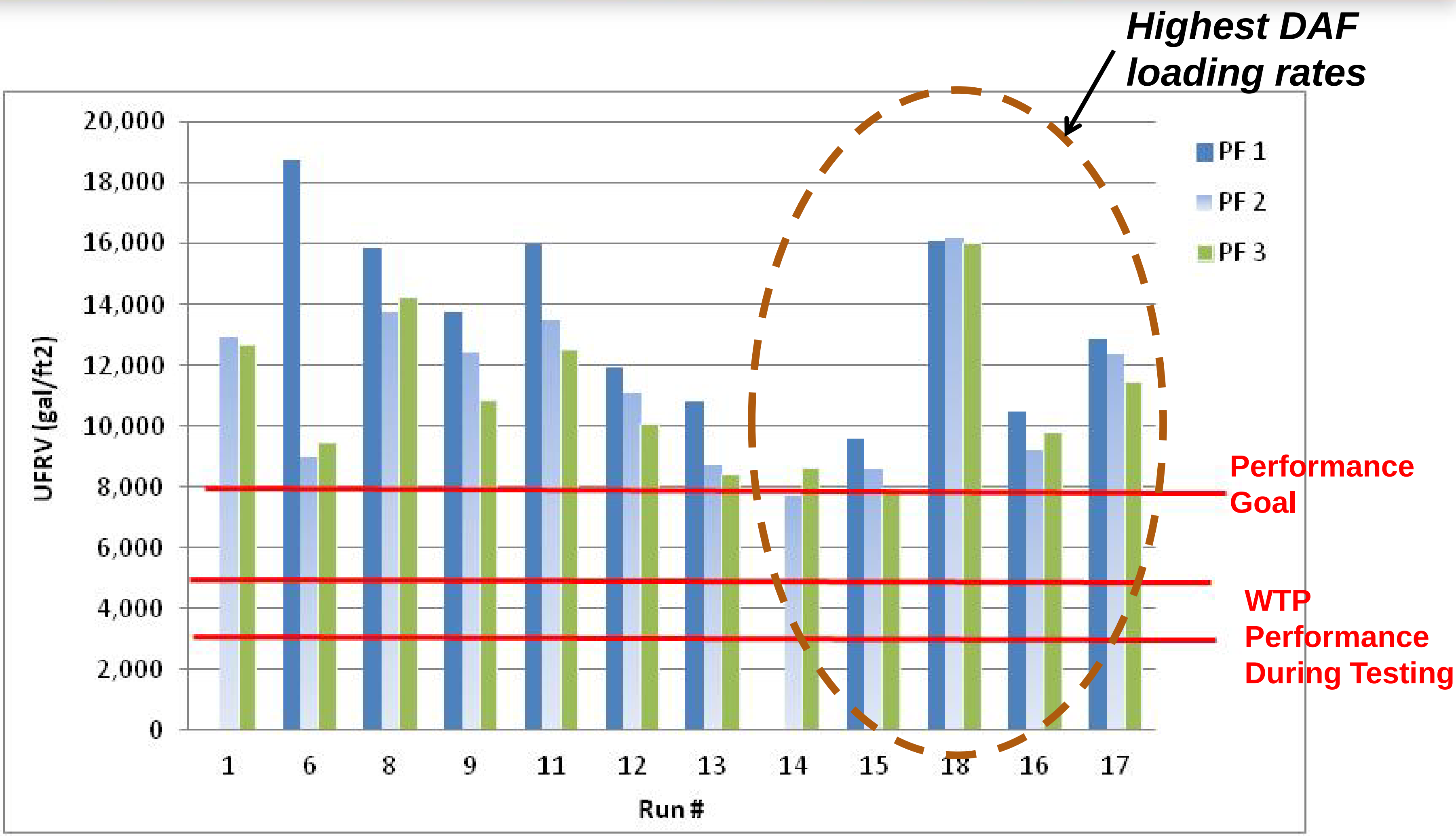
- Completed in August and September 2011
- Typical Water Quality
  - Low turbidity, low alkalinity, low TOC
  - Neutral pH, no dissolved metals
  - Low algal counts except for late summer period
- Operational conditions
  - Jar Testing – 10 ppm Alum, 0.2-0.4 ppm polymer
    - Similar to existing WTP
  - 5 minutes flocculation time
  - 10-12 % recycle rate
  - Hydraulic loading rates from 10 to 20 gpm/sf
  - Filter loading rates at 5,6, and 7 gpm/sf
    - Media design same as existing filters - 31 inches anthracite over 11 inches sand

Pilot Testing Schematic

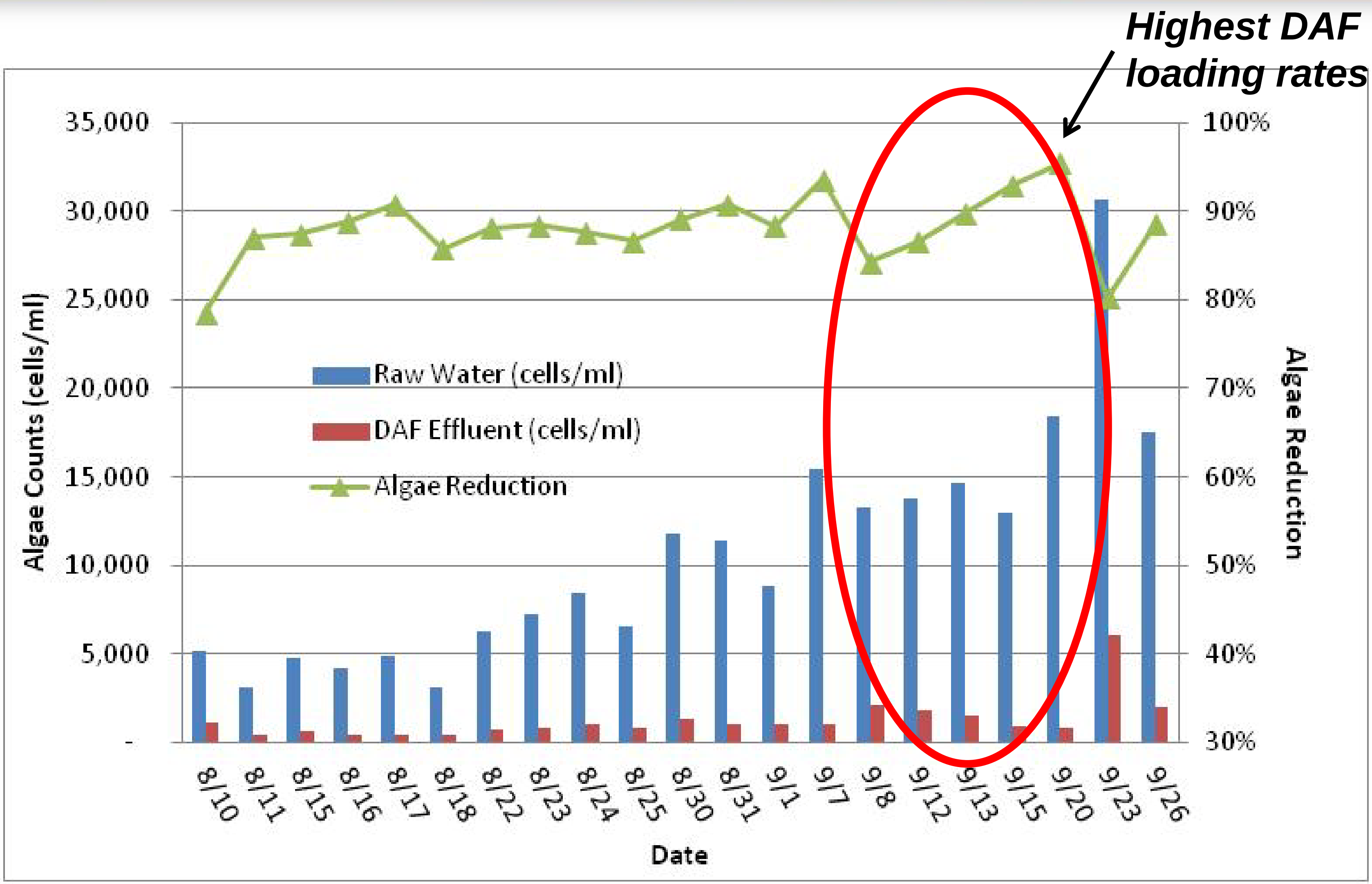


DAF Pilot Test Equipment

Filtration Performance During Testing Exceeded Goals



Algal Reduction in Pilot was Significant

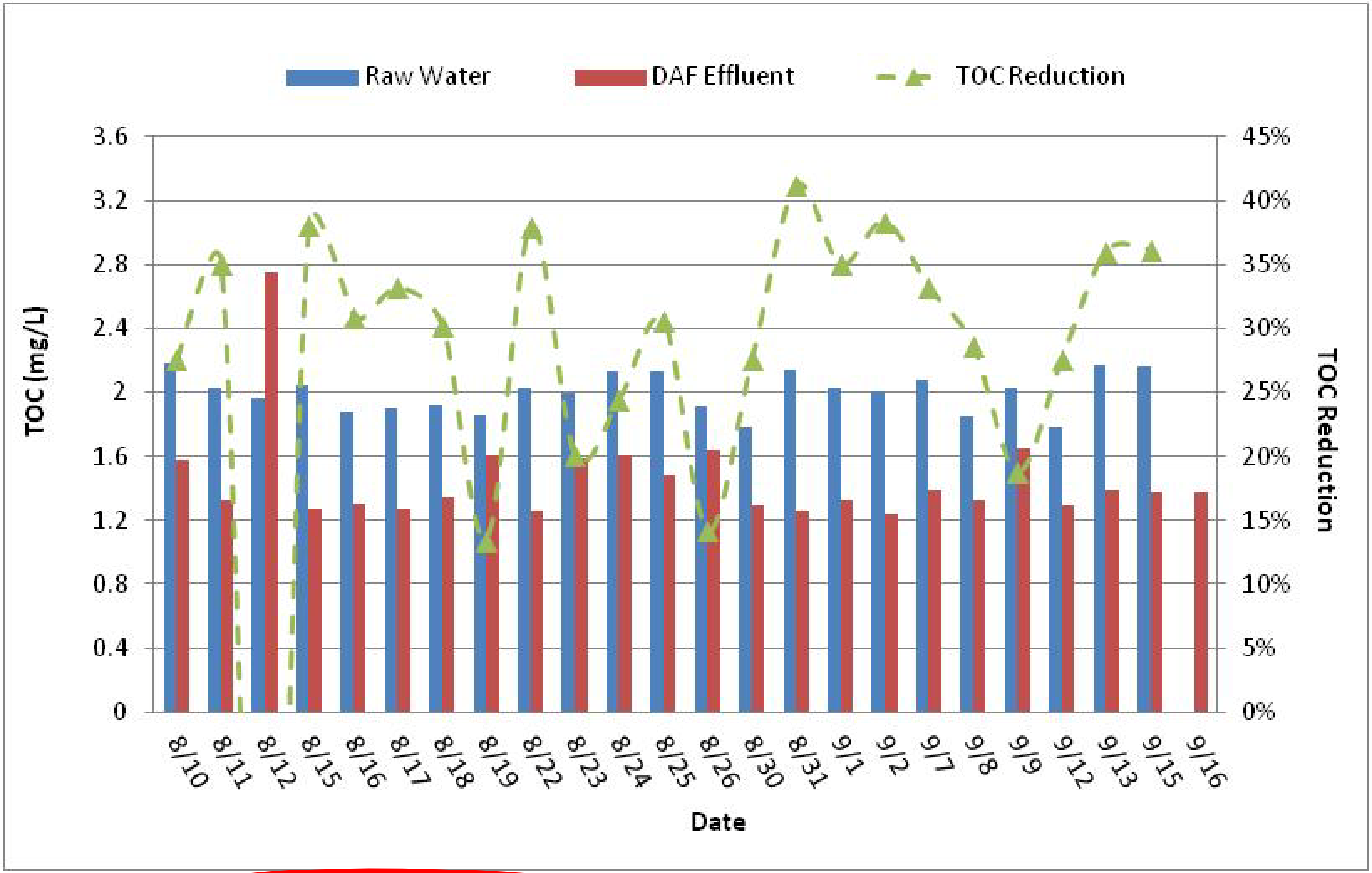


Algal surrogate monitoring showed mixed results

- Chlorophyll A and Phycocyanin as algal presence and removal indicators
- Chlorophyll A correlation was good; Phycocyanin was not useful

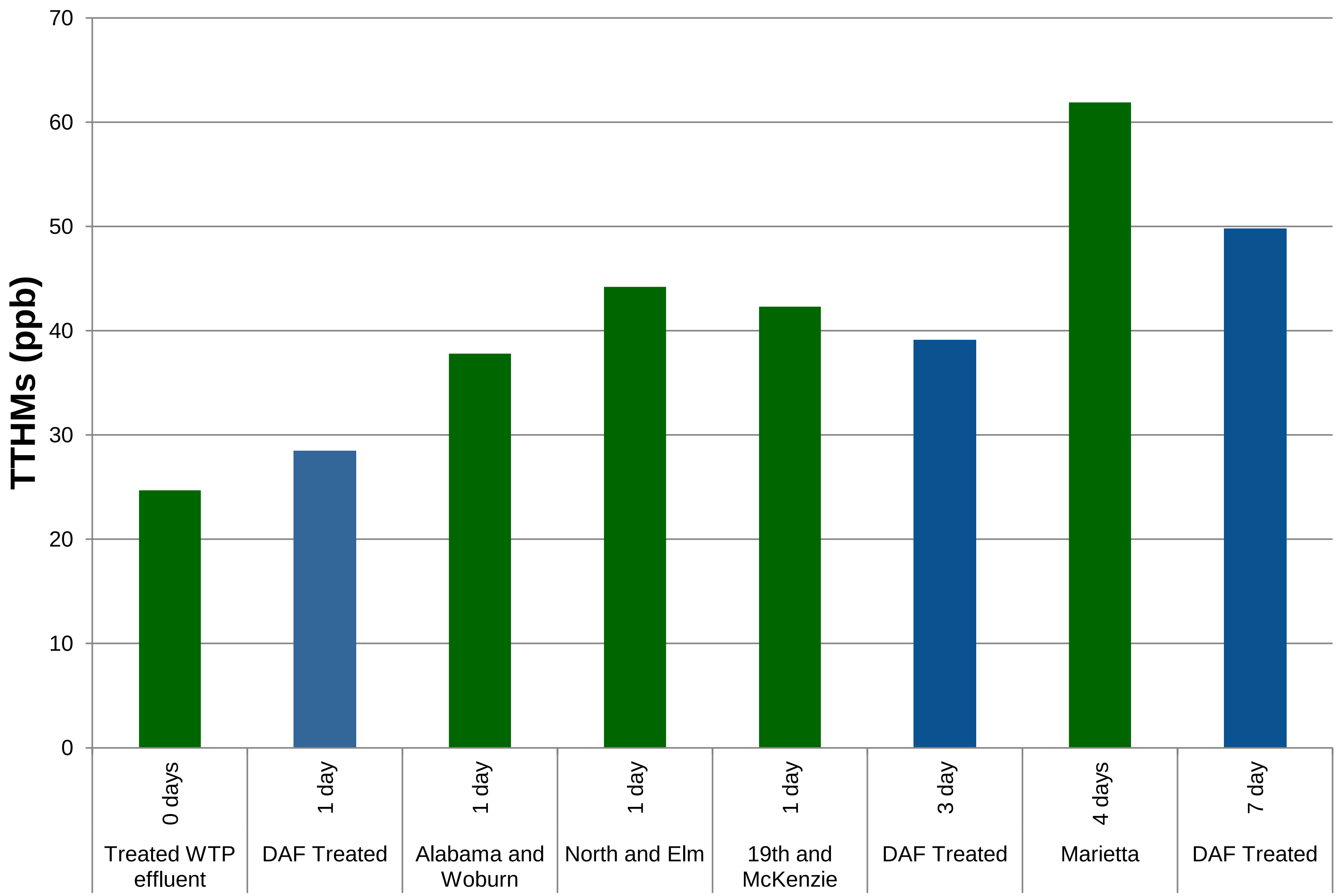
	Algae Removal (WWU)	Chlorophyll Removal (WWU)	Chlorophyll Removal (handheld fluorometer)	Phycocyanin Removal (handheld fluorometer)
Average	88%	86%	72%	48%
Max.	95%	97%	84%	98%
Min.	78%	40%	15%	14%

TOC reduction across DAF process was variable



Average SUVA in DAF effluent was 1.3 L/mg-m during testing

DAF Reduced DBP Formation



Potential Site Layout

Conclusions

Conclusions

- Coagulant dosages similar to in-line filtration plant were effective
- Only 5 minutes flocculation required
  - Reduces footprint and cost
- Pilot filter productivity was improved to 7,600 to 18,000 gal/sf
  - Full-scale plant during same period averaged 3,000 gal/sf
- DAF loading rates operated effectively up to 20 gpm/sf
  - Design at 16 gpm/sf
- DAF reduces the formation of TTHMs by 25%
  - Less chlorine demand with additional precursor removal
- ***DAF is an effective process for the Lake Whatcom supply to reduce algae and mitigate risk for the City to meet its water demands in the future***

Questions?

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Emerging Industry Changes in Medium Pressure UV Disinfection Reactor Validation and Design:

Sub 240nm Correction Factors

2012 PNWS Annual Conference in Yakima, WA

Presentation Outline

- Introduction
- Issue Discussion
- Industry Actions
- Case Studies
- Summary

Introduction

Introduction

- **Why UV Disinfection?**
  - ***Cryptosporidium inactivation***
  - ***Giardia inactivation***
  - ***Reduce free-chlorine contact (DBPs)***
- **How is UV Implemented?**
  - ***USEPA's UV Disinfection Guidance Manual***
  - ***UV reactor validation***

Introduction (cont.)

- **Guidance (UVDGM Chapter 5)**

If the UV reactor uses MP lamps and validation testing is performed using a challenge microorganism other than MS2 phage or *B. subtilis*, an action spectra correction factor (CF_{as}) may need to be applied to the RED values to account for differences in the action spectra of the target pathogen and challenge microorganism. Section D.4.1 in Appendix D describes this concept and presents the correction factors that should be used for the RED adjustment (i.e., divide RED by the correction factor).

- **Action Spectra Correction Factor (CF_{AS})**
  - ***2006 UVDGM: Default of 5 percent (1.05)***
  - ***RED is adjusted by dividing by the CF_{AS}***
  - ***Under-dosing if CF_{AS} not applied***

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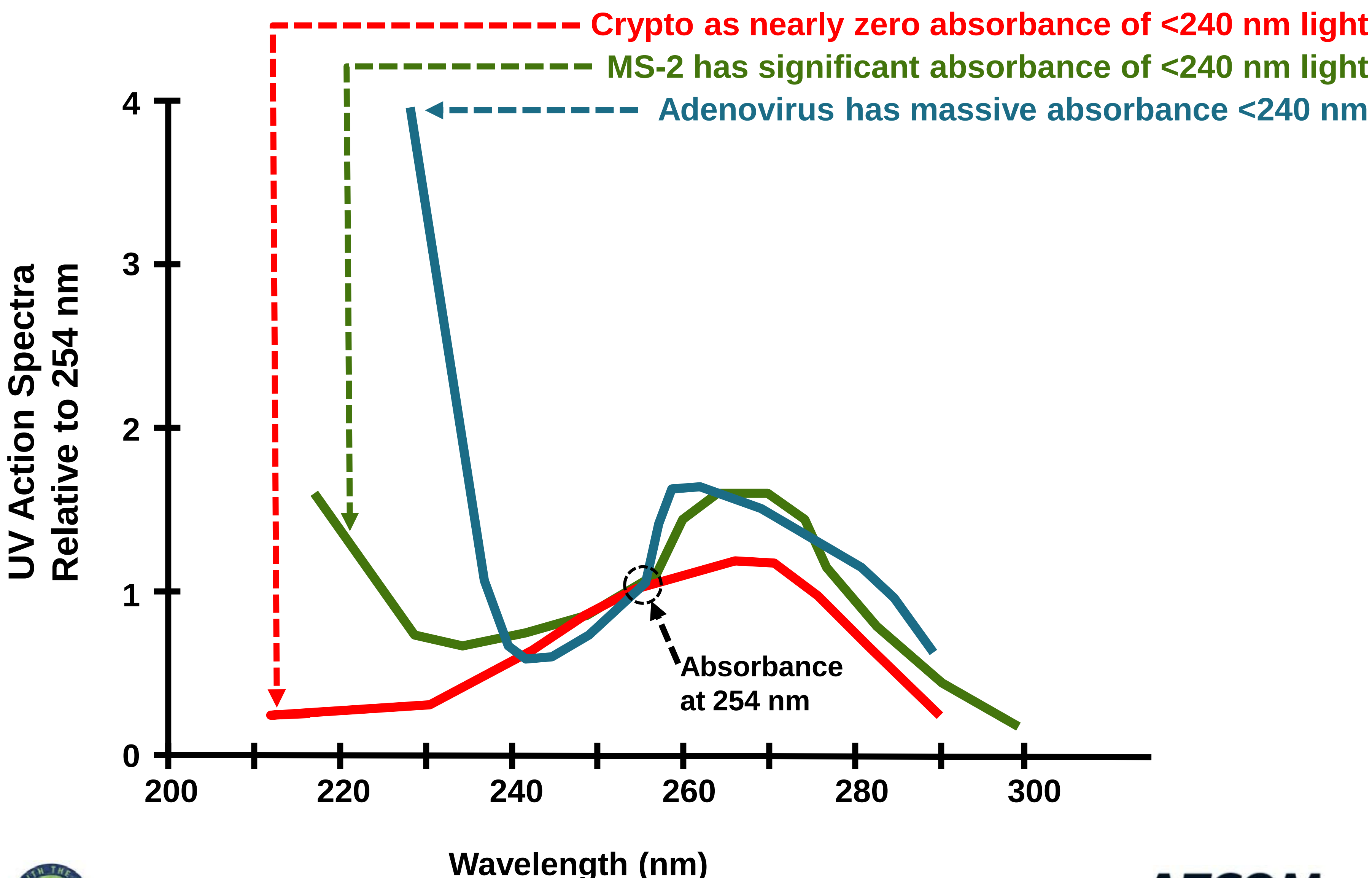
Issue Discussion

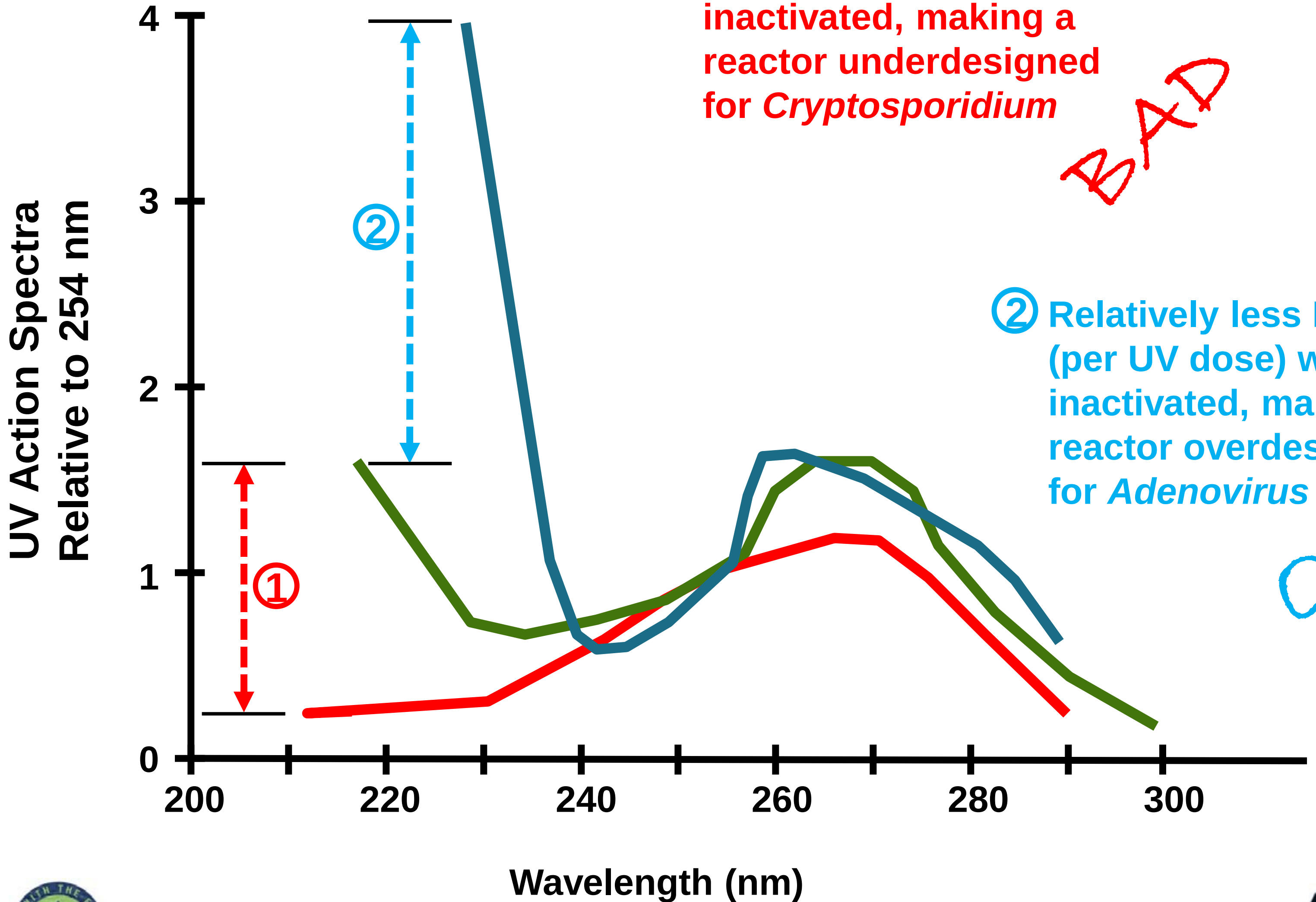
Under-Dosing if CF_{AS} Not Applied

Low-UV Wavelength Absorbance



Low-UV Wavelength Absorbance

If absorbance difference is not corrected:



① **Relatively more MS-2 (per UV dose) will be inactivated, making a reactor underdesigned for *Cryptosporidium***

BAD

② **Relatively less MS-2 (per UV dose) will be inactivated, making a reactor overdesigned for *Adenovirus***

OK

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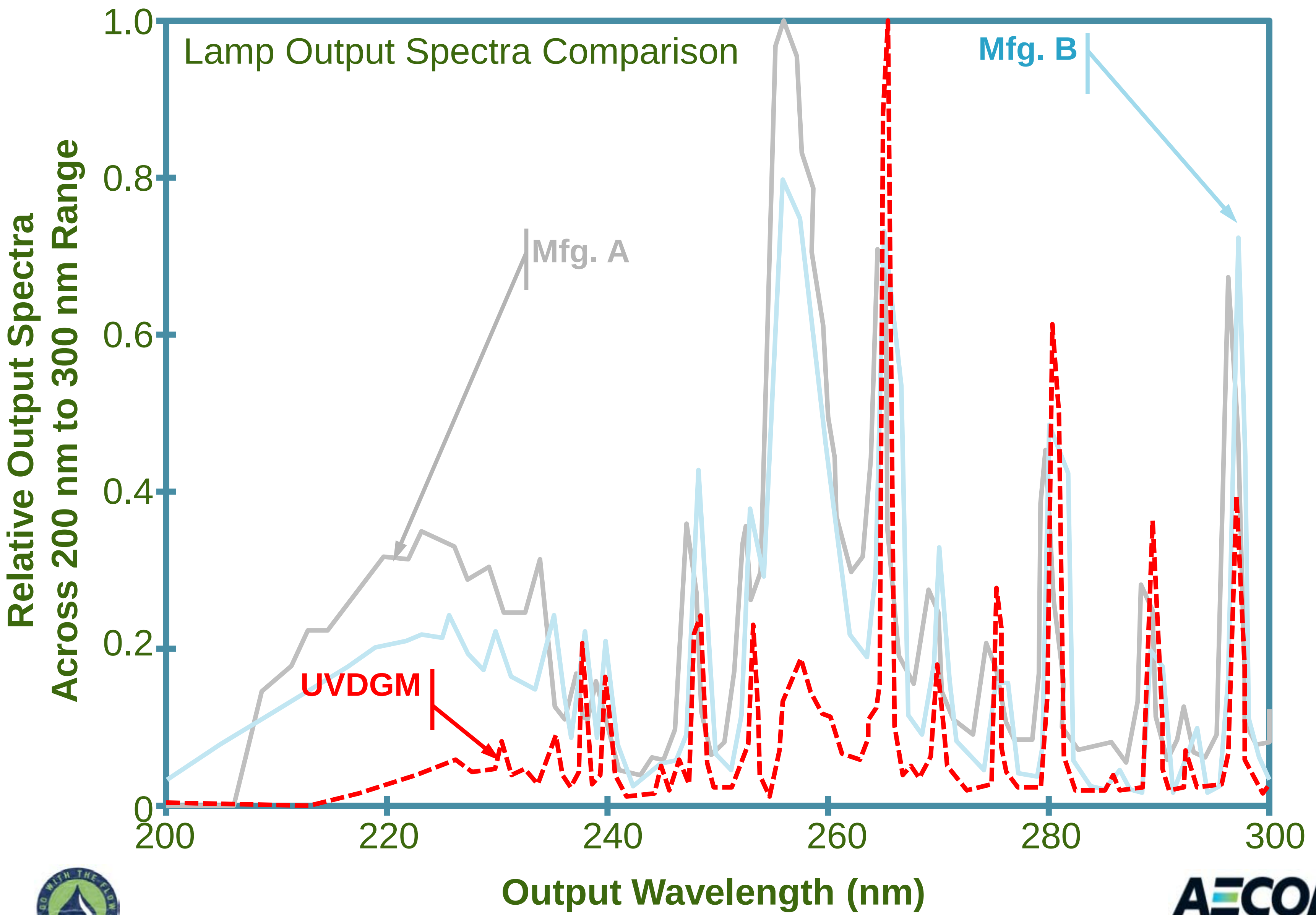
Lamp Output vs. UVDGM Estimate



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Summarizing Issue At Hand

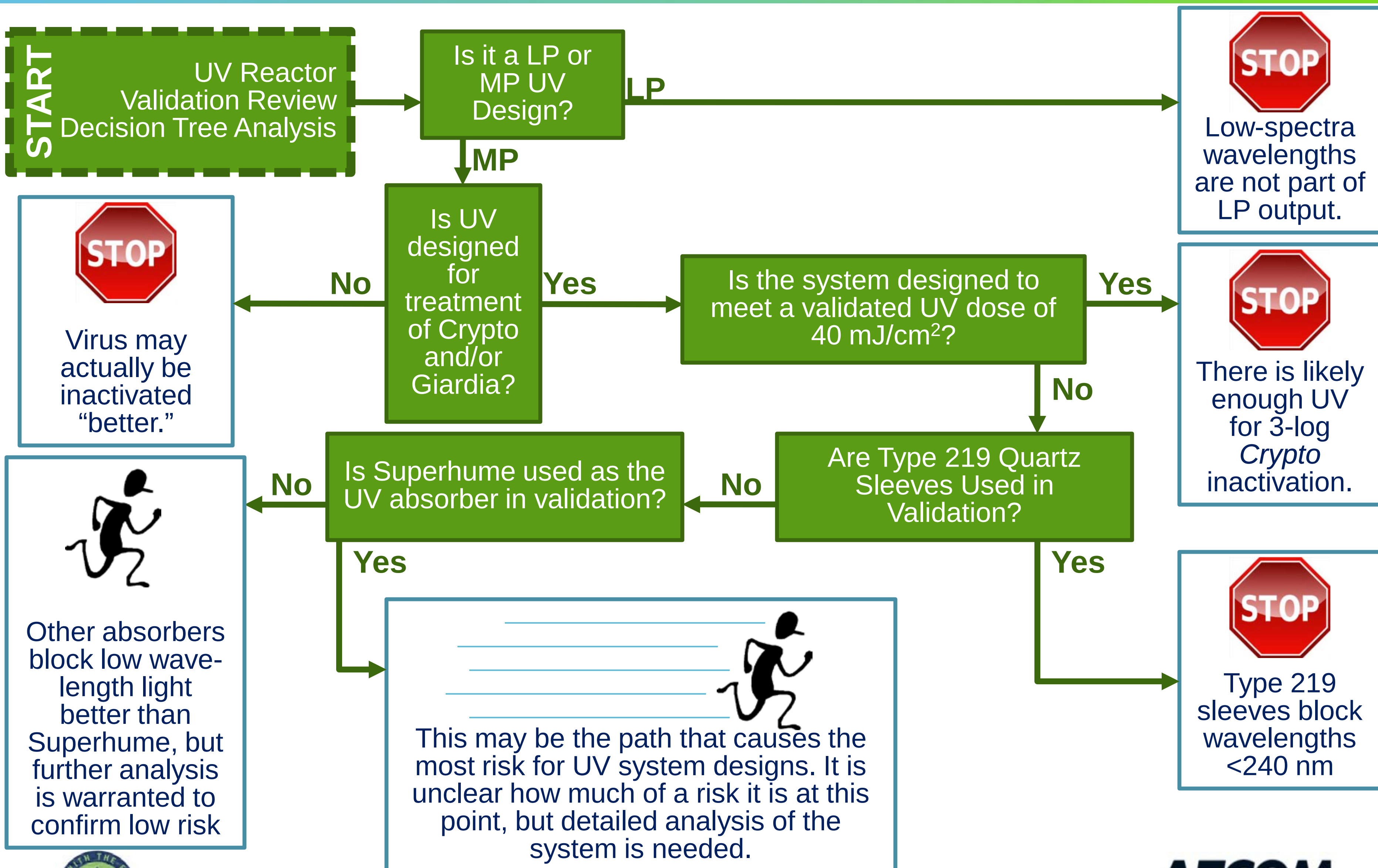
- **Low-Wavelength (low-λ) Absorbance Not Corrected**
- **Contributing Factors**
  - ***Proprietary lamp output spectra (not measured)***
  - ***Validation conditions allowing <240-nm λ***
- **Compounding Factors**
  - ***Spectra not always measured, just 254 nm***
  - ***Secondary microorganism-specific issues***
- **What is the Impact?**
  - ***UVDGM CF_{AS} = 1.05***
  - ***Current estimates indicate CF_{AS} ranges >1.20***

Industry Actions

Related Industry Activities

- **UVDGM Development (Past)**
  - ***Authors, experts, AWWA & utility representatives***
  - ***2000 to 2005, publication in 2006***
- **Low-λ Issue Ad-Hoc Committee Meetings**
  - ***May 2011: IOA/IUVA Congress (Paris, France)***
  - ***Jun 2011: AWWA Annual (Washington, D.C.)***
  - ***Sep 2011: IUVA Congress (Toronto, Ontario, Canada)***
  - ***Nov 2011: AWWA WQTC (Phoenix, Arizona, USA)***

Issue Analysis Flowchart



Related Industry Activities

- **Water Research Foundation (WaterRF) 4421**
  - ***Developing CF_{AS} by CFD Modeling***
  - ***Is revalidation needed?***
  - ***End of 2012 will bring first 'community' answers…..***
- **WaterRF 4376**
  - ***Microbial investigations (Cryptosporidium)***
- **What about *Giardia*?**

Case Study

Facility 1

In-Filter Dissolved Air Flotation

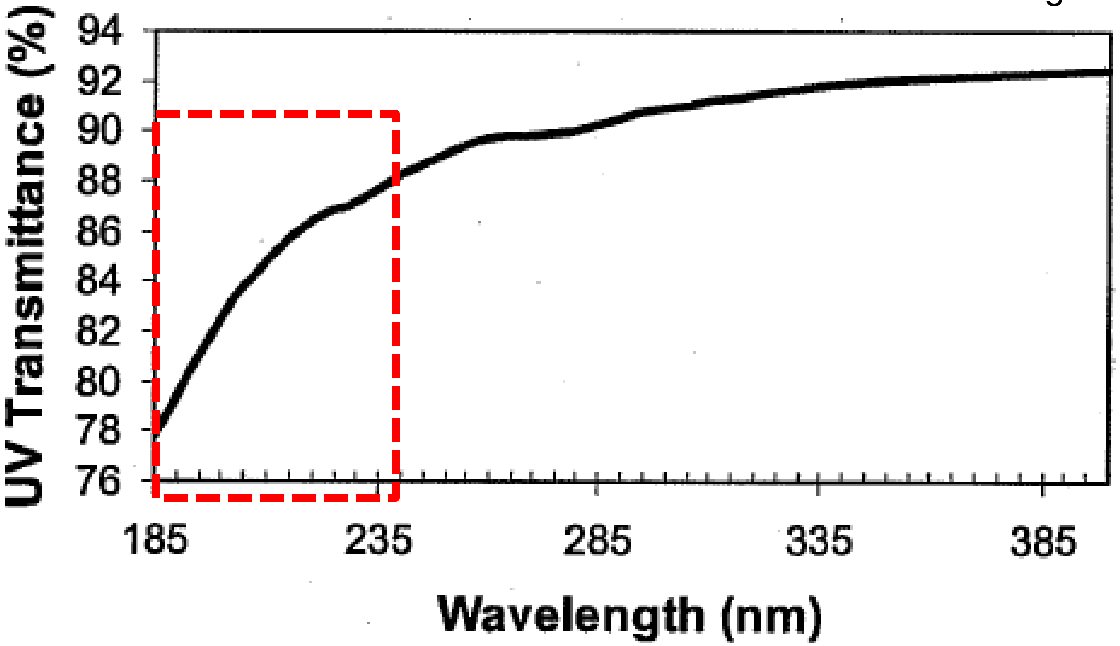
UV Disinfection

Chlorine Disinfection

Facility No. 1

- **20 MGD (24" MP Reactors)**
- **3-log *Crypto.* & 3-log *Giardia* Inactivation**
- **Sub-40 mJ/cm² Design UV dose**

Quartz Sleeve
allowed low-λ light



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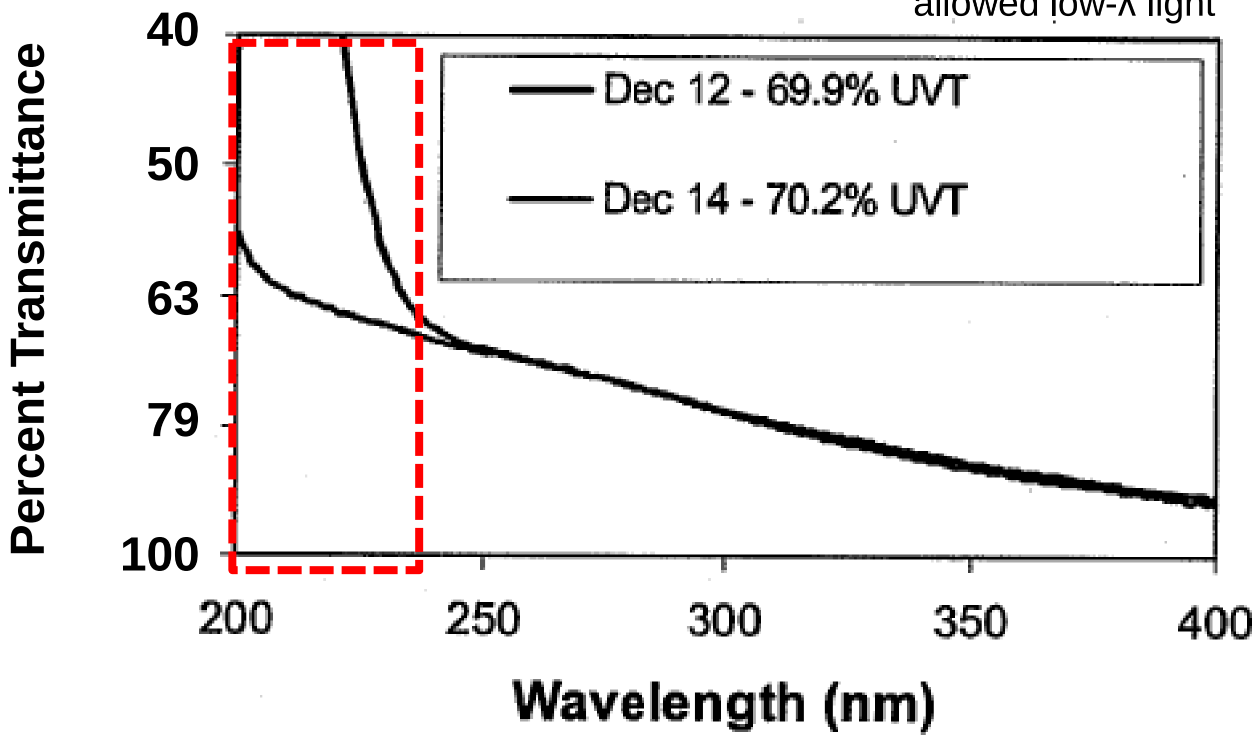
Facility No. 1

- **20 MGD (24" MP Reactors)**
- **3-log *Crypto.* & 3-log *Giardia* Inactivation**
- **Sub-40 mJ/cm² Design UV dose**

Water quality and absorber allowed low-λ light



AECOM

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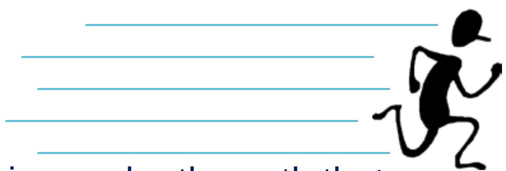


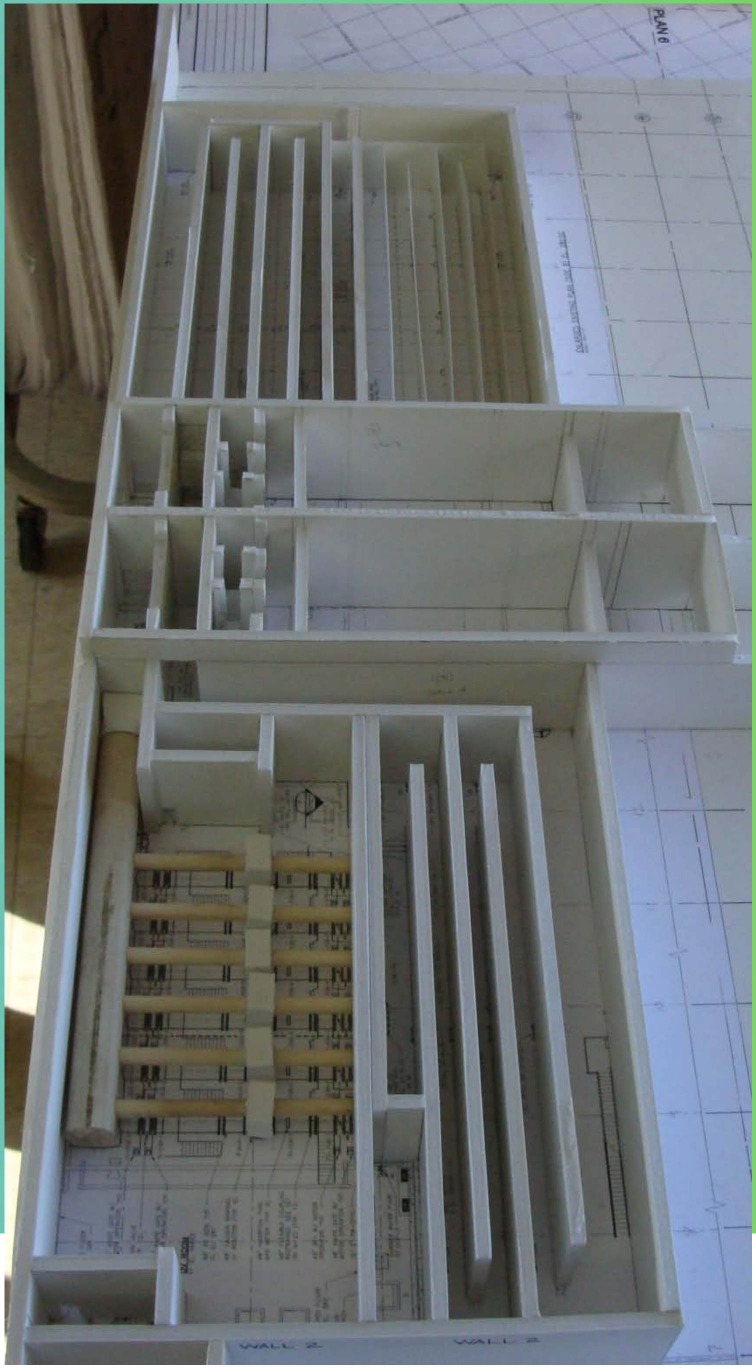
This may be the path that causes the most risk for UV system designs. It is unclear how much of a risk it is at this point, but detailed analysis of the system is needed.

- **Results of Initial Validation Assessment**
  - ***Low λs were allowed during validation***
  - ***Impact on the Crypto inactivation credit: Yes***
  - ***Impact on Giardia inactivation credit: ?***
  - ***Needs detailed assessment***

AECOM

Case Study

Facility 2

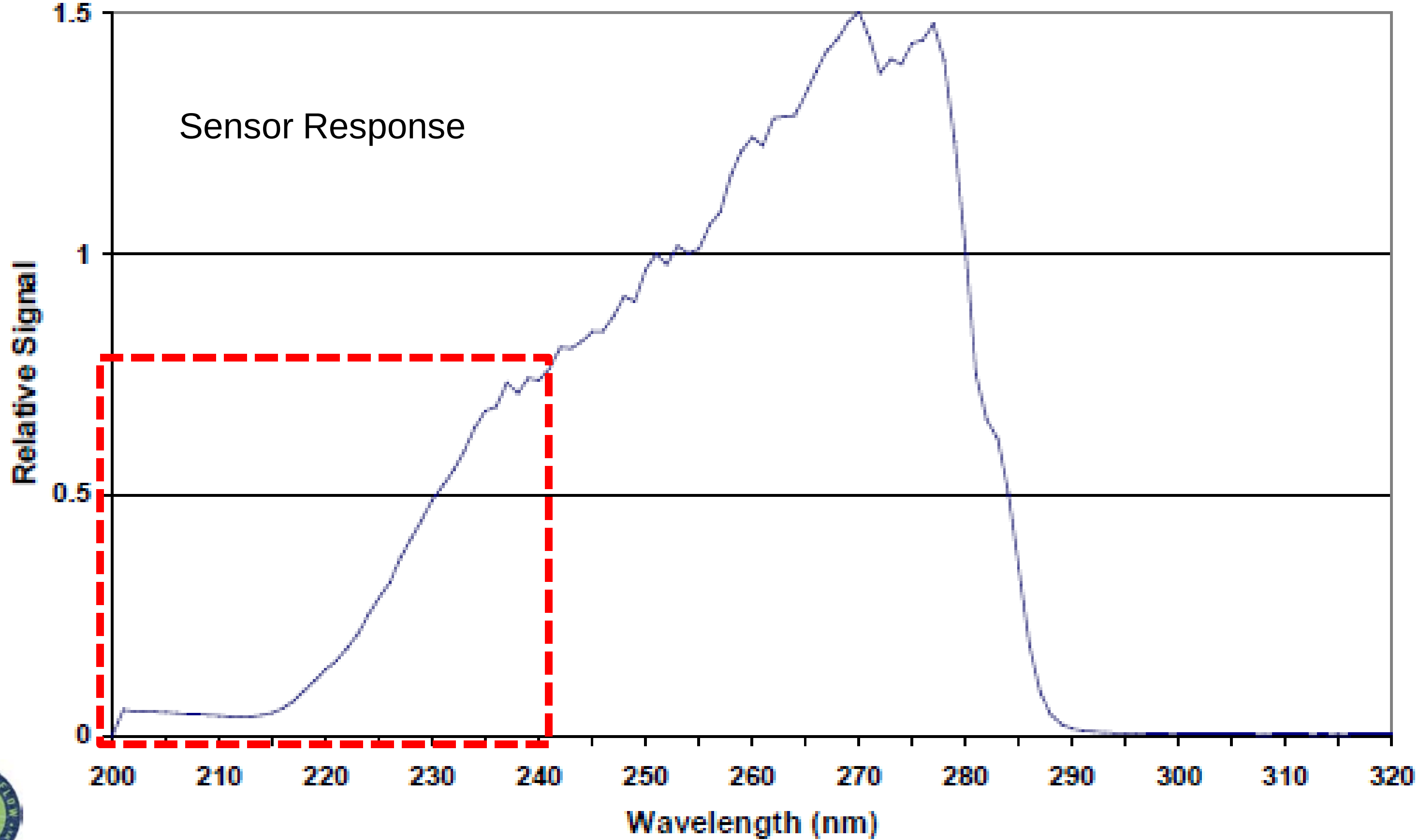


Existing Ozone and Chlorine Contact (Now)

Ozone and UV Reactors & Chlorine Contact (Construction)

Facility No. 2

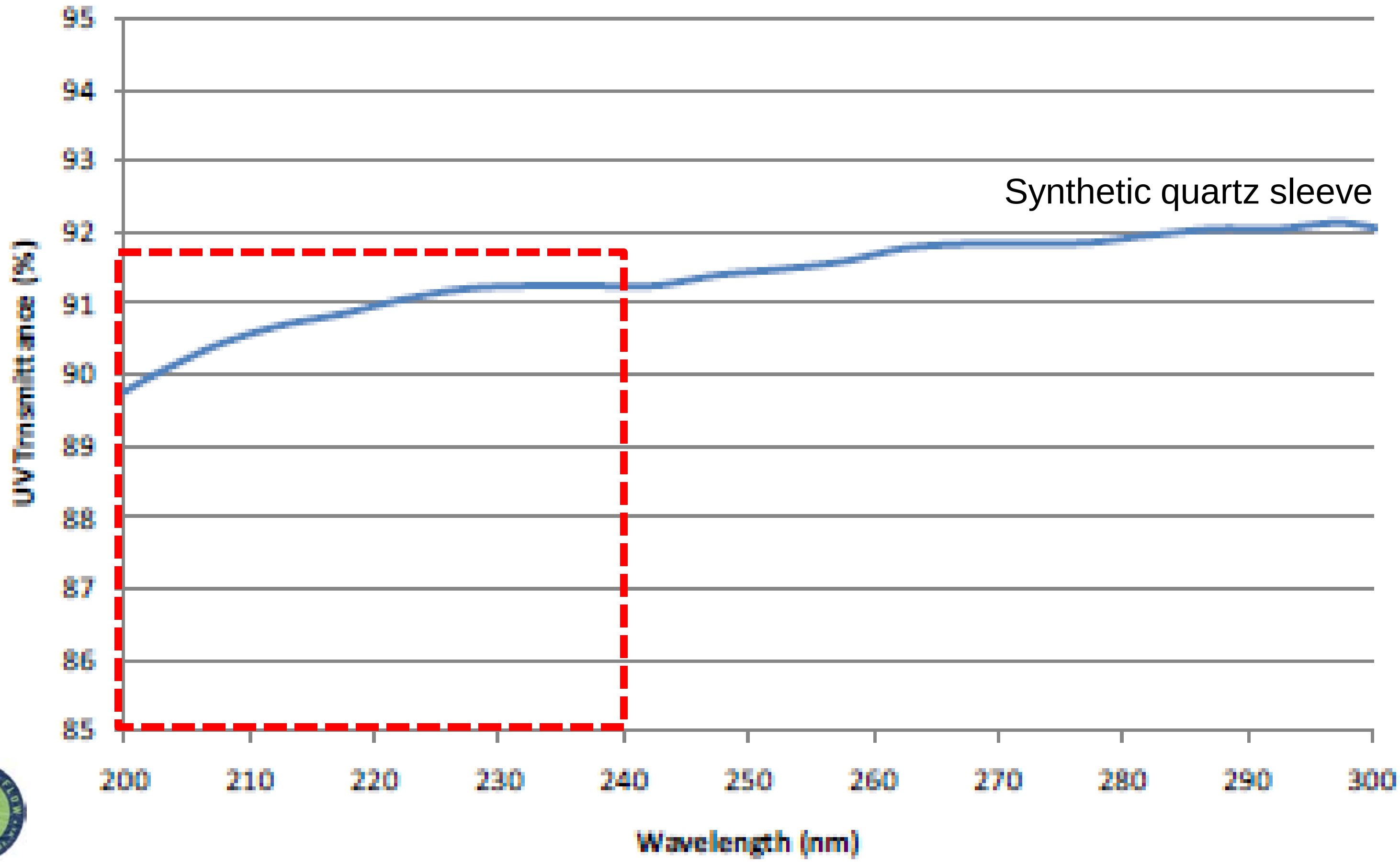
- **450 MGD (48” MP Reactors)**
- **3-log *Crypto.* inactivation (ozonated, unfiltered)**
- **Sub-40 mJ/cm^2 Design UV dose**



AECOM

Facility No. 2

- **450 MGD (48” MP Reactors)**
- **3-log *Crypto.* inactivation (ozonated, unfiltered)**
- **Sub-40 mJ/cm² Design UV dose**

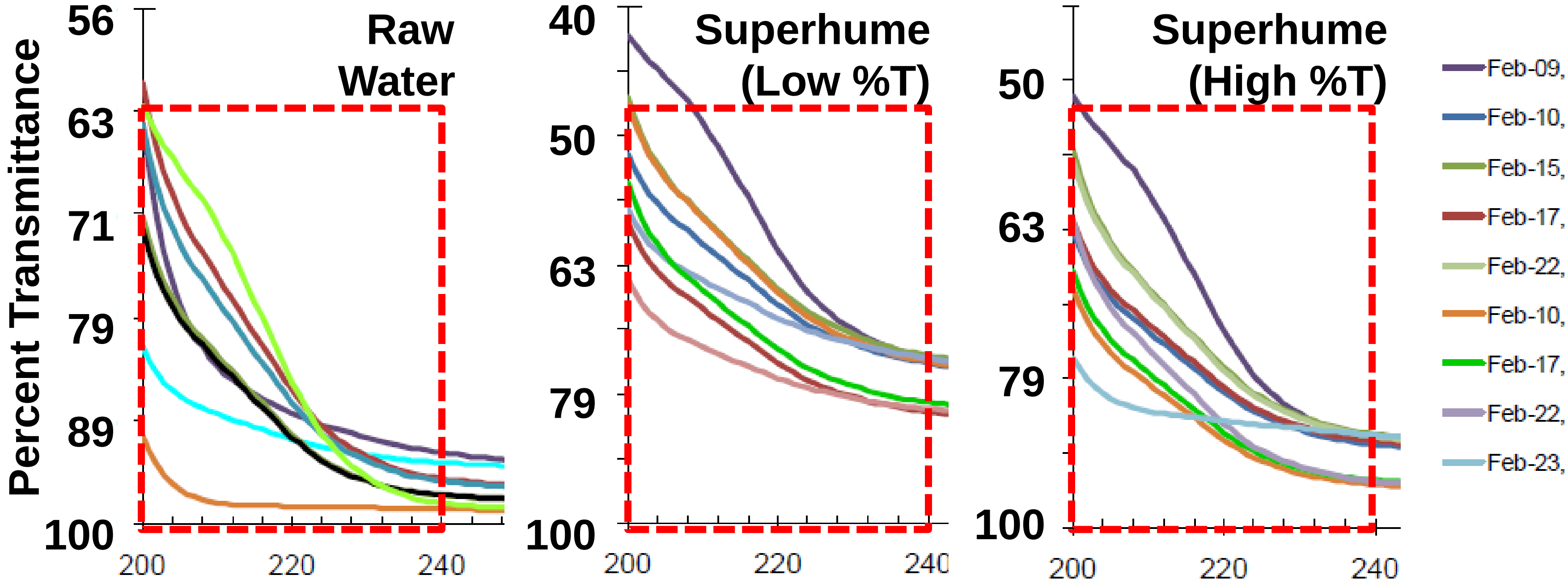


AECOM

Facility No. 2

- **450 MGD (48” MP Reactors)**
- **3-log *Crypto.* inactivation (ozonated, unfiltered)**
- **Sub-40 mJ/cm² Design UV dose**

Water quality and absorber conditions allowed



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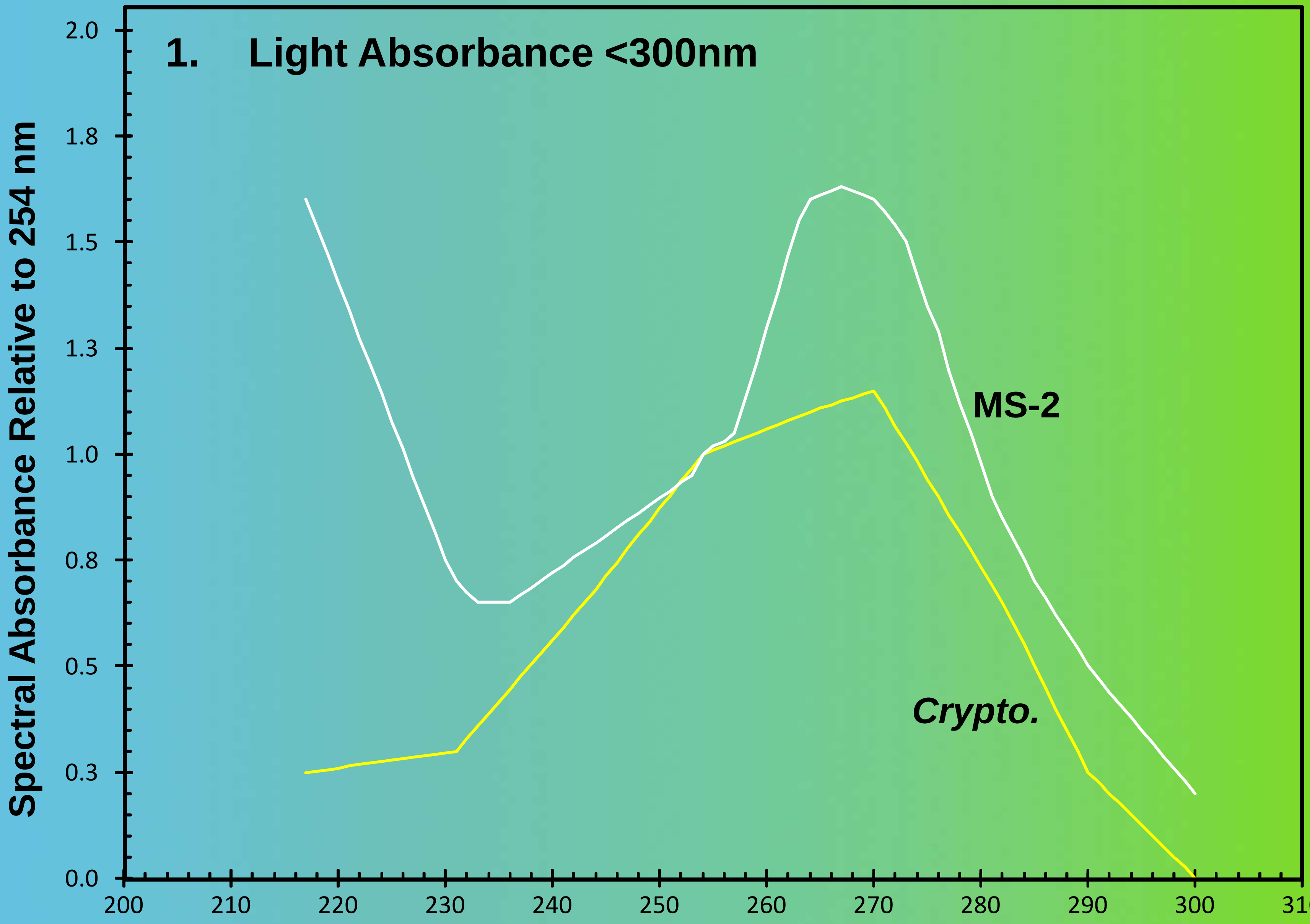
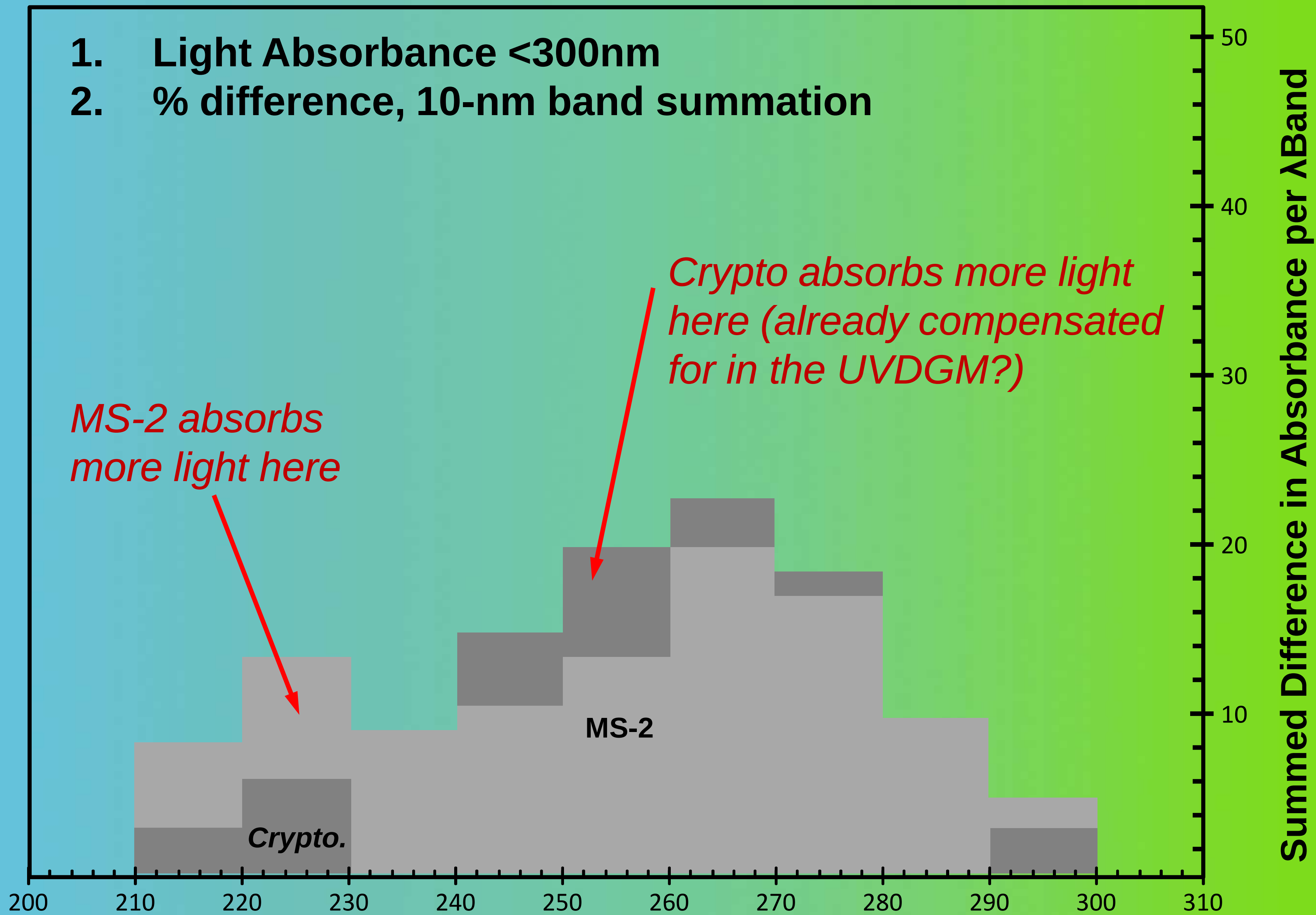
Facility No. 2 Example Calculation

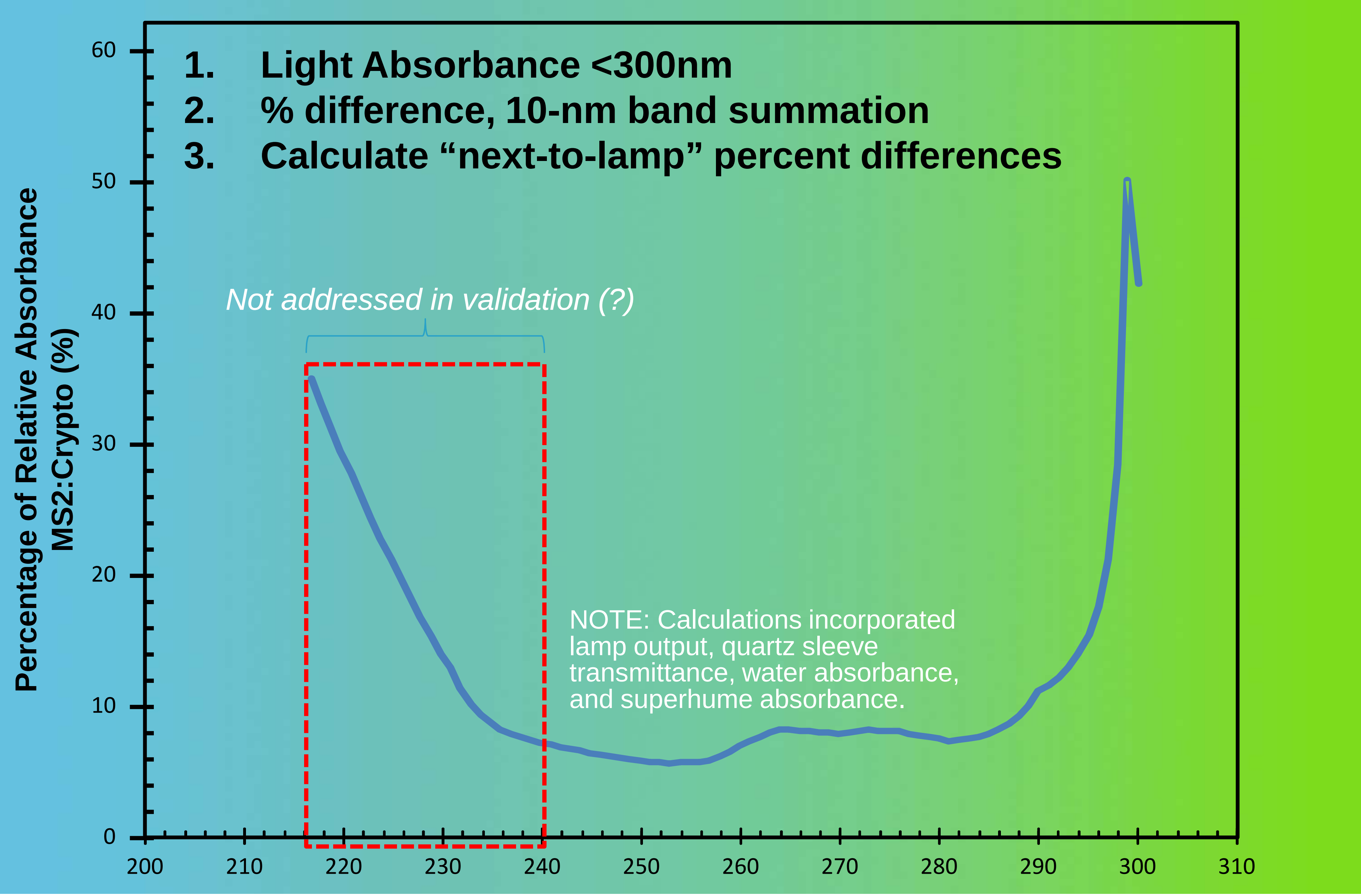
- **Reactor Validation for Facility No. 2**
  - ***Only looking at one water quality***
  - ***Only looking at one superhume condition***
- **Compensating for anomalies**
  - ***Organism absorbance spectra***
  - ***Lamp output, sleeve absorbance***
  - ***Natural and added (superhume) organics***

1. Light Absorbance <300nm

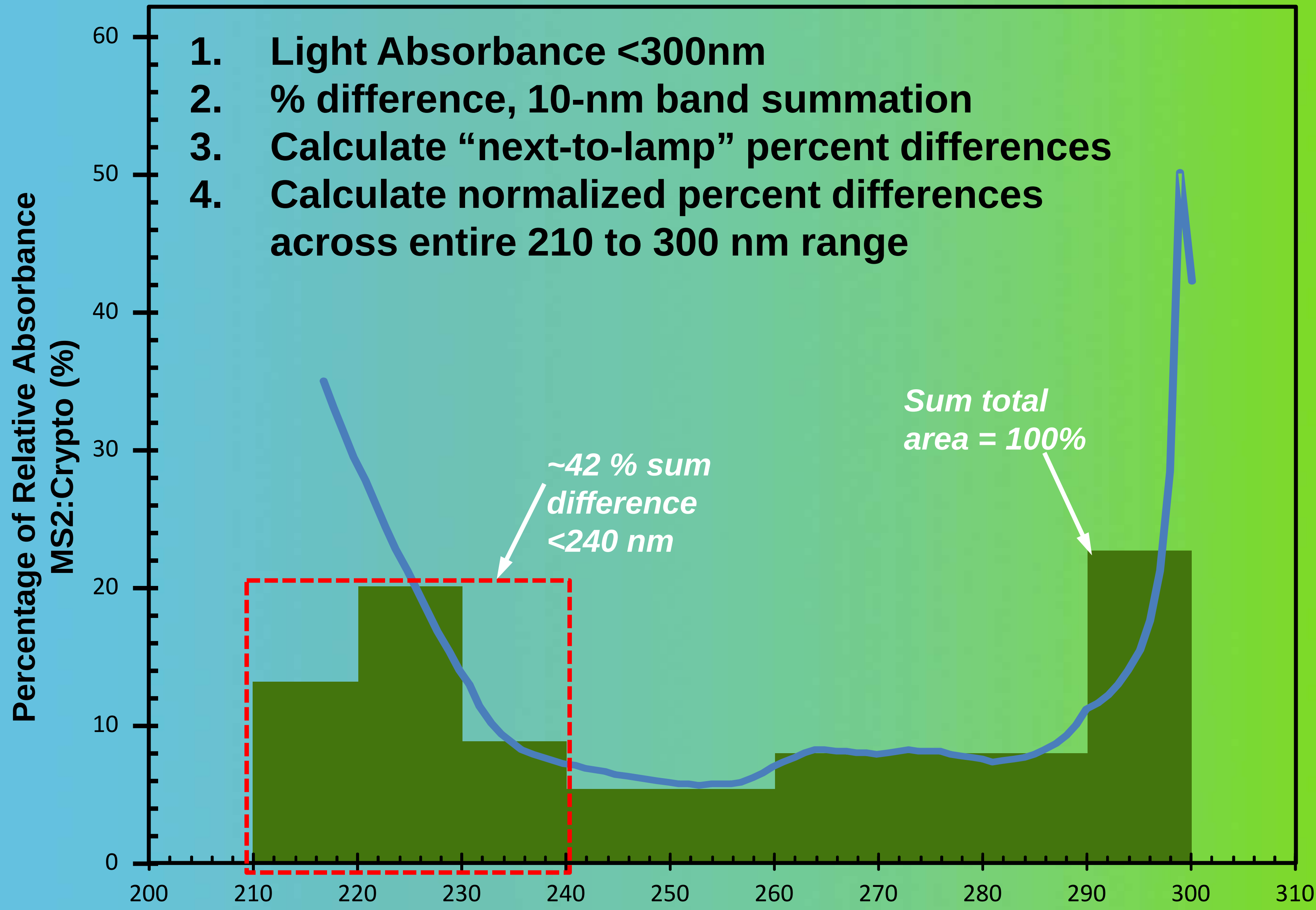



1. Light Absorbance <300nm
2. % difference, 10-nm band summation
Crypto absorbs more light here (already compensated for in the UVDGM?)
MS-2 absorbs more light here
MS-2
Crypto.
Summed Difference in Absorbance per λBand
50
40
30
20
10
200
210
220
230
240
250
260
270
280
290
300
310

AECOM



1. Light Absorbance <300nm
2. % difference, 10-nm band summation
3. Calculate “next-to-lamp” percent differences
Not addressed in validation (?)
NOTE: Calculations incorporated lamp output, quartz sleeve transmittance, water absorbance, and superhume absorbance.
Percentage of Relative Absorbance MS2:Crypto (%)
0
10
20
30
40
50
60
200
210
220
230
240
250
260
270
280
290
300
310



1. Light Absorbance <300nm
2. % difference, 10-nm band summation
3. Calculate “next-to-lamp” percent differences
4. Calculate normalized percent differences across entire 210 to 300 nm range
~42 % sum difference <240 nm
Sum total area = 100%
Percentage of Relative Absorbance MS2:Crypto (%)
0
10
20
30
40
50
60
200
210
220
230
240
250
260
270
280
290
300
310

Facility No. 2 Example Calculation

- **Validation Condition Summary**
  - MS-2 used for *Cryptosporidium* credit
  - Water quality and equipment allowed low-λ light
  - Expanded CFD needed for thorough analysis
- **Calculation Summary**
  - Lamp output (power/wavelength)
  - Organism absorbance (above)
  - Organism absorbance ratio
    - *Each wavelength*
    - *Summed ratios from 217 through 300 nm*
    - *Relative values for each wavelength compared to entire range*
- **Initial Results**
  - Approximately 40% inactivation error next to the lamp
  - Detailed evaluation required (all conditions, distances from lamp)

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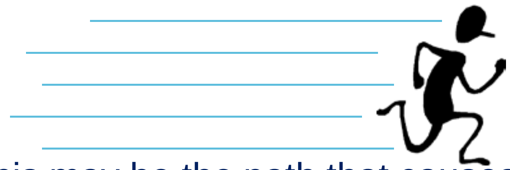
Facility No. 2

- **1,700 MLD (48” MP Reactors)**
- **3-log *Crypto.* inactivation (ozonated, unfiltered)**
- **Sub-40 mJ/cm^2 Design UV dose**



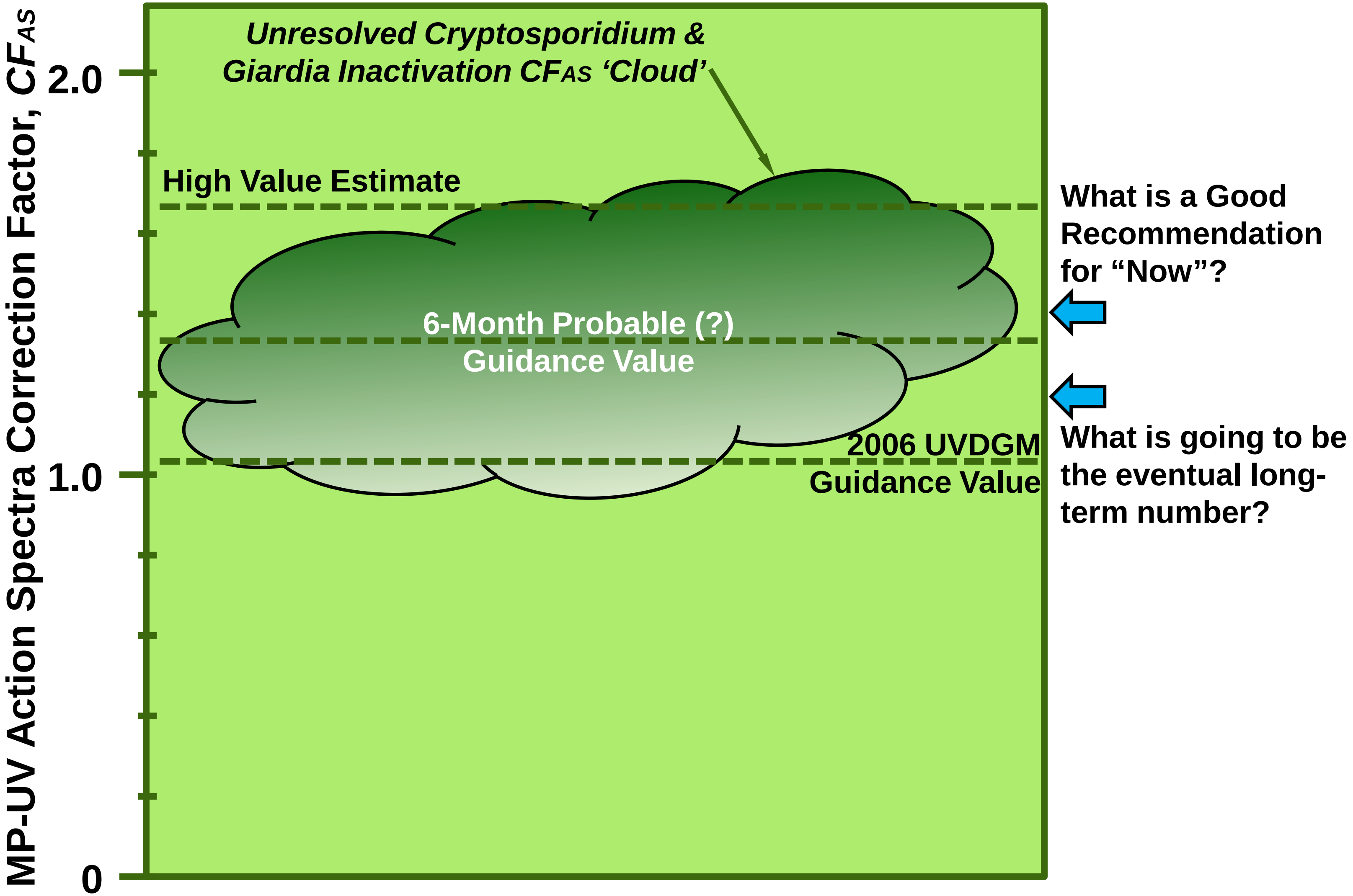
This may be the path that causes the most risk for UV system designs. It is unclear how much of a risk it is at this point, but detailed analysis of the system is needed.

Summary

Summary of Issues

- **Medium pressure UV Installations**
  - Reassessment required
  - Possible validation inaccuracies for *Crypto*. & *Giardia*
  - Surrogate organism vs *Cryptosporidium*
- **Revised safety factor**
  - Possibly increased by ≥10-20%
  - Depends on low-λ validation conditions
- **Industry Research Continuing**
  - AECOM involvement
  - Updates expected toward end of 2012
- **Facility Impacts?**
  - Do nothing
  - Increased O&M? (power, lamps)
  - Increased Capital? (reactors, etc.)

Summary of Possible Approach



AECOM

Thank You!

ETV testing of a Biological Arsenic, Iron, Manganese and Ammonia Removal Technology

PNWS AWWA

Overview

- System Overview
- Examples
- ETV Requirements
- Initial Water Quality Data

Figure 1: Photo of biologicalwater treatment system

Iron and Manganese Treatment Alternatives

Alternatives

- Aeration, precipitation, filtration
- Chlorination, precipitation, filtration
- Ozone, precipitation, filtration
- Potassium permanganate, precipitation, filtration
- Biological Removal
- Ion exchange (zeolite) softening
- Manganese-greensand filtration
- Oxide coated sand filtration
- Pyrolusite media filtration
- Membrane filtration
- Lime softening

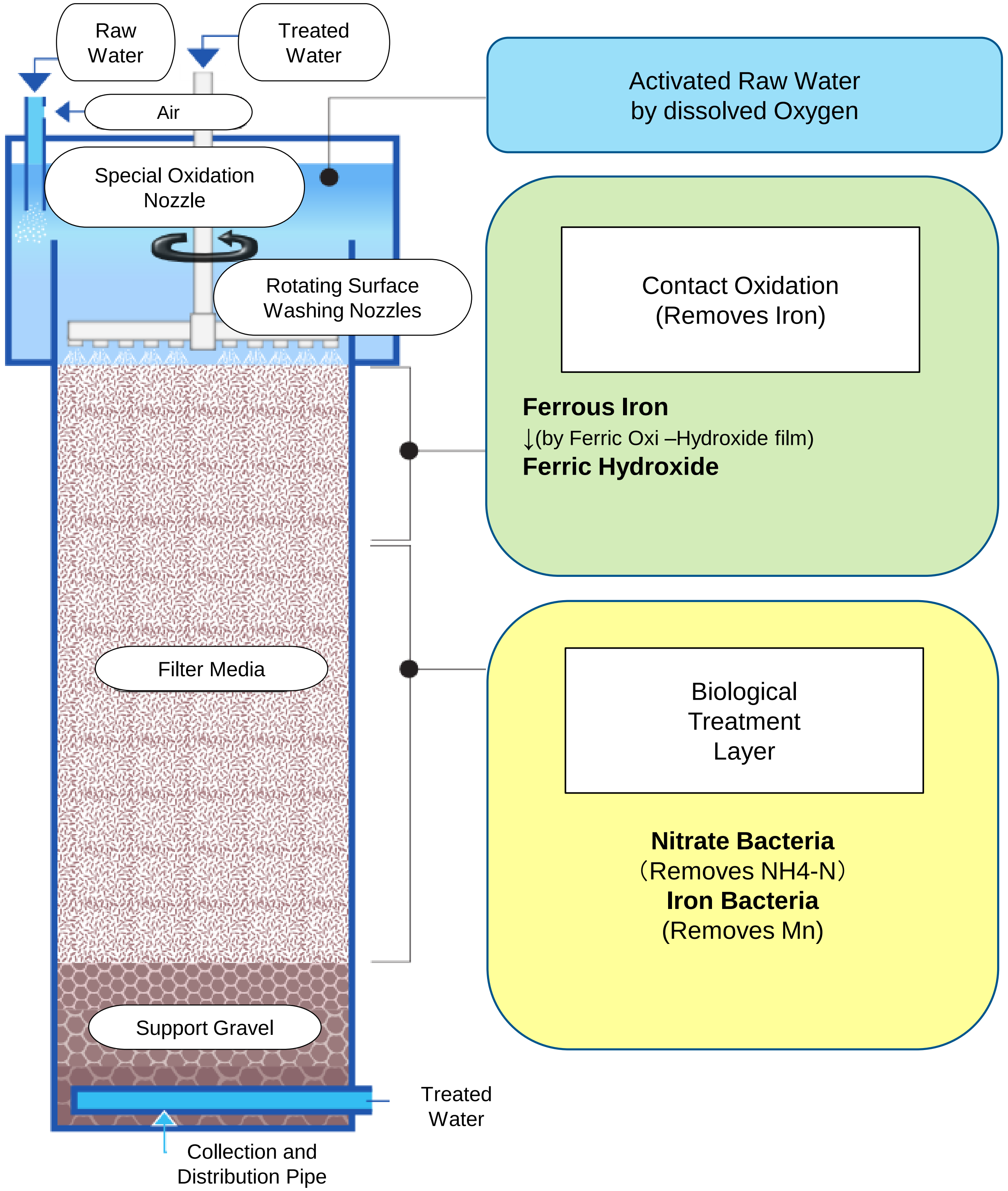
Removal Mechanisms

1. Precipitation
2. Ion Exchange
3. Adsorption
4. Biological Removal

Chemical & Cost Savings using Biological Filtration of Waters with High Iron Concentrations

	Heda Oya/ Pottuvil, Sri Lanka	Jefferson PUD, WA
Raw Water Iron Concentration	11 to 21 mg/L	7.5 mg/L
Capacity	1,500 gpm	1,500 gpm
	Annual Chemical Costs	
Raw Water Cl2 & KMnO4	$76,000/Yr	$109,000/Yr
Biological System Chemical Cost (Chlorine Post Feed)	$23,000/Yr	$21,000/Yr
Savings	**$53,000/Yr**	**$88,000/Yr**

Iron, Manganese, Nitrate and Arsenic Removal



EPA ETV Testing Via NSF

Woodland, WA

- Biological System
  - 40 mg/L Iron
  - 2 mg/L manganese
  - 1 mg/L ammonia
  - 50 ug/L arsenic
- Deep Bed Filter System
- Can backwash top part independent of remaining filter
- Linear Velocity
  - 400m/d

Water Treatment Equipment

Photographs of site in Japan

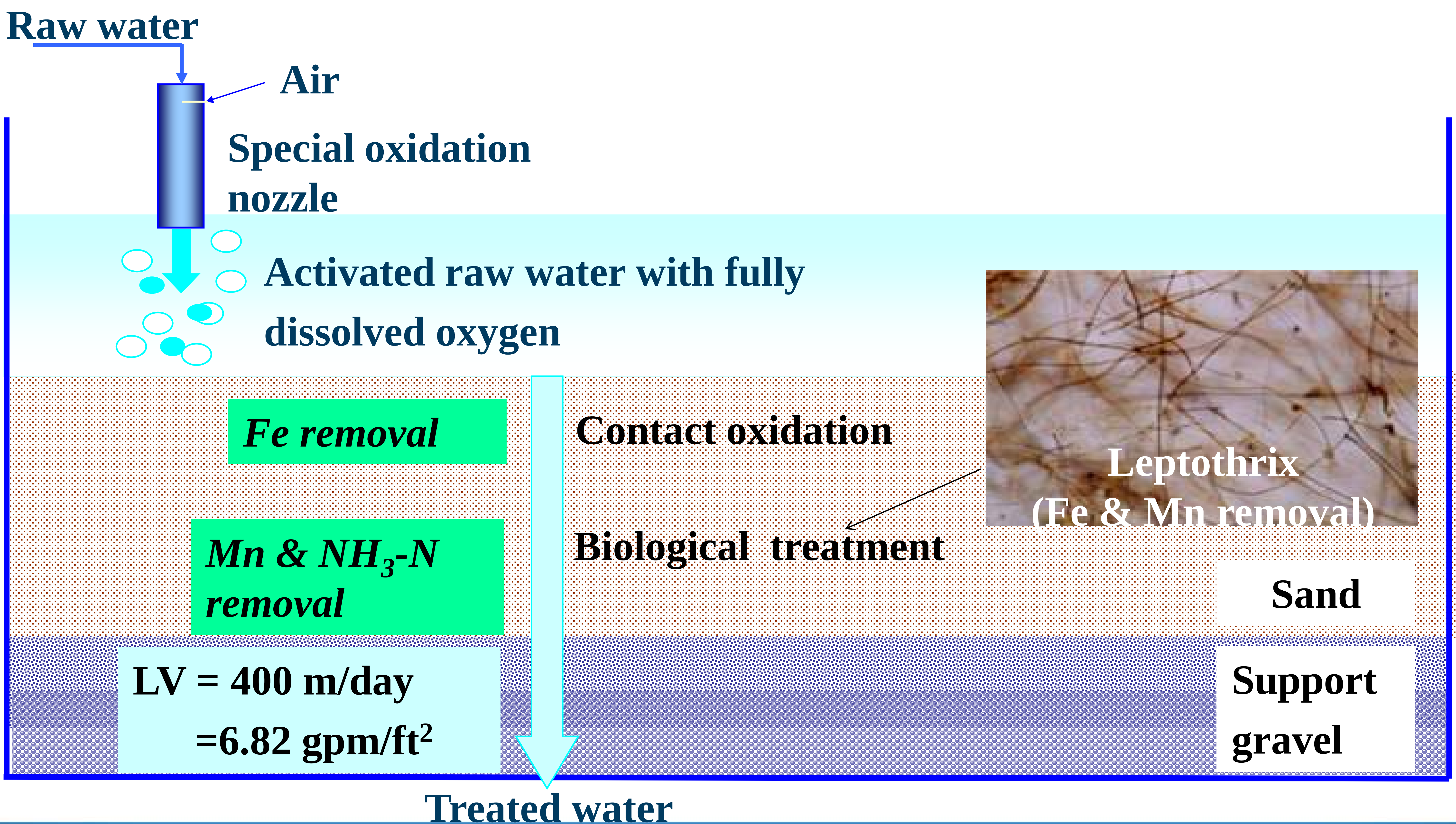
Figure 3: Photo of B Site City Public Utilities, Japan

Figure 2: Photo of A Site Food Company , Japan

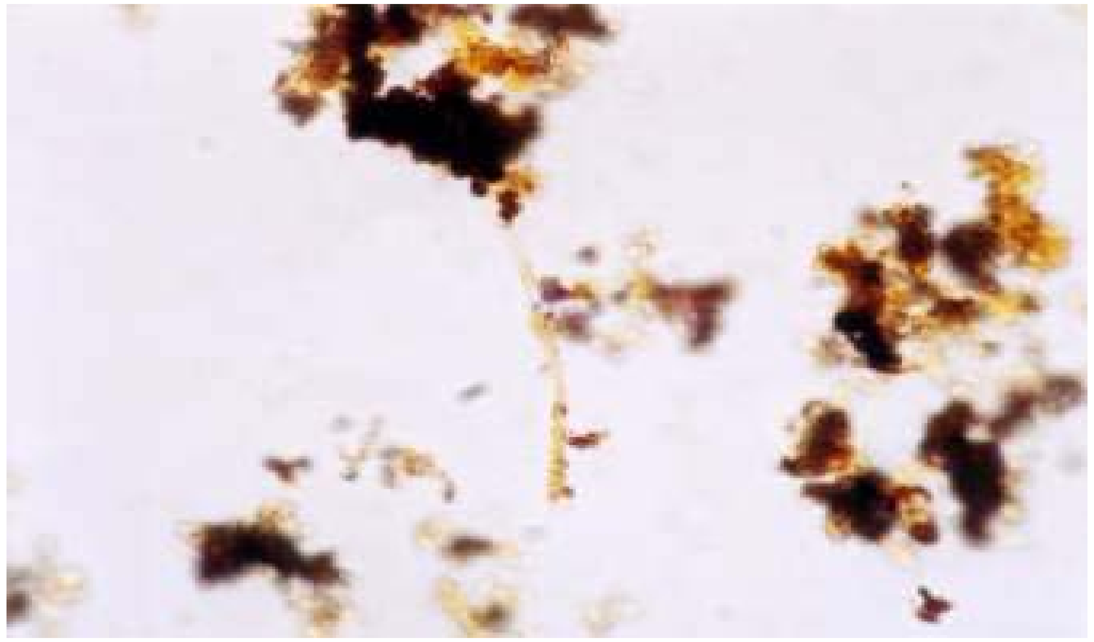
Japanese Biological Removal Systems

Site	Purpose	Capacity		Raw Water Quality (mg/L)	Treated Water Quality (mg/L)
		m^3/d	Million Gallon/d		
T-City H-Plant	Drinking	6,600 x 2 train	1.74 x 2train	Fe:11.1 Mn:1.1 NH_4^+-N:0.4	Fe:0.03 Mn:0.02 NH_4^+-N:<0.05
M-City J-Emergency Water Souce	Drinking	4,500	1.19	Fe: 8.2 Mn:3.3 NH_4^+-N:0.5	Fe:0.03 Mn:0.05 NH_4^+-N:<0.10
Y-Town Y-Plant	Drinking	3,000	0.79	Fe:19.2 Mn:0.6 NH_4^+-N:0.5	Fe:0.08 Mn:0.02 NH_4^+-N:0.00
Y-Town M-Plant	Drinking	1,800	0.48	Fe: 8.1 Mn:0.5 NH_4^+-N:0.5	Fe:0.05 Mn:0.02 NH_4^+-N:0.00
S-City S-Paper Company	Industrial	500	0.13	Fe: 6.9 Mn:0.5 NH_4^+-N:0.9	Fe:0.03 Mn:0.05 NH_4^+-N:<0.10
Car Manufacturer	Pure Water Line	240	0.06	Fe:26.9 Mn:0.9	Fe:0.09 Mn:0.01
Hospital	Private water	600	0.16	Fe: 2.8 Mn:0.8	Fe:0.08 Mn:0.02
Agricultural Association	Tank farming	120	0.03	Fe:25.5 NH_4^+-N:1.4	Fe:0.08 NH_4^+-N:<0.05
Fisheries Association	Fish farming	120	0.03	Fe:12.5	Fe:0.04
Swimming Pool	Swimming	36	0.01	Fe: 6.6 Mn:2.5 NH_4^+-N:1.8	Fe:0.02 Mn:<0.001 NH_4^+-N:<0.05
University	Aspersion	120	0.03	Fe:21.0	Fe:0.12
Construction site	River effluent	8,000	2.11	Fe:30.0	Fe:<0.20

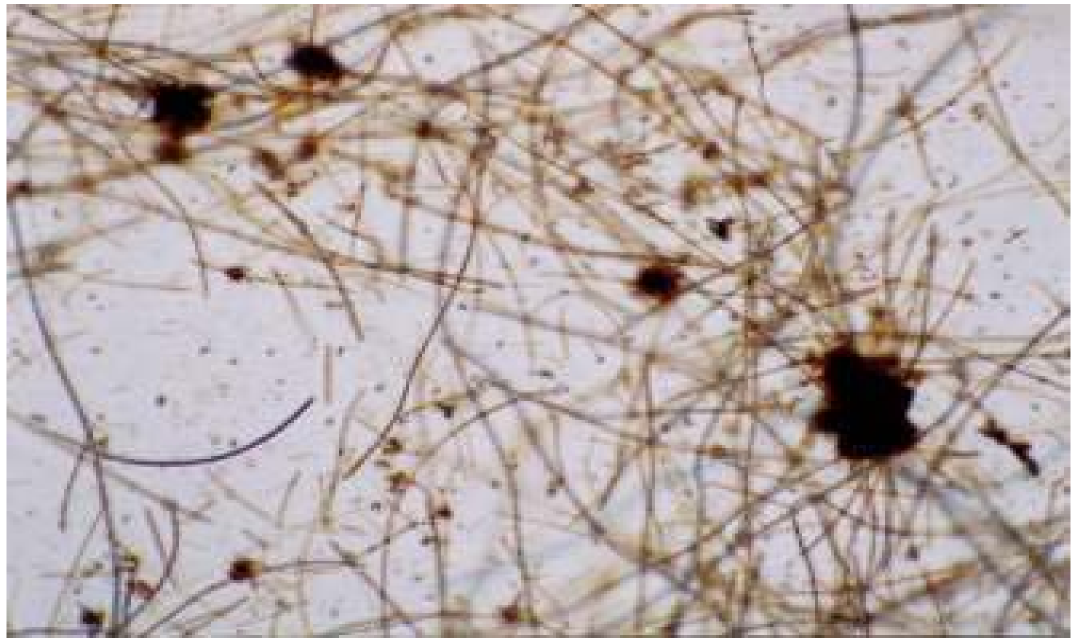
Removal main mechanism



Iron Bacterium

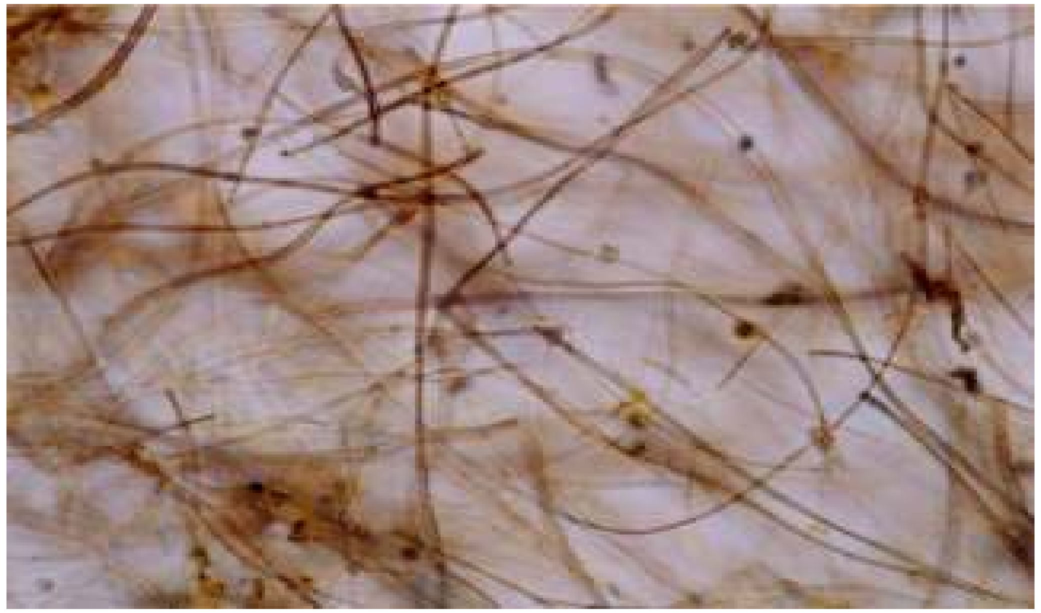


leptothrix-sp400



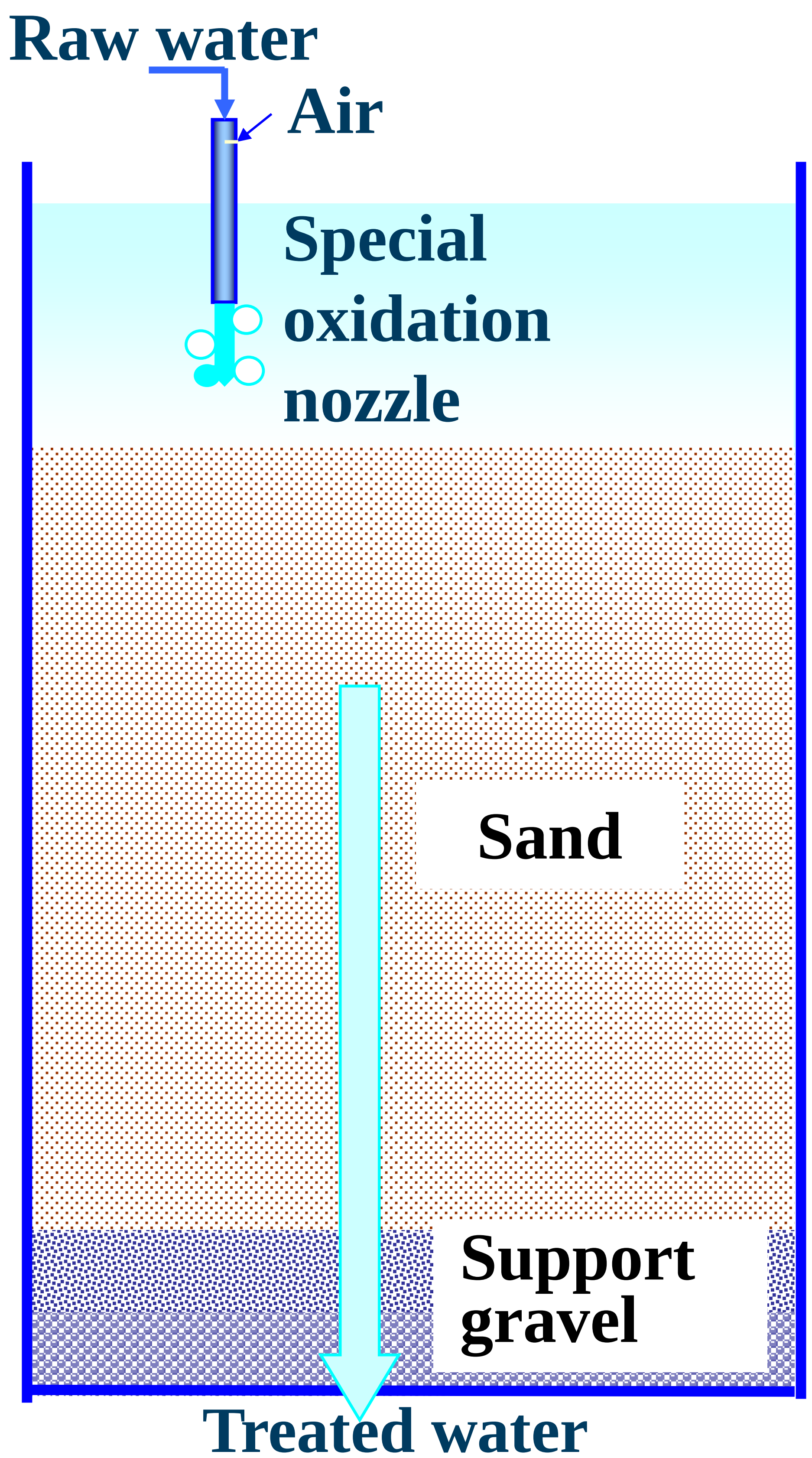
leptothrix-sp200

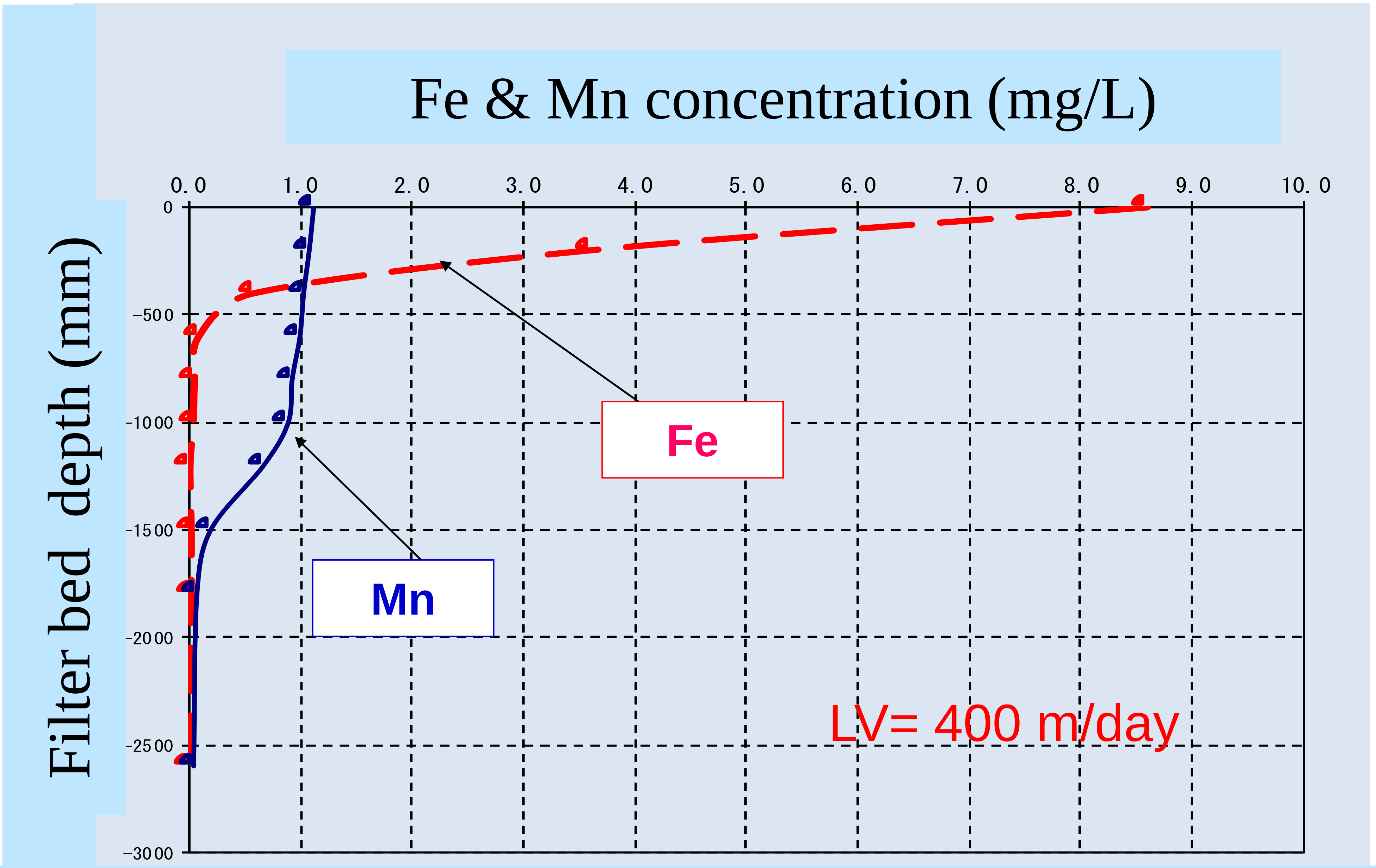
gallionella-sp400



leptothrix-sp400

Removal main mechanism





Change of Fe & Mn concentration with increasing filter bed depth

WP Washing System

WP washing system:

W-washing : Short time normal back washing. (W = Whole)

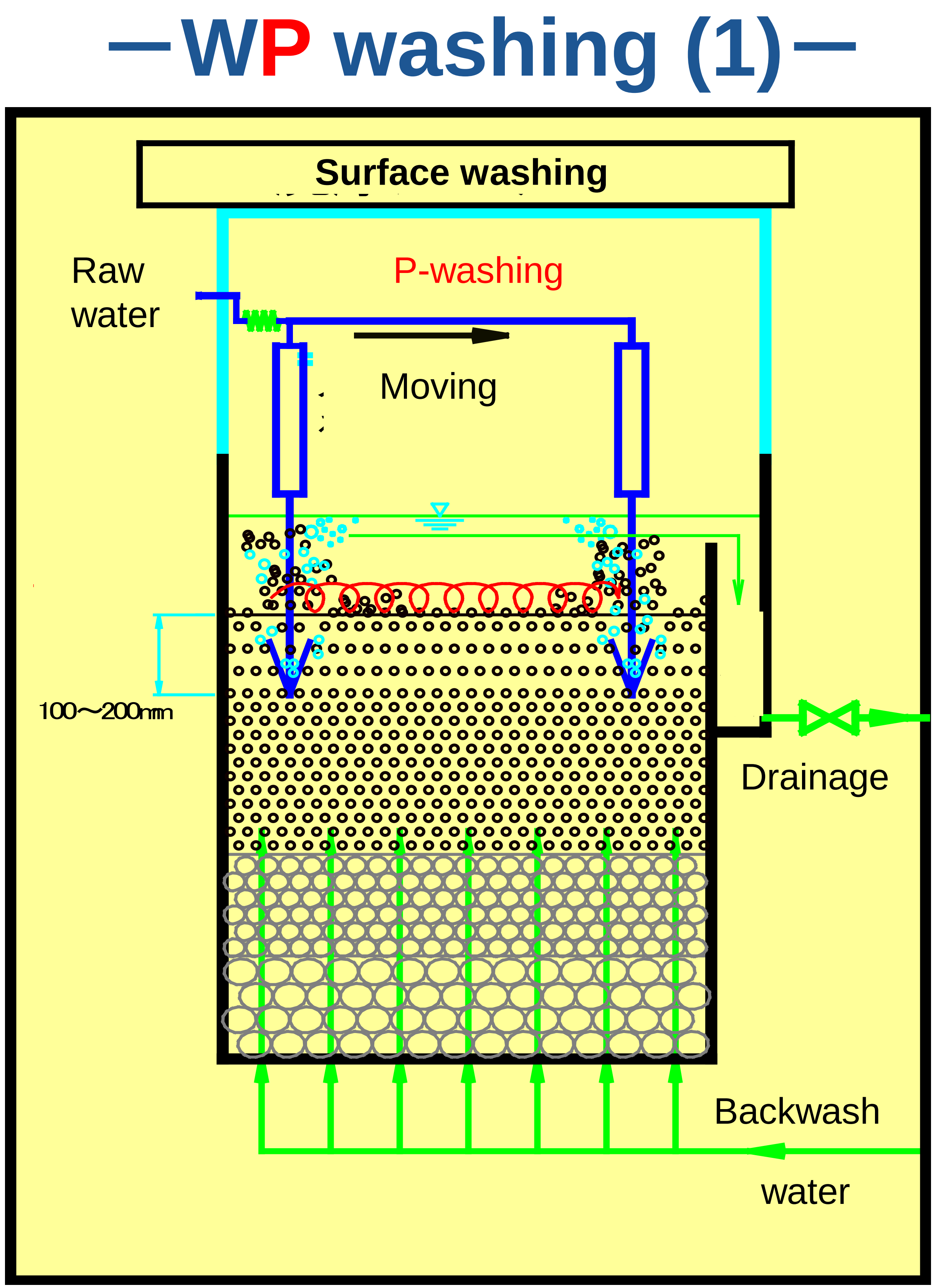
P-washing : By jet stream of nozzles, surface water will be lightly cultivated without moving filter bed, and then drain out through upper channel. (P = Partial)

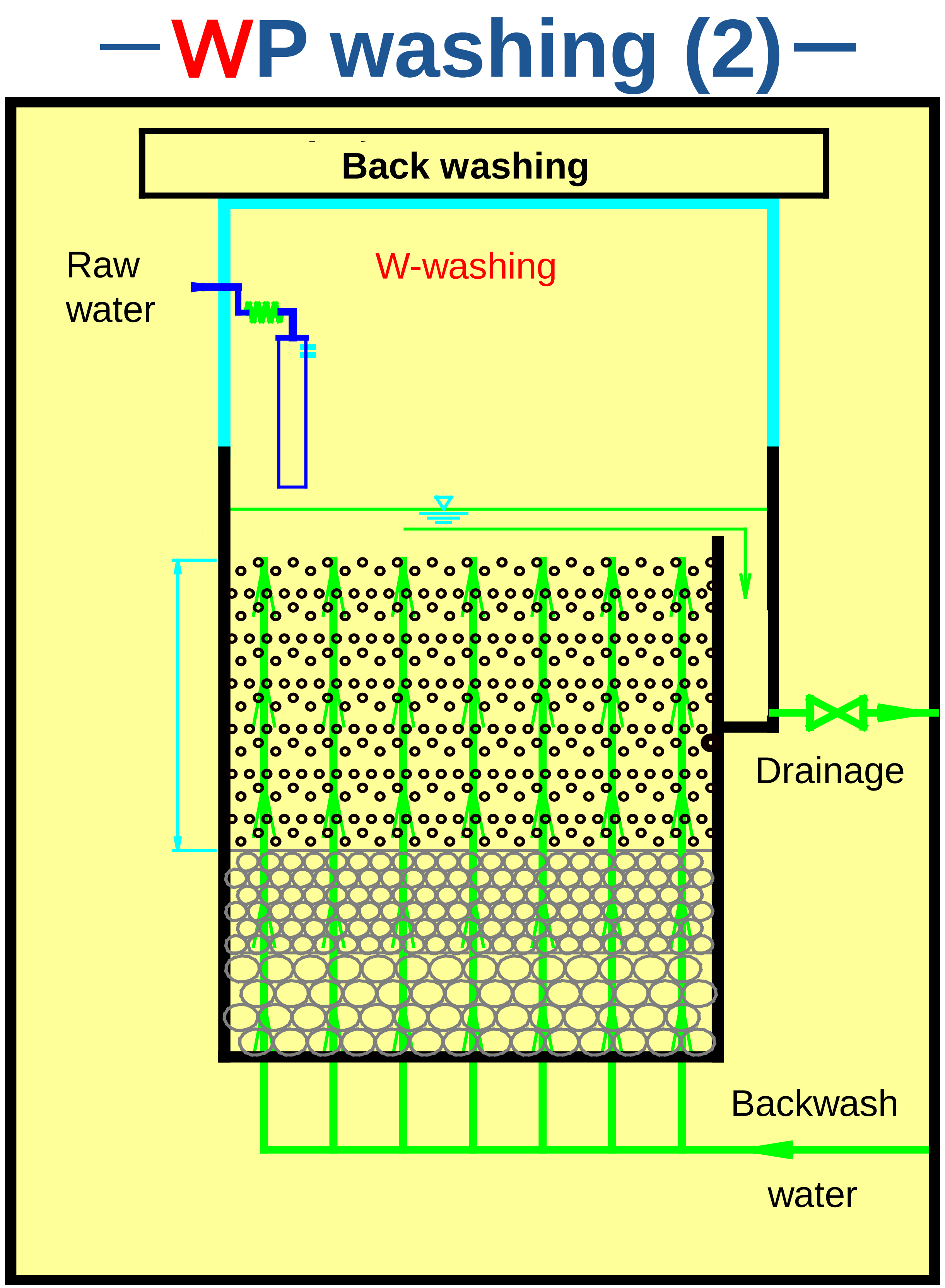
WP washing : Apply more P-washing and minimize W-washing

P-washing : Several times a day
W-washing : Once a day

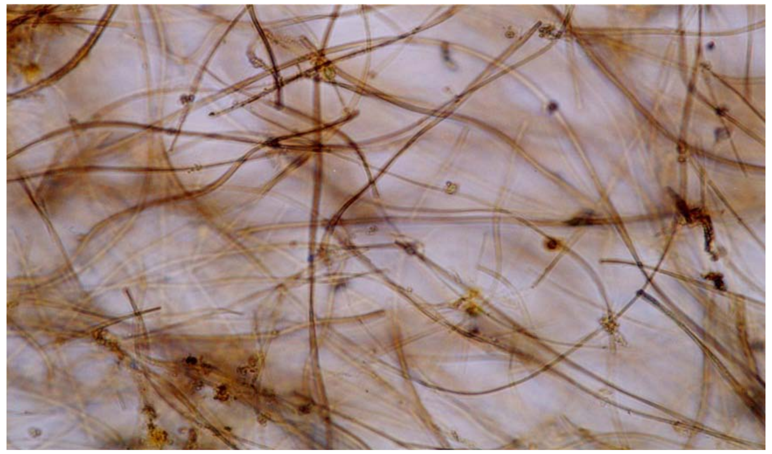
By WP washing system, damages to filter bed with bacteria living in, can be minimized.

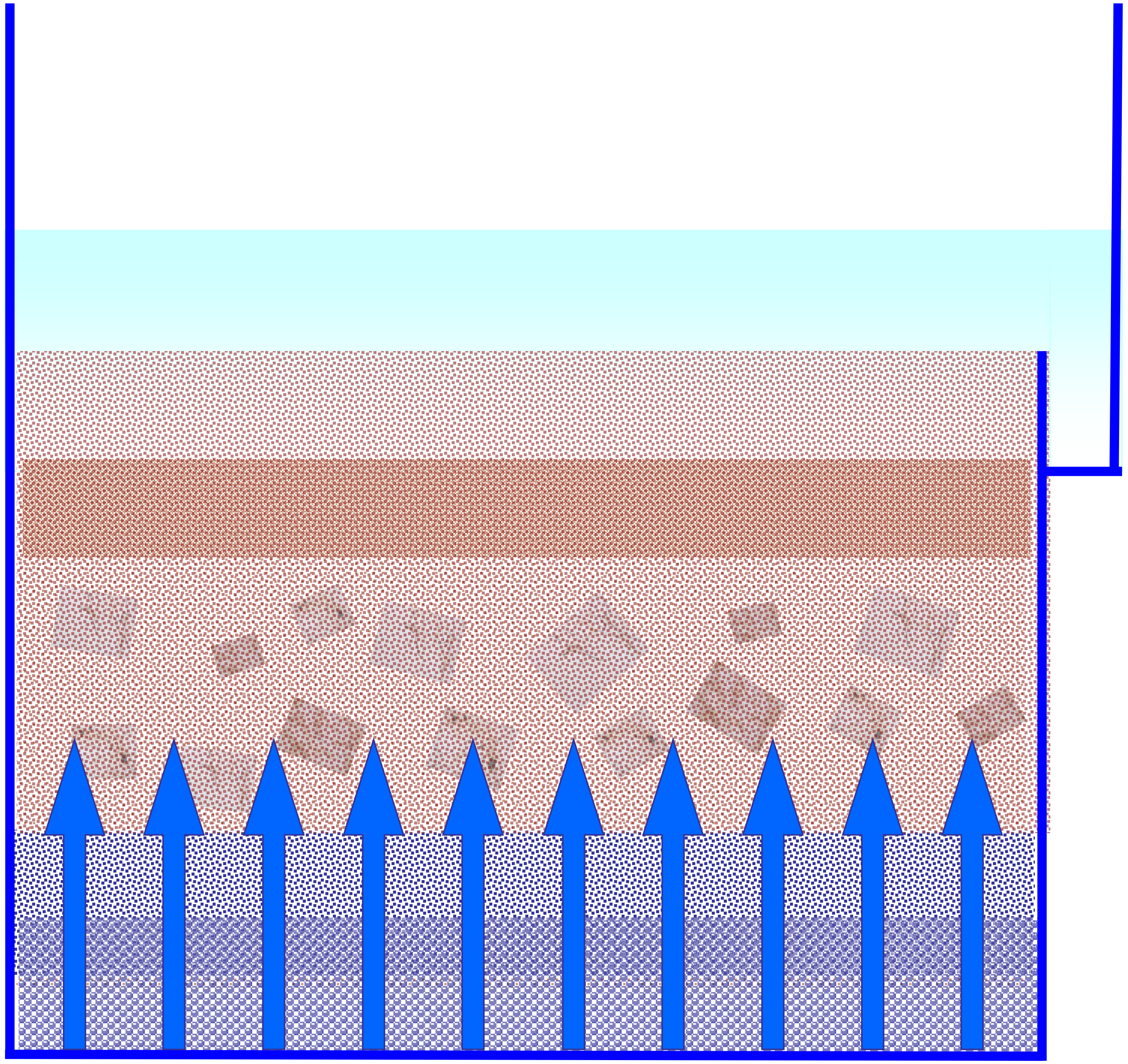
WP Washing System

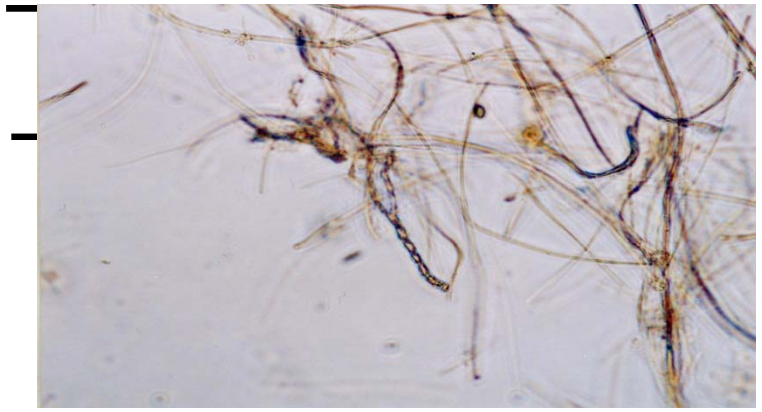




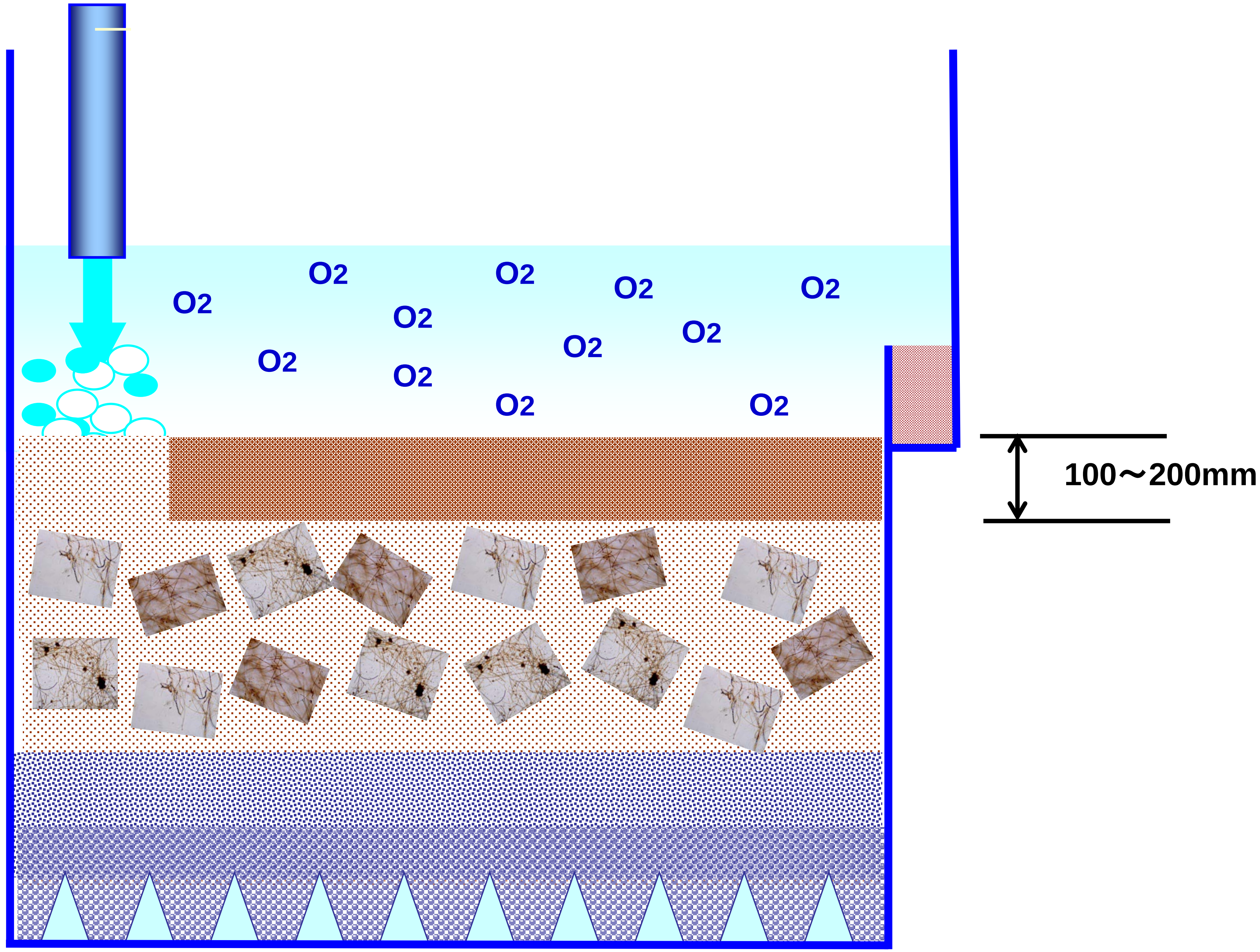
W-washing





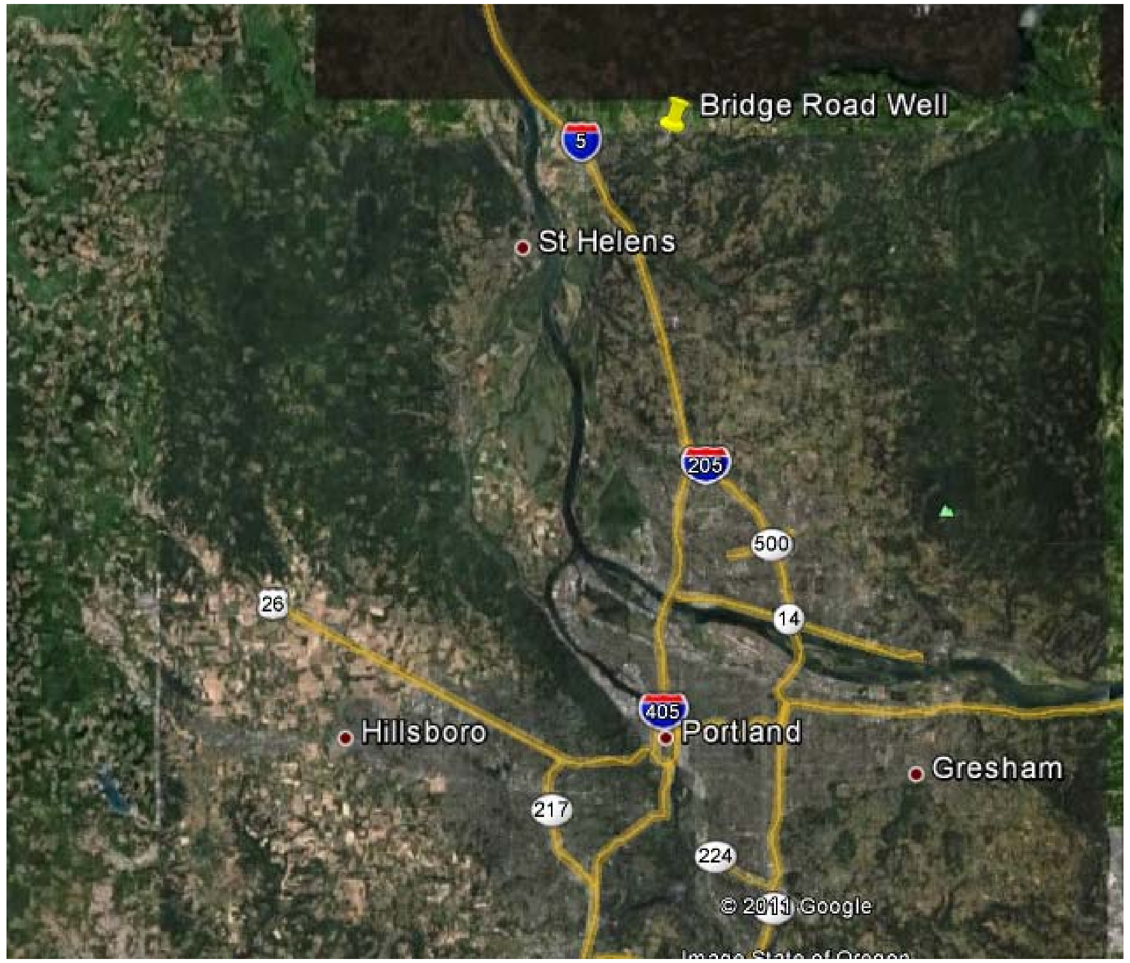


P-washing



Candidate Site: Clark Public Utilities Bridge Road Well

Bridge Road Well



Water Quality

- pH – 6.0 to 6.5
- Iron – 10-18 mg/L
- Manganese 0.2 - 0.45 mg/L
- Arsenic – 30-40 µg/L
- Ammonia – 0.2-0.4 mg/L

Pilot Unit

ETV Process

Organization

- Owner – Contracts with NSF for ETV Testing
- NSF Carries out Testing for EPA
- CH2M HILL Contracts with NSF for Third Party testing

Environmental Technology Verification Test/QA Plan Drinking Water Systems Center

TEST/QUALITY ASSURANCE PLAN FOR THE NAGAOKA INTERNATIONAL CORPORATION CHEMILES NCL SERIES GROUNDWATER TREATMENT SYSTEM FOR REMOVAL OF ARSENIC, IRON, MANGANESE, AND AMMONIA

Prepared by

NSF

NSF International

Under a Cooperative Agreement with

EPA United States Environmental Protection Agency

ETV ETV ETV

ETV Agencies

- USEPA/NRMRL
- NSF International
- Scherger Associates
- Owner
- CH2M HILL
- Clark Public Utilities

- ETV Program Owner
- ETV Program Manager
- ETV Consultant
- Equipment Supplier
- Third Party Testing Agency
- Host Utility

ETV Testing – Evaluation

Quantitative Factors

- Feed Water Flow Rate
- Treated Water Quality
- Length of Operating Cycle
- Frequency of Backwash
- Power Consumption
- Maintenance Requirements
- Required Level of Operator Attention
- Spatial Requirements
- Discharge Requirements
- Waste Disposal

Qualitative Factors

- Ease of Operation
- Safety
- Susceptibility to Environmental Conditions
- Impact of Operator Experience on Successful Operation

ETV Testing

Water Quality

- Temperature
- Alkalinity
- pH
- Oxidation Reduction Potential
- Turbidity

Inorganic Parameters

- Arsenic (III)
- Arsenic (V)
- Total Iron
- Dissolved Iron
- Ammonia
- Nitrate/Nitrite
- Manganese
- Total Kjeldahl Nitrogen

Other Parameters

- Hardness
- True Color
- DO
- Total Organic Carbon (TOC)
- Total Suspended Solidds (TSS)
- Volatile Suspended Solids (VSS)
- Color
- Sulfate
- Sulfide
- Fluoride
- Heterotrophic Plate Count (HPC)
- Silica
- Sodium
- Potassium

Bridge Road Well Installation

Nice Crane Work

The Crate

Bridge Road Well

Assembly

Bridge Road Well

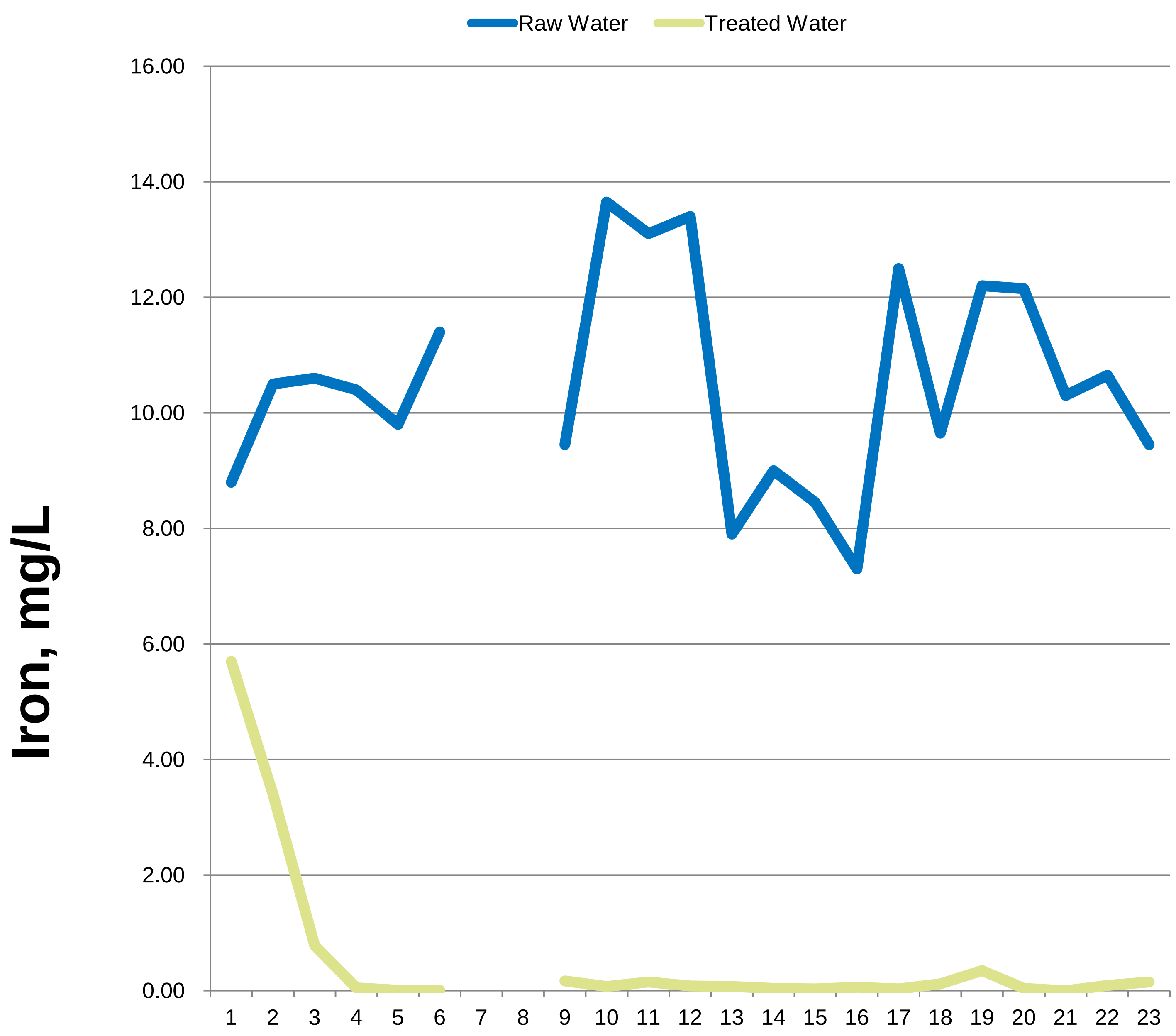
Assembly Day 5

ETV Testing

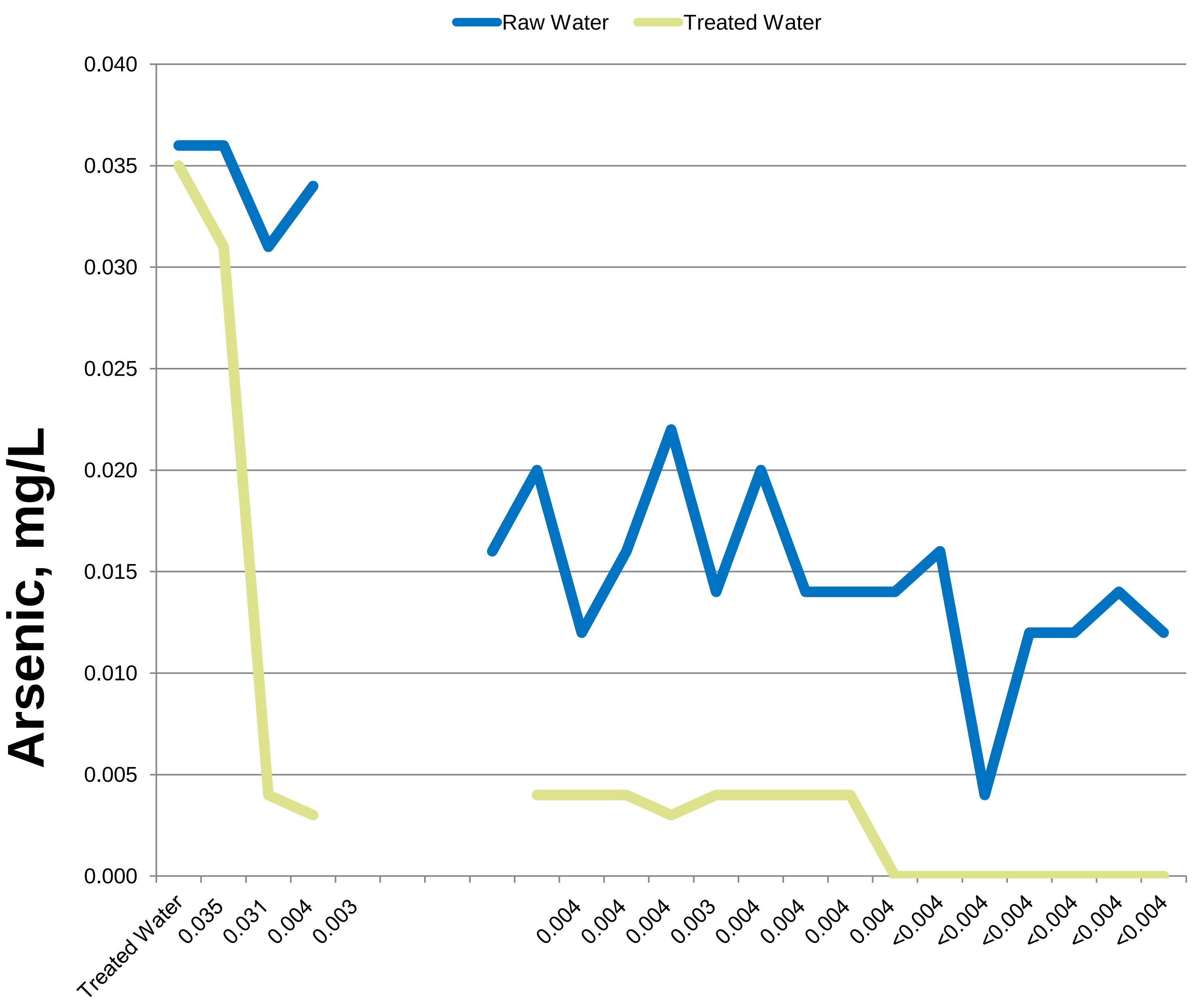
Milestone	Time Frame
EPA Approval of the Test Plan	October 2011
Equipment Installation	October 15, 2011
Startup/Shakedown Testing	October 15 – 25, 2011
Raw Water Characterization (Task A)	October 2011
Filter Cultivation & Initial Test Runs (Task B)	October 2011 to January 2012
Verification Test (Task C)	
-Iron and Arsenic Removal	November 2011 – April 2012
-Manganese and Ammonia	February 2012- July2012
Complete Analytical Data and Summaries	September 2012
Draft Final Report	September 2012 to December 2012

Initial Bridge Road Well Results from 10/17/2011 – 5/1/2012

Initial Iron Removal

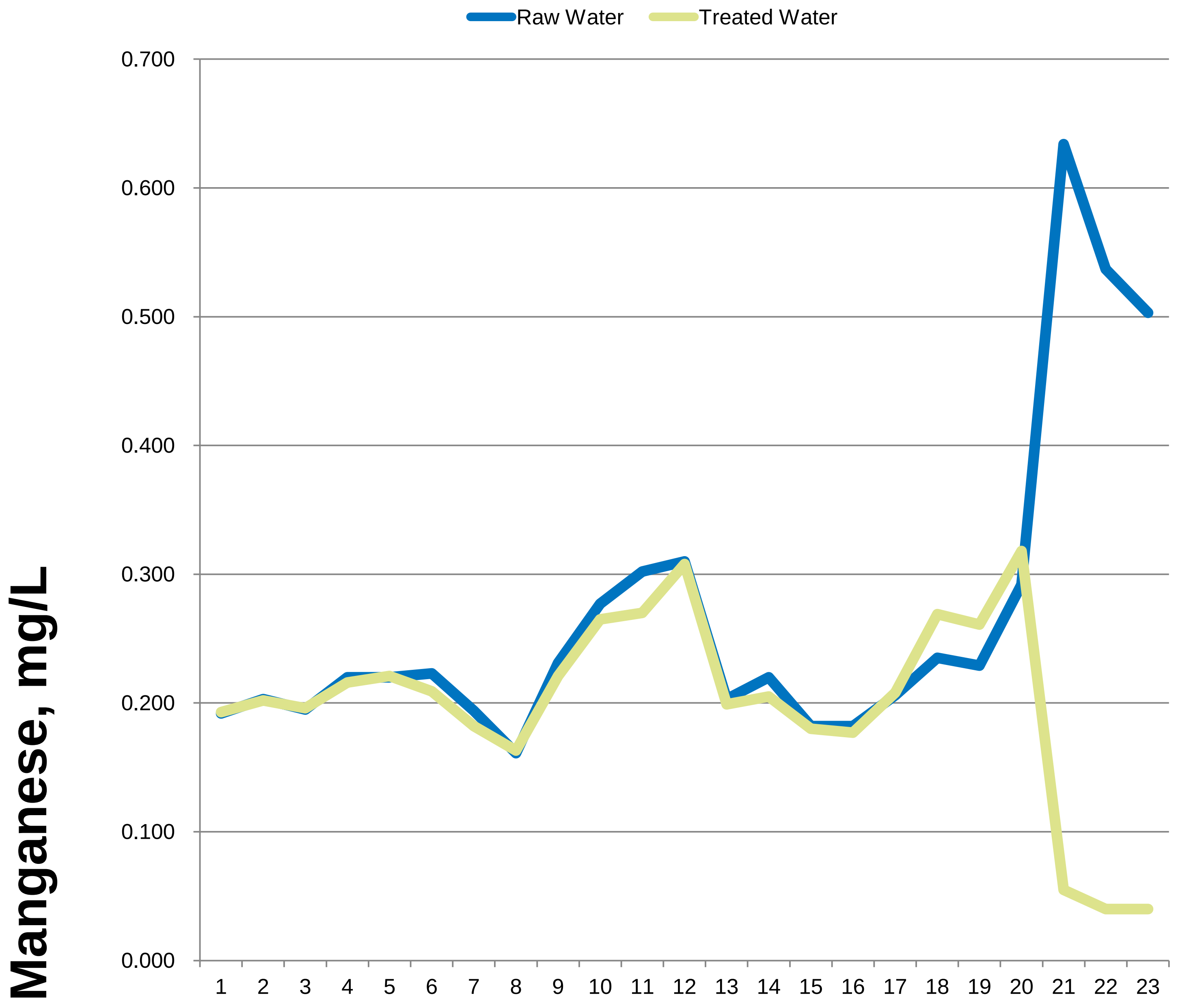


Initial Arsenic Removal

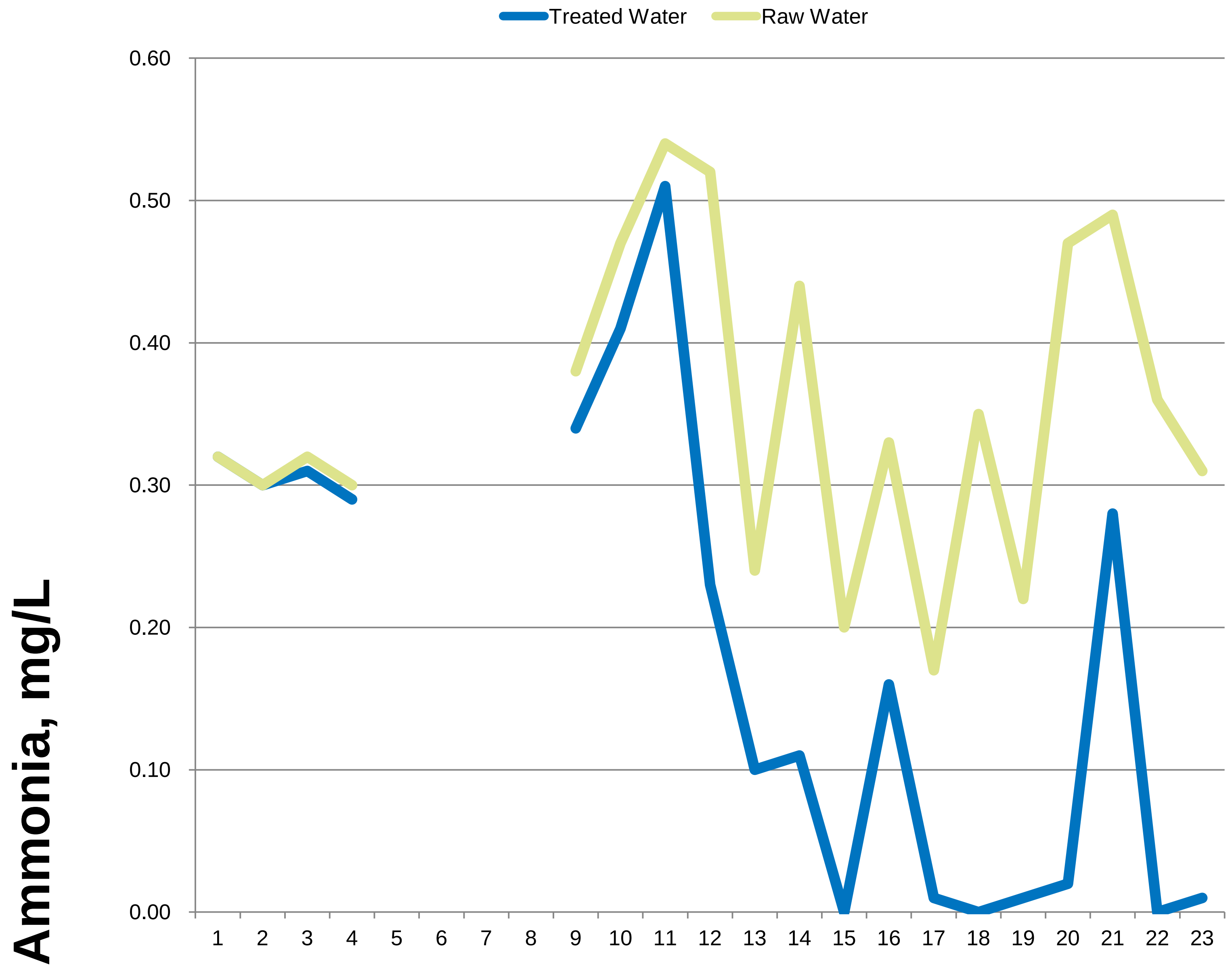


Initial Bridge Road Well Results from 10/17/2011 – 5/1/2012

Initial Manganese Removal



Initial Ammonia Removal



Pilot Operating Conditions

Parameter	Value
Flow, gpm	4.7
Loading Rate, gpm/sq ft	6.2
Nozzle Pressure, psi	17
P-Washing Frequency	8 hours
W-Washing Frequency	36 hours
pH	6.5 Inlet/7.2 outlet
Temperature, C	12-14
DO	6-7 mg/L in Treated Water

Lee Odell, PE
Water Treatment Global Technology Lead
CH2M HILL
lee.odell@ch2m.com

Sunlight-Driven Generation and Activation of Free Chlorine in Drinking Water Disinfection: Looking at Chlorination Processes in Another Light

Michael Dodd,[1*] Jenna Forsyth,[1] Christine Fagnant,[1] Nina Mao,[1] J. Scott Meschke[2]

[1]Department of Civil and Environmental Engineering
[2]Department of Environmental and Occupational Health Sciences
University of Washington

Pacific Northwest Section – American Water Works Association
2012 Annual Conference, Yakima, WA
Friday, May 4, 2012

Modern-day disinfection practice

Commonly-used disinfectants:

- **"Free" available chlorine (FAC)** – Applied as $Cl_{2(g)}$ or NaOCl (HOCl is typically the active disinfectant in either case)
- **Chloramines, or "Combined" chlorine** – Applied either as pre-formed NH_2Cl, or by mixing NH_3 and HOCl
- **Chlorine dioxide** – Applied as $ClO_{2(g)}$
- **Ozone** – Applied as $O_{3(g)}$ (no long-term residual)
- **Ultraviolet light** – Applied via submerged UV lamps (no residual)

Facility Type	**Percentage (%) of U.S. Treatment Facilities Using Each Disinfectant (Alone or in Combination with Others)**				
	HOCl	NH_2Cl	O_3	ClO_2	UV
Wastewater	75	-	0.2	-	21
Drinking Water	97	31	4	6	2

*Wastewater usage as of 2006 (WERF); Drinking water usage as of 2000 (EPA)

I. Sunlight-Driven Chlorine Generation

"Green" on-site Cl_2 production?

- Safety and security concerns of storing Cl_2(g) make it increasingly unattractive for WTPs
- NaOCl or $CaOCl_2$ are relatively low cost alternatives, but decomposition and oxyhalide by-product formation can occur during storage,
- On-site, electrolytic chlorine synthesis methods are quite energy intensive
- A convenient, off-grid means of generating chlorine on-site could be very useful for improving sustainability of centralized and decentralized water treatment
- Solar photosensitized activation of Cl^- may provide an attractive option

Aromatic ketone-halide photochemistry

- Triplet states of certain aromatic ketones are capable of oxidizing halide ions by electron-transfer processes:

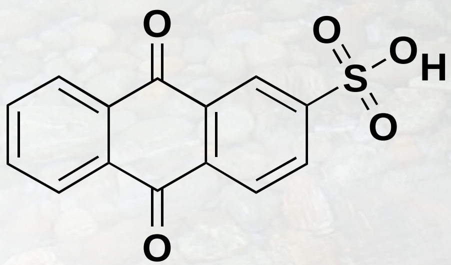
Adapted from Loeff et al. (1993), Canonica et al. (2005)

- At high Cl^- concentrations, formation of Cl_2 occurs
- 2 moles of $O_2^{\bullet -}$ are produced for every 2 moles of $Cl_2^{\bullet -}$:

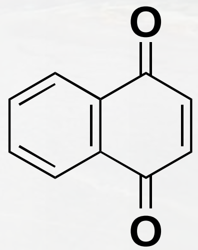
$\Rightarrow$ resulting H_2O_2 formation can limit Cl_2 production

Examples of aromatic ketone photosensitizers

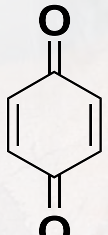
- Quinones
  - Anthraquinone-2-sulfonate



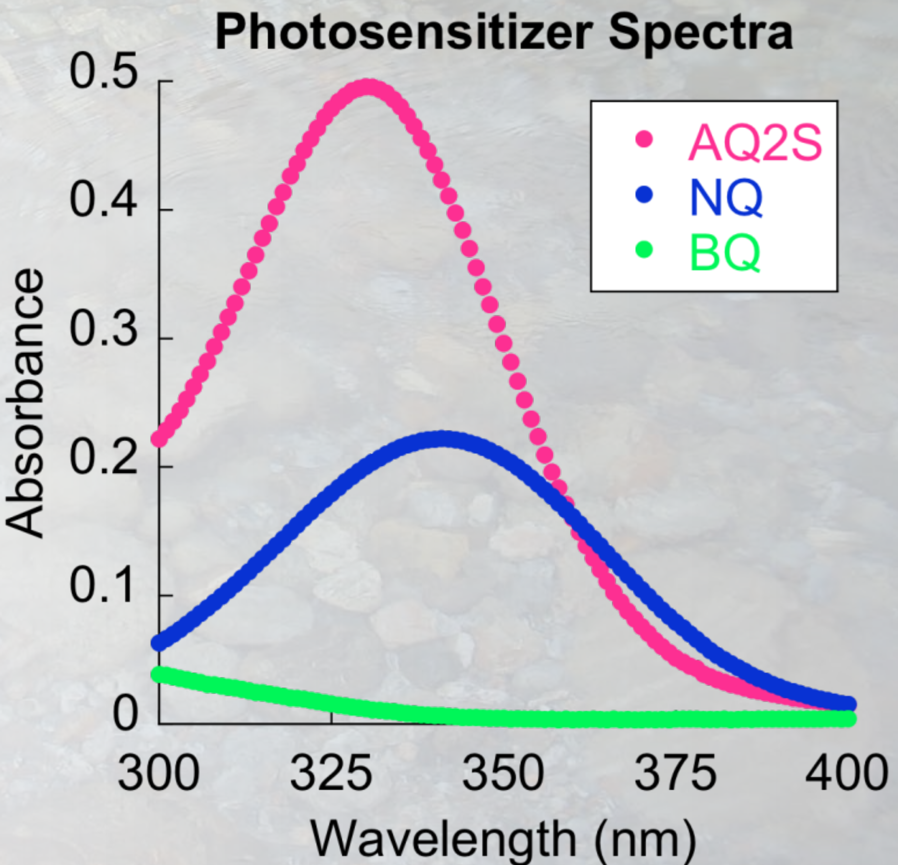
  - 1,4-Naphthoquinone



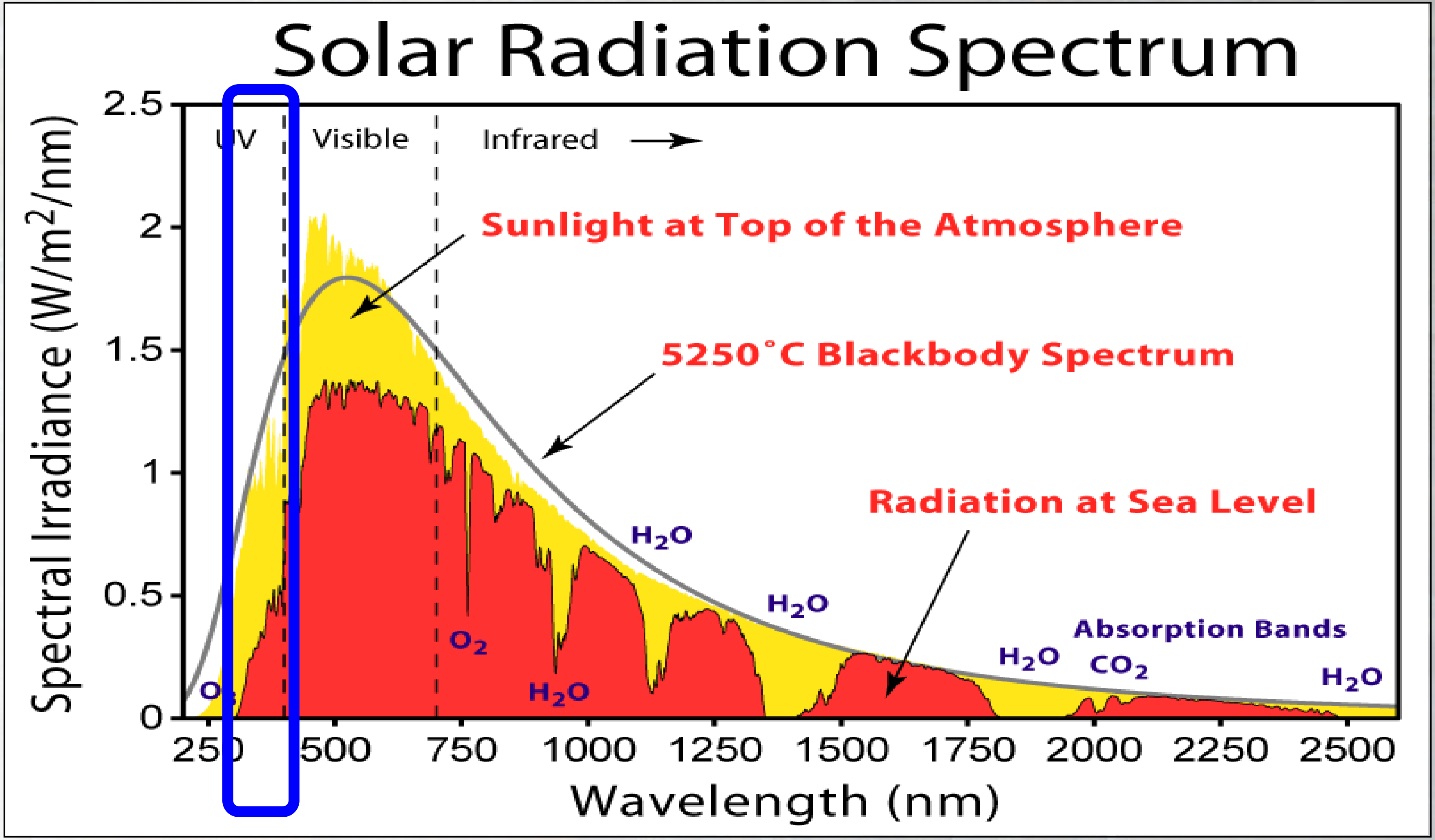
  - 1,4-Benzoquinone



Anthraquinones, in particular, characterized by substantial absorbance of UVA radiation ⇒ overlap with solar spectrum



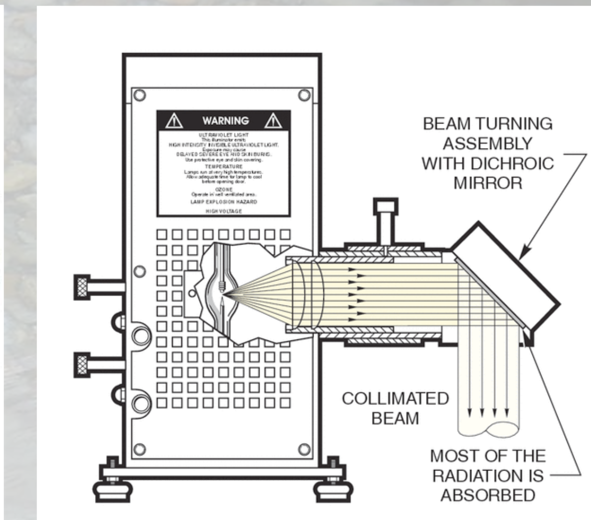
Solar spectrum



Adapted by Rohde (2009) from ASTM Terrestrial Ref. Spectra

Experimental – Collimated solar simulator

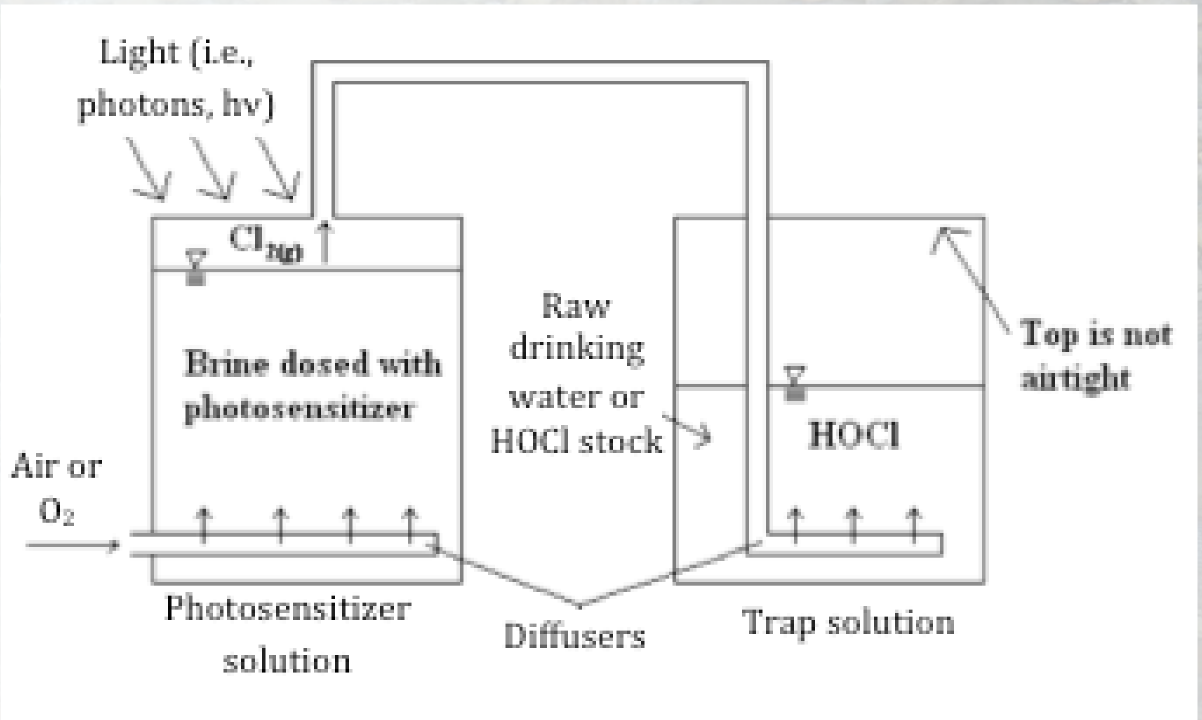
- Newport-Oriel 450-W Xe (O_3-free) arc research lamp with 2” collimated beam
- Output ~1.3 “suns”



- Lamp output reflected at right angle with a coated dichroic mirror for IR attenuation ⇒ light passage limited to ~250-450 nm
- Atmospheric attenuation filter used in all experiments; limits emission spectrum to 300-400 nm (simulation of direct sunlight at ocean surface)
- Irradiance checked periodically by means of:
  - Spectradiometric measurement (Ocean Optics USB2000)
  - Chemical actinometry (typically using PNA/pyridine)

Cl_2 generation, transfer, and trapping

- Samples irradiated in glass photochemical reactor



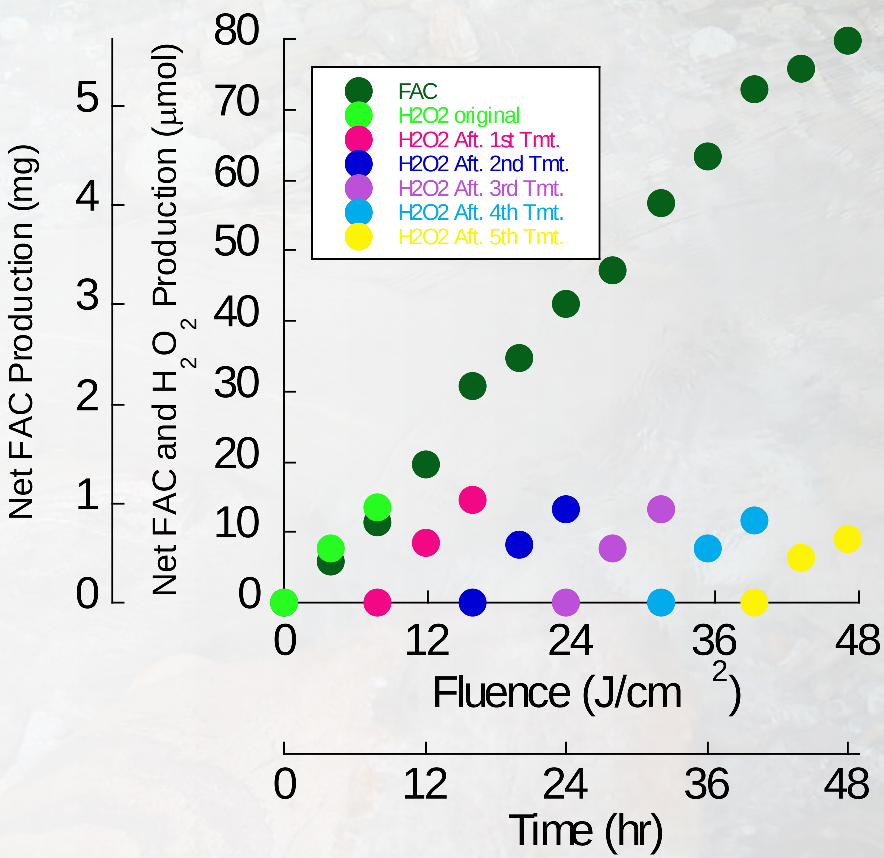
- Acidic conditions, Cl_2-HOCl equilibrium shifted to Cl_2:

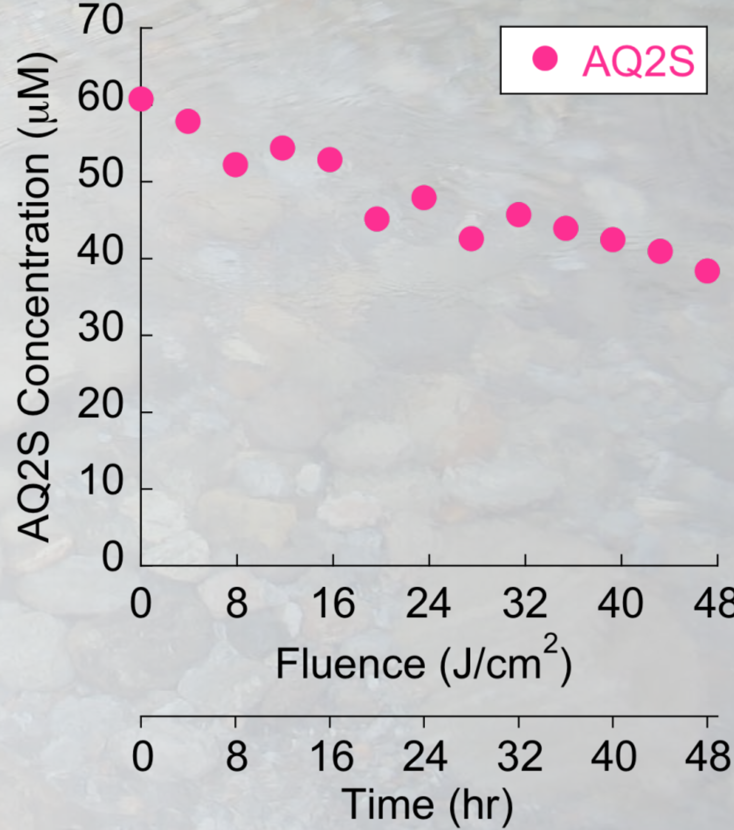
$$Cl_2 + H_2O \leftrightarrow HOCl + Cl^- + H^+ \; (pK_{hydrolysis} = 3.0)$$

- $Cl_{2(g)}$ purged with a stream of compressed air from photosensitizer solution and into alkaline trap solution (0.1 M NaOH), where Cl_2 immediately hydrolyzes to HOCl

Cont. irradiation w/ offline H_2O_2 quenching

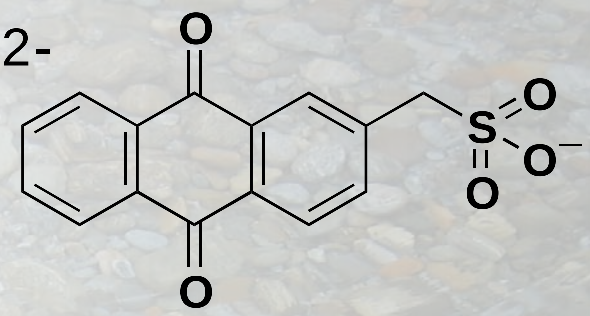
- AQ2S reactor solutions (within 51-mm diam. reactor)
- After pre-determined irradiation intervals, solutions taken off-line for elimination of H_2O_2 by cerium oxide (CeO_2)
- H_2O_2-free solution returned to service

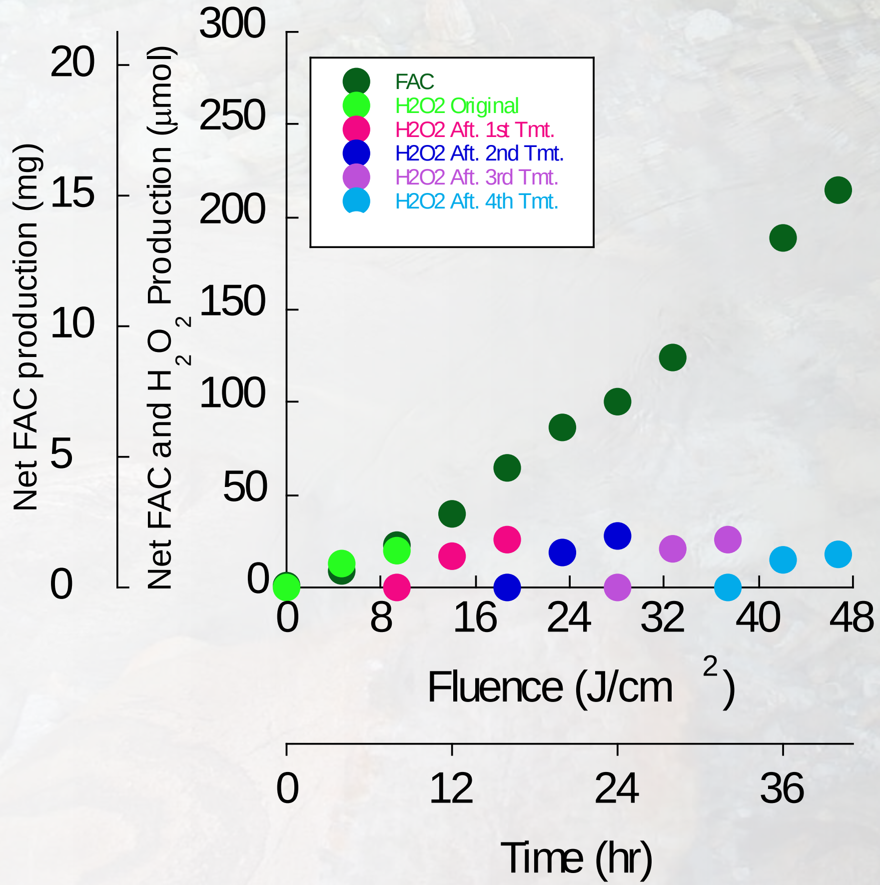


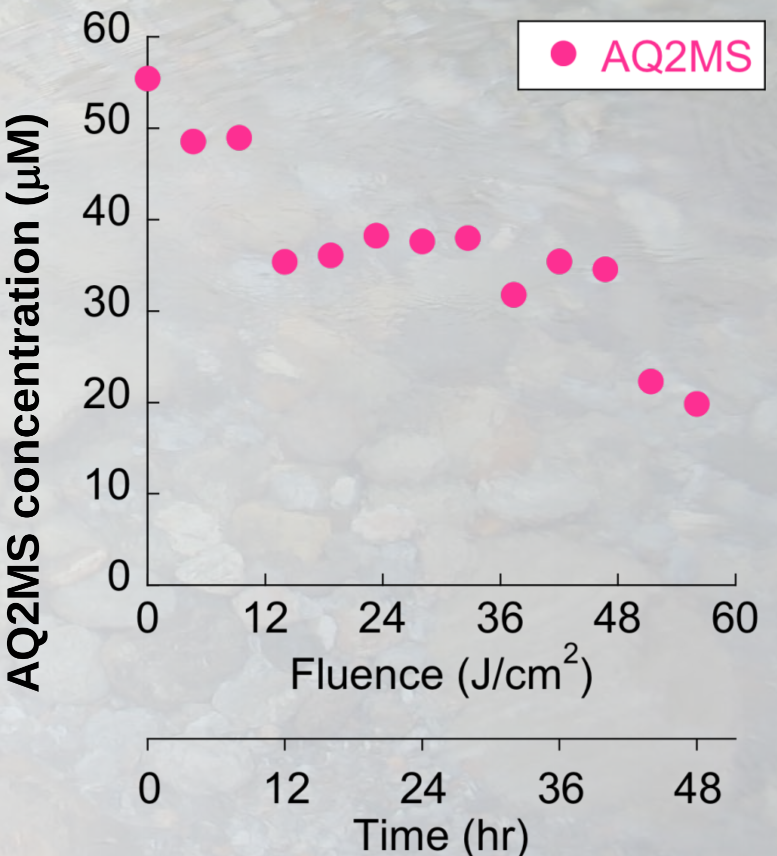


Cont. irradiation w/ offline H_2O_2 quenching

- Solutions of anthraquinone-2-methylsulfonate (theoretically more photoactive than AQ2S):







Key findings

- Anthraquinones capable of photochemically activating Cl^- to free chlorine under simulated sunlight and at moderate acidity
- Outputs directly scalable to surface area. For typical solar output, Cl_2 yields would be ~4-5 x 10^{-11} mol/cm^2/s with AQ2S.
- For a 10 m^2 reactor surface under natural sunlight, theoretical chlorine production rate should be ~1-2 g/hr.

$\Rightarrow$ Treatment of up to 1000 L (264 gallons) of water per hour (daylight) w/ 2 mg/L free chlorine

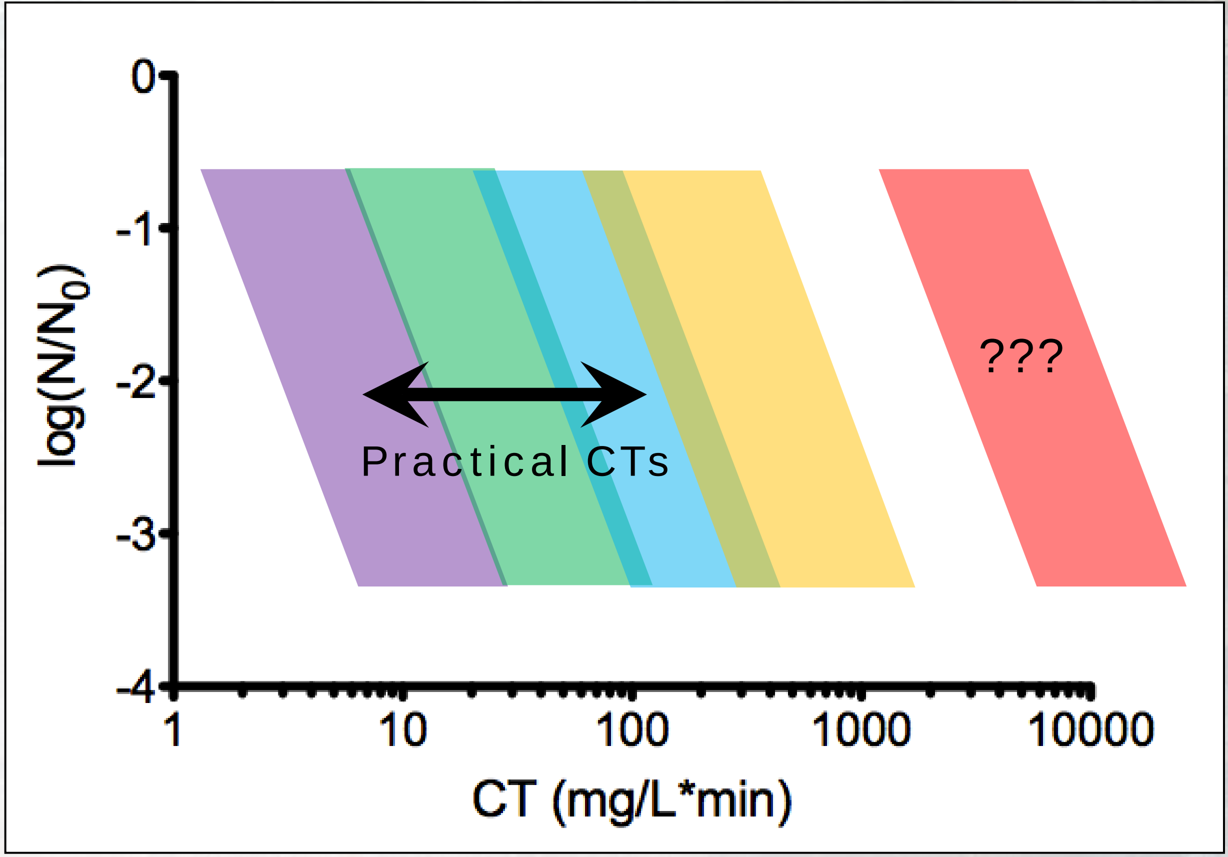
- Yields and system longevity may be extended through the use of optimally-designed anthraquinones.

II. Sunlight-Driven Chlorine Activation

Free chlorine CTs in water treatment

Free chlorine in WTPs:

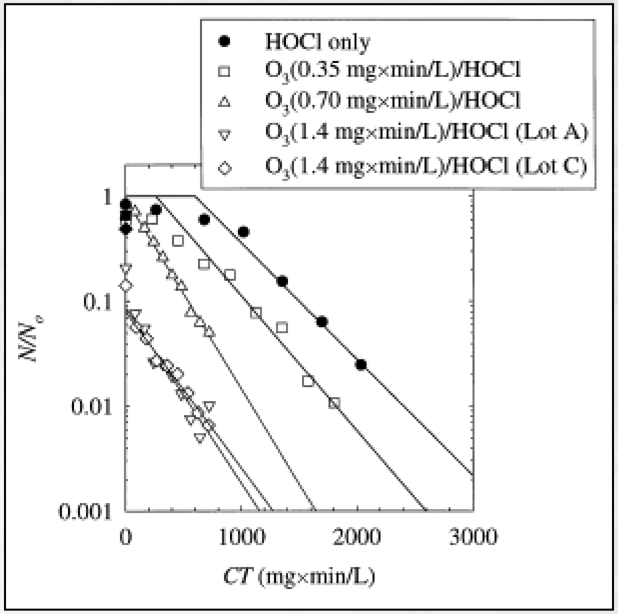
- For disinfection with HOCl/OCl$^-$, typical chlorine CTs insufficient to inactivate various highly chlorine-resistant pathogens (e.g., *C. parvum*, *M. avium*):

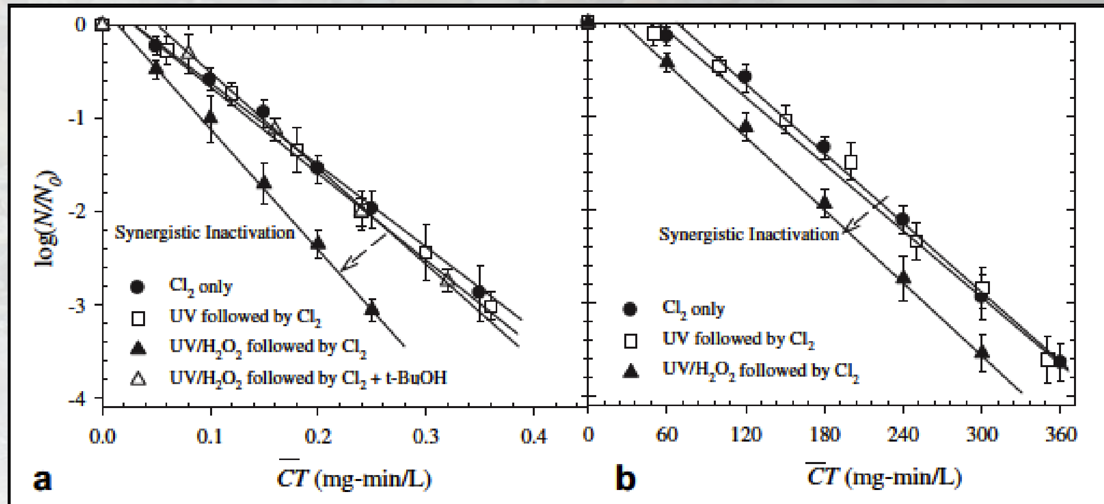


Typical ranges of CT values required for various degrees of microorganism inactivation (pH 8, *T* = 25° C):

- Viruses
- *G. lamblia*
- *B. subtilis*
- *M. avium*
- *C. parvum*

Pre-oxidation of chlorine-resistant pathogens



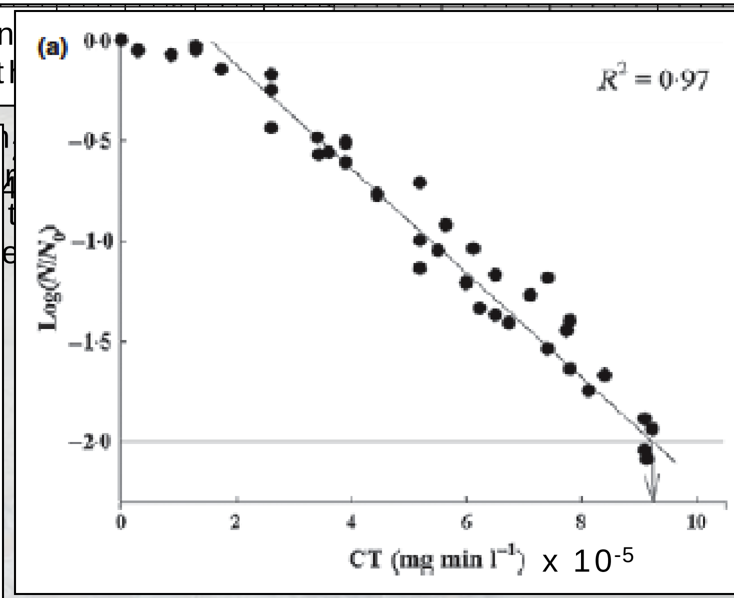


Inactivation kin... spores during th... and sequential...

	OH radical*	Ozone	Chlorine dioxide	Free chlorine
C. parvum	$9\cdot3 \times 10^{-5}$	3·5	70	4200
B. subtilis spores	$8\cdot2 \times 10^{-5}$	4·1	50	450
E. coli	$1\cdot5 \times 10^{-?}$†	$6\cdot0 \times 10^{-3}$	$8\cdot0 \times 10^{-2}$†	$1\cdot3 \times 10^{-1}$
Oxidation potential (V)	2·70	2·07	0.95	1·36

Table 3 Comparison of the CT (mg min l^{-1}) values of four important disinfectants for the 2 log inactivation of *Cryptosporidium parvum*, *Bacillus subtilis* spores and *Escherichia coli* at pH 5·8 and 20°C

*Results using the photo/ferrioxalate system.
†Cho *et al.* (2004a).

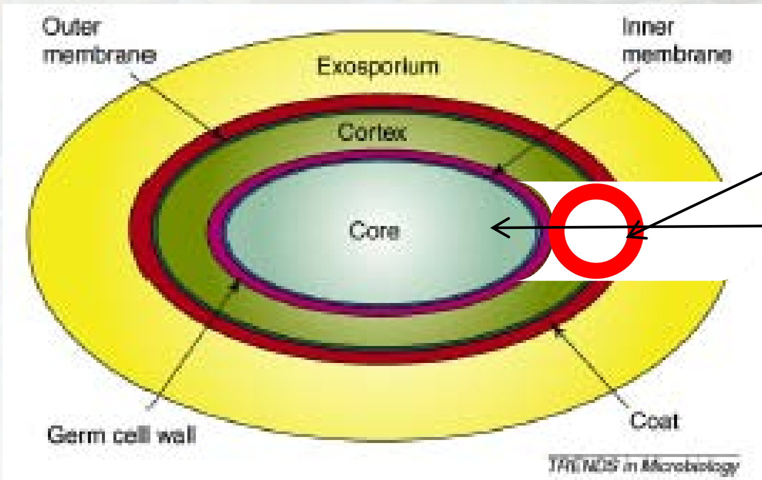


CT values for $OH^•$ inactivation of *C. parvum* using the photo/ferrioxalate system to generate $OH^•$ (Cho and Yoon, 2008)

B. subtilis spore inactivation

Possible mechanism(s) of enhancement:

- Pre-oxidation of spore coat, and/or spore cortex?



Adapted from Setlow (2007)

Coat composed of various proteins (HOCl-reactive?)

Cortex composed of peptidoglycan (HOCl-nonreactive)

Highly impermeable inner membrane composed of lipids and proteins, integrity linked to cortex and germ cell wall

Exosporium not relevant to *B. subtilis*

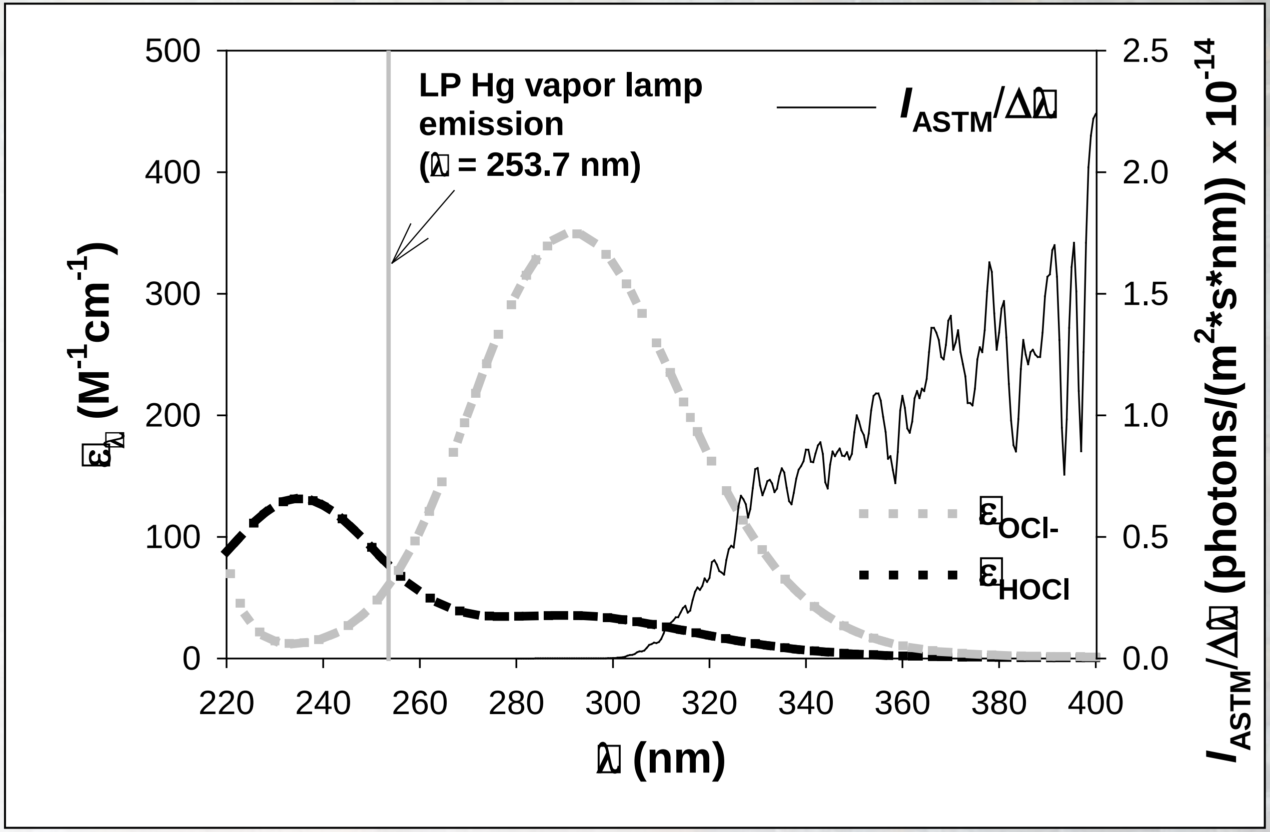
Table 1. Summary of general disinfectant reactivities toward major biomolecule classes

Disinfectant	**Reactivities of Various Disinfectant Species toward Microbial Biomolecules**			
	Lipids	**Proteins (Amino acids)**	**Polysaccharides**	**Nucleic acids (Nucleobases)**
FAC[a]	Moderate	Low to Moderate	Low	Moderate
NH_2Cl[b]	Low	Low	Low	Low
O_3[c]	High	High	Low	Moderate
ClO_2[d]	Low	Low to High[f]	Low	Low
HO•[e]	High	High	High	High

[a-e]General reactivities based on the following references for [a]FAC (*19-30*), [b]NH_2Cl (*31-33*), [c]O_3 (*34-45*), [d]ClO_2 (*46-50*), [e]HO• (*51-53*); [f]ClO_2 appreciably reactive only toward tyrosine, tryptophan, cysteine, and methionine

Free available chorine photochemistry

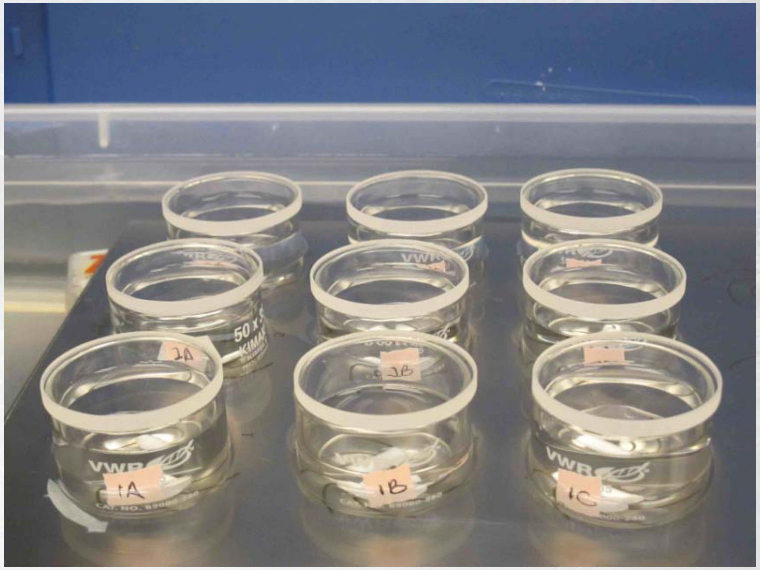
- Substantial overlap of HOCl/OCl⁻ spectra with solar spectrum
- pH-dependent photolysis rates for solar illumination, due to differences in UV absorption spectra for HOCl and OCl⁻



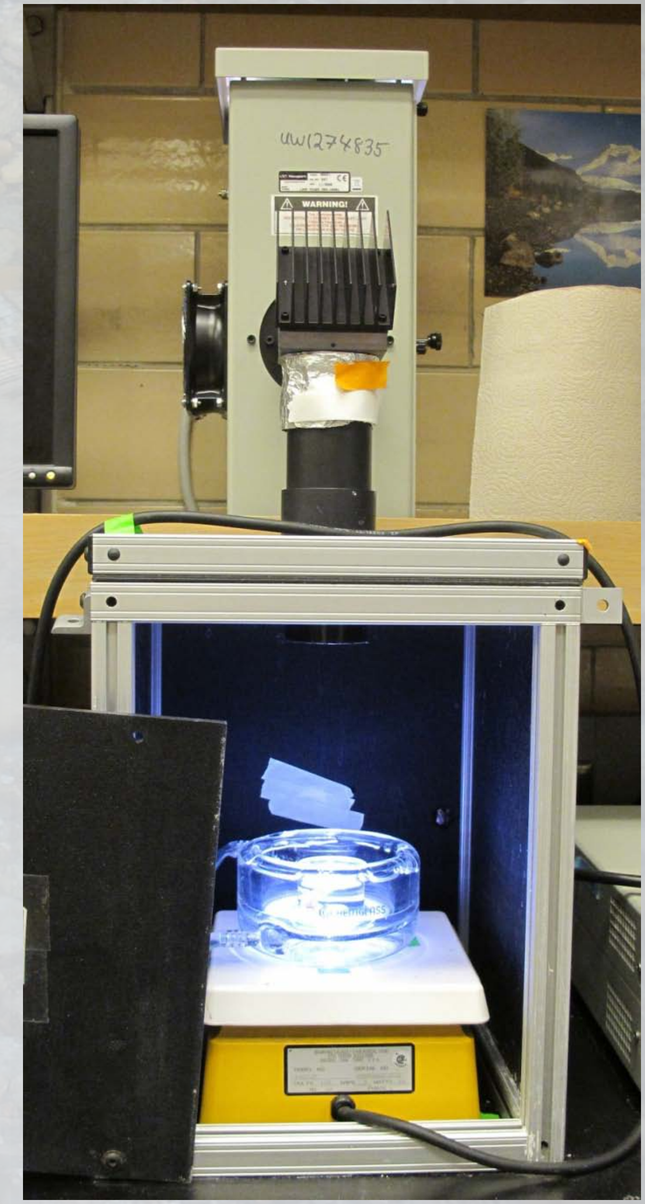
$HOCl + h\nu \rightarrow HO^{\bullet} + Cl^{\bullet}$ $\Delta[HO^{\bullet}]_{generated}/\Delta[HOCl]_{photolyzed} = 0.7$

$OCl^{-} + h\nu \rightarrow O^{\bullet -} + Cl^{\bullet}$ $\Delta[O^{\bullet -}]_{generated}/\Delta[OCl^{-}]_{photolyzed} = 0.1$

Experimental approach



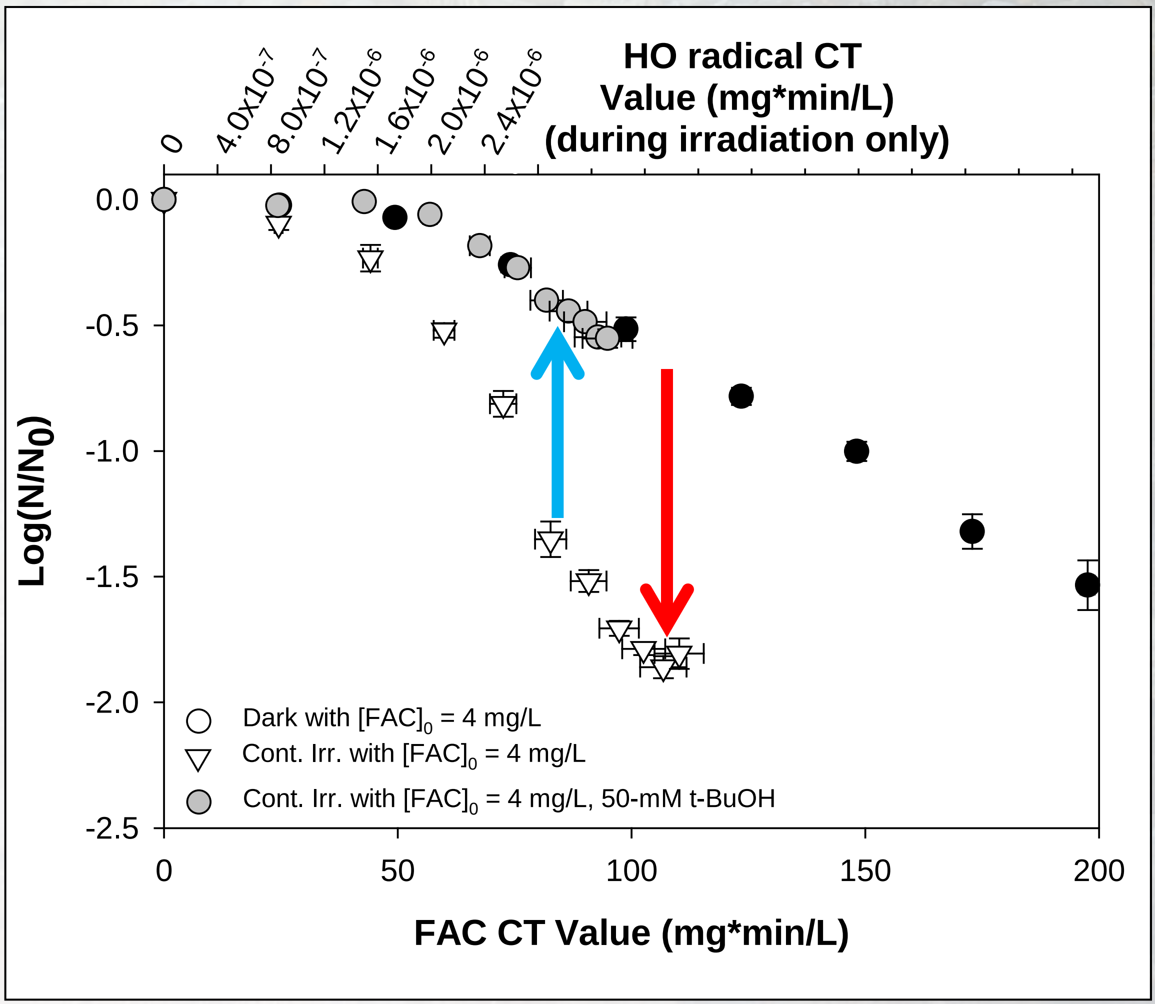
- 10-mM phosphate-buffered reactor solutions irradiated under constant stirring, in 50-mL crystallization dishes covered with quartz lids
- Solutions dosed with ~10^6 CFU/mL of ATCC 6633 spores and 1 μM of *p*-chlorobenzoic acid ($HO^{\bullet}$ probe)
- Reactions initiated by dosing with FAC at t = 0, and sampled at intervals for residual FAC, spores, *p*CBA



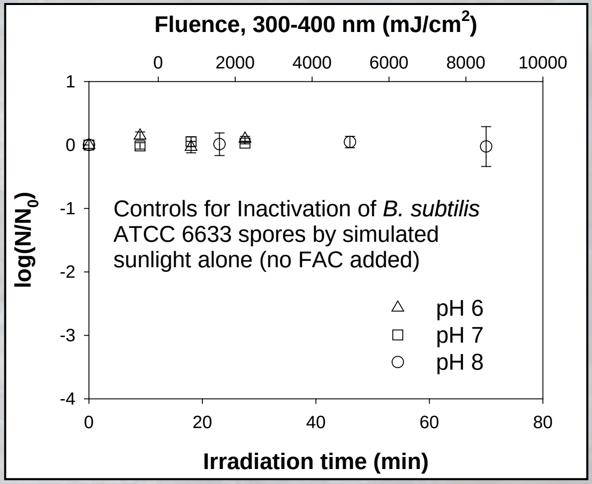
B. subtilis spore inactivation - I

Inactivation by FAC + simulated sunlight:

- Influence of $HO^{\bullet}$ on inactivation rates during continuous irradiation at pH 8; 25° C



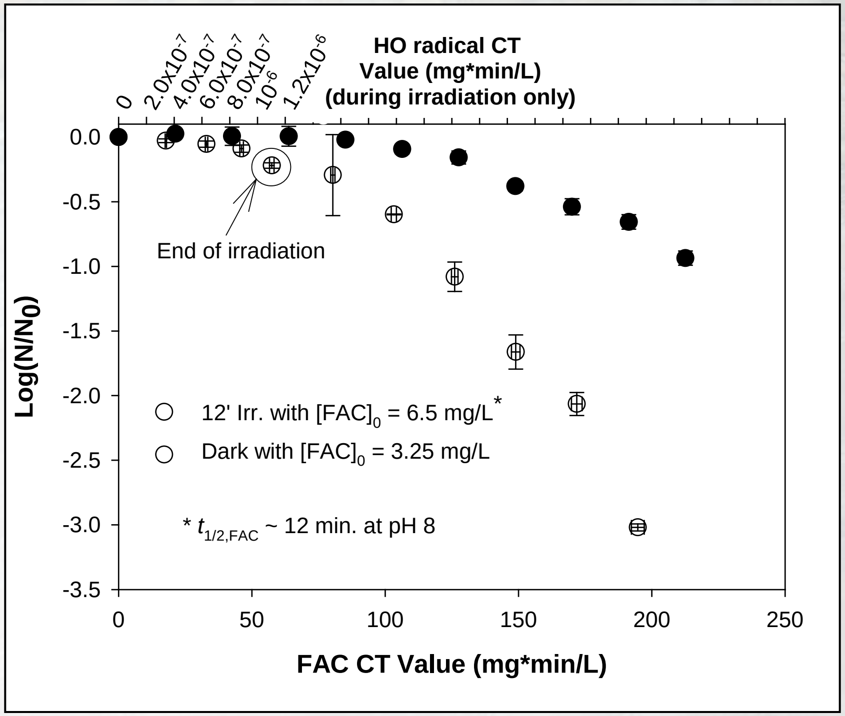
- In presence of $HO^{\bullet}$-scavenger (*tert*-BuOH) no difference between dark and irradiated samples
- No inactivation observed under light alone

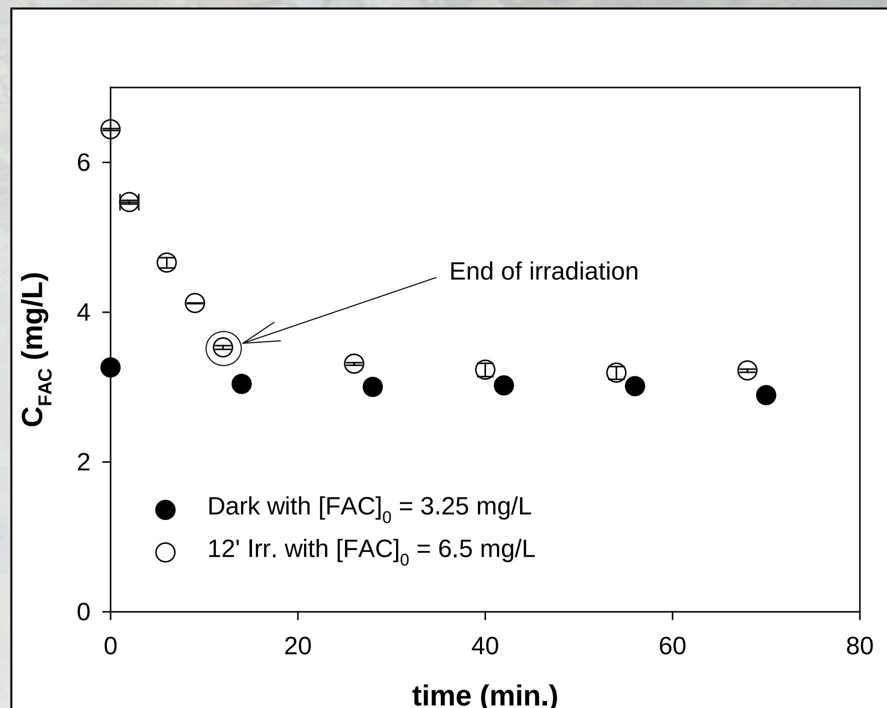


B. subtilis spore inactivation - II

Inactivation by FAC + simulated sunlight:

- Pre-irradiation to target residual at pH 8; 25° C, $C_{FAC,0}$ = 6.5 mg/L



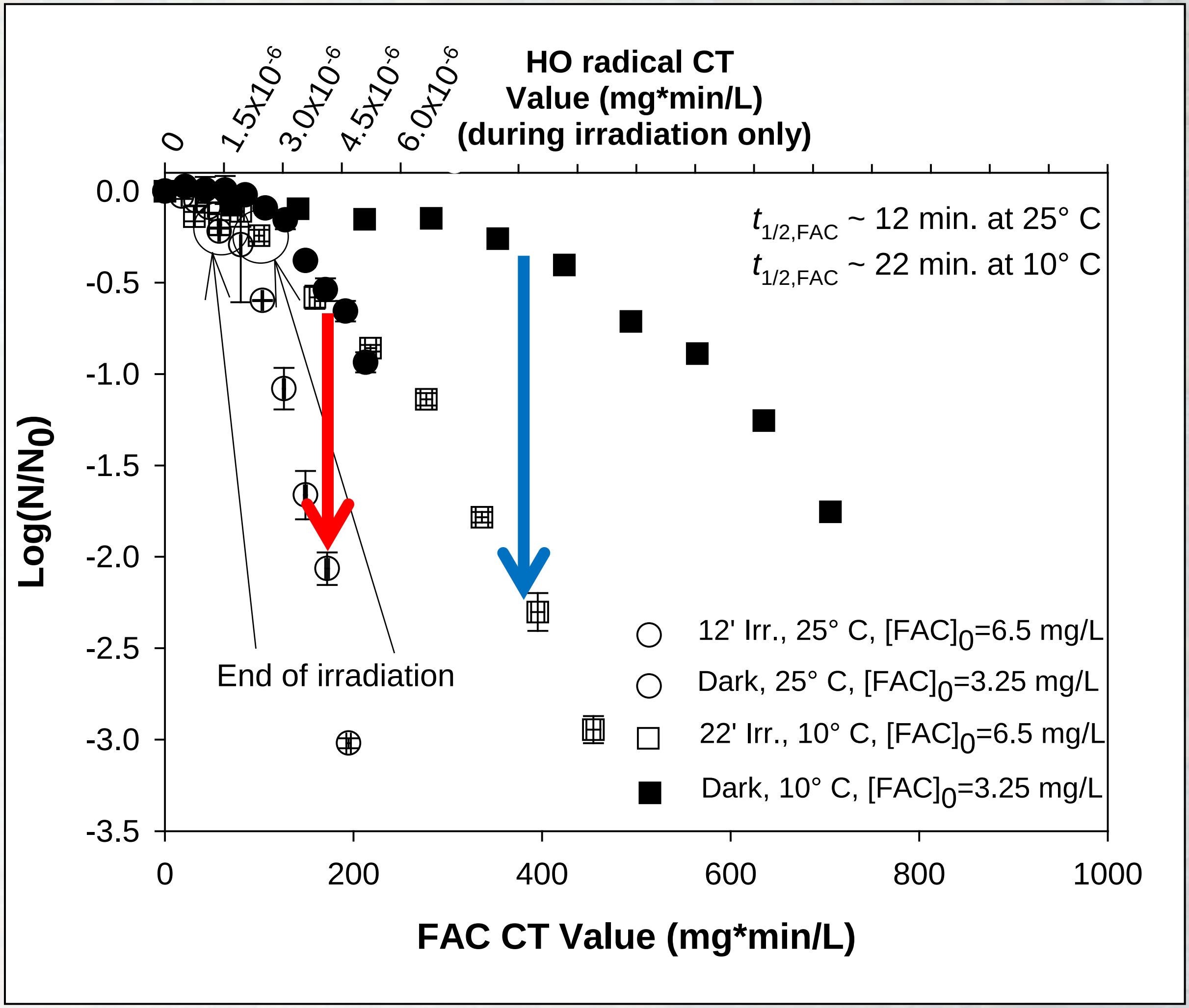


- Lag phase shortened
- Clear enhancement of post-irradiation, post lag-phase inactivation rate

B. subtilis spore inactivation - III

Inactivation by FAC + simulated sunlight:

- Pre-irradiation to target residual at pH 8; 10 and 25° C

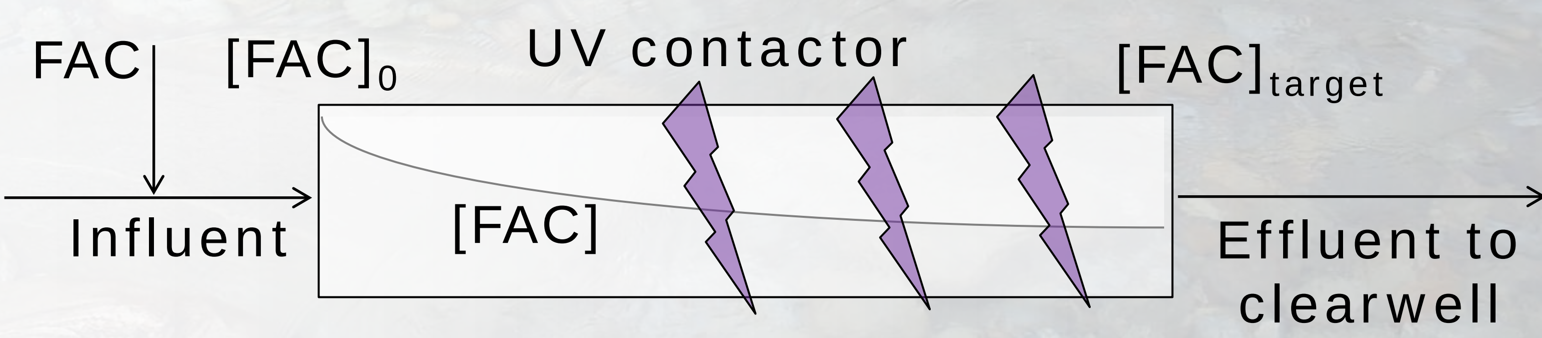


- Substantial enhancement even at lower temperatures

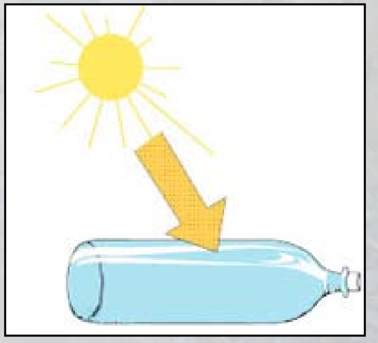
Practical implementation

Possible approaches for implementation:

- Sunlight/UVA - In situ solar pre-irradiation in (low Br^-) reservoirs, application of low-energy LEDs with emission in UVA range
- UVB/UVC - Dosage of FAC prior to an existing UV contactor installation (e.g., at SPU's Cedar Water Treatment Facility, Marysville's planned Edward Springs facility)



- Portable – Solar illumination of Nalgene and/or low-density polyethylene bottles dosed with chlorine for backpacking, low-cost applications in decentralized treatment scenarios



Key Findings and Future Directions

Key Findings

- In situ generation of $HO^{\bullet}$ during solar photolysis of FAC leads to substantial enhancement of inactivation rates for chlorine-resistant *B. subtilis* spores
- Enhancement is greatest for continuous photolysis during which $HO^{\bullet}$ is generated throughout the process (until FAC is depleted)
- However, marked enhancement can be achieved even for limited pre-irradiation intervals followed by dark chlorination
- Improvements are greatest at higher pH, lower temperature (representative of actual DW conditions)

Future Directions

- Experiments in real waters (underway), under natural sunlight
- Transmission electron microscopy; analysis of spore damange
- Investigate inactivation of human pathogens: *C. parvum*, *M. avium*, *Coxsackievirus B5*

Acknowledgements

Solar chlorine generation:

- UW Royalty Research Fund (project support)
- US EPA STAR Fellowship (Christa Fagnant)
- Doug Latch and John Berude (Seattle University) (for assistance with AQ2MS synthesis)

Solar chlorine activation:

- US NSF Graduate Research Fellowship (Jenna Forsyth)
- Nicky Beck (UW EOHS) (technical assistance)
- Dr. Gwy-Am Shin (UW EOHS) (advice and comments)

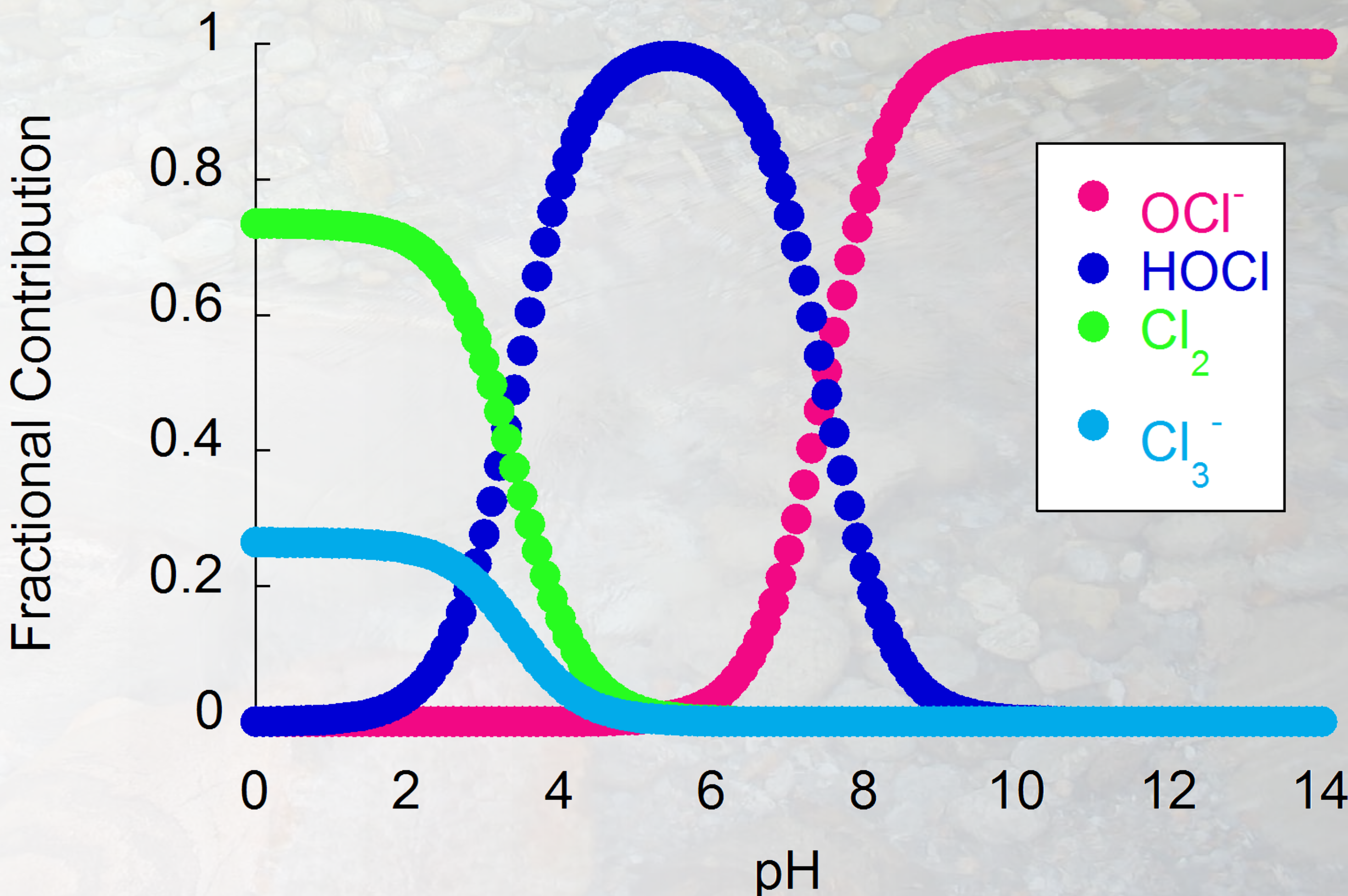
Questions?

Appendix

Predominance of free chlorine species vs. pH

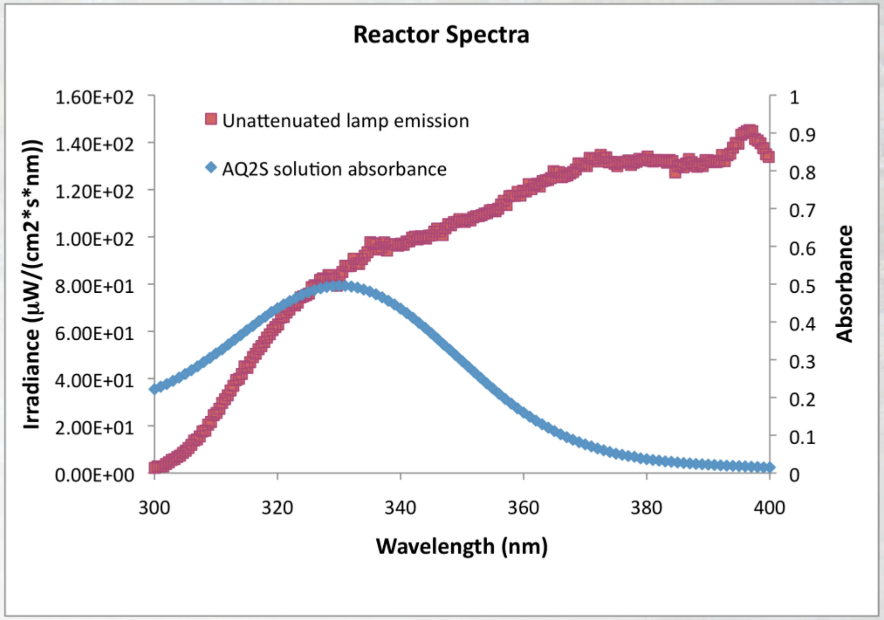
pH > 3: HOCl/OCl^- – non-volatile

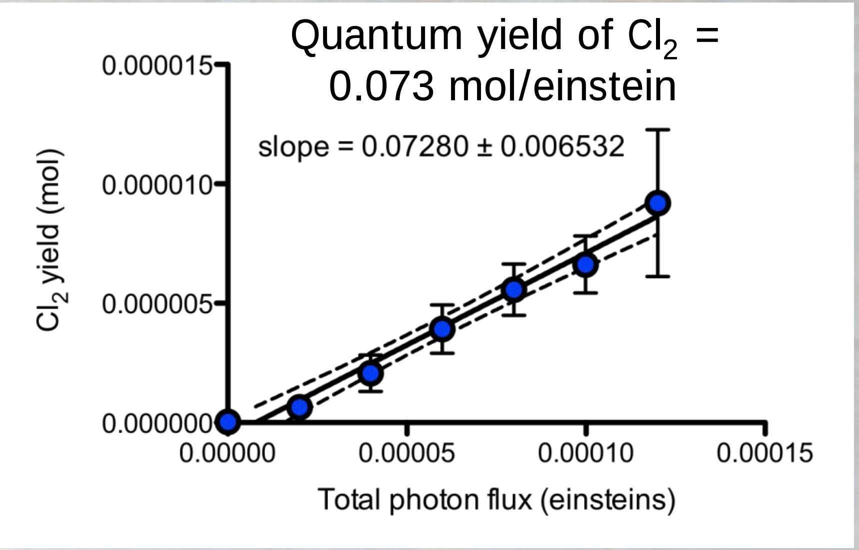
pH < 3: Cl_2 – volatile, Cl_3^- - non-volatile

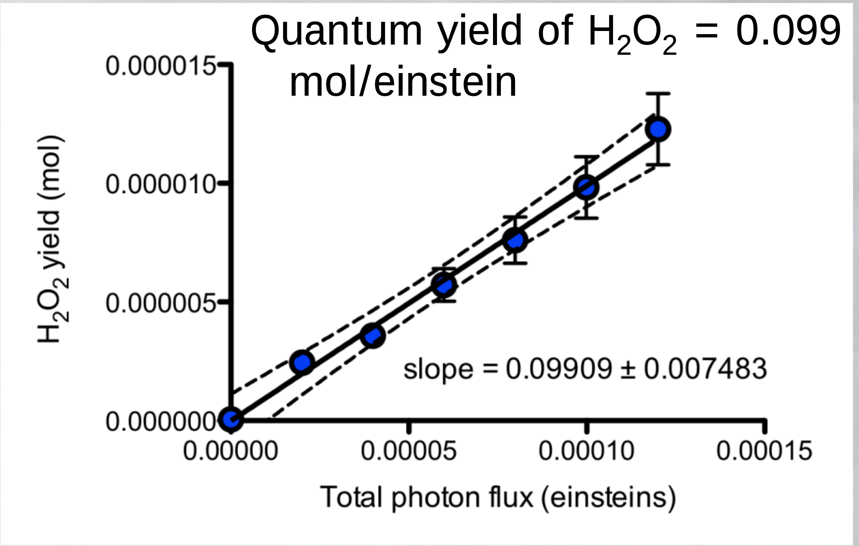


Quantum yields of Cl_2, H_2O_2

- Cl_2 quantum yield integrated over λ = 300-400 nm







- 2 moles of $O_2^{\bullet -}$ are produced for every 2 moles of $Cl_2^{\bullet -}$:

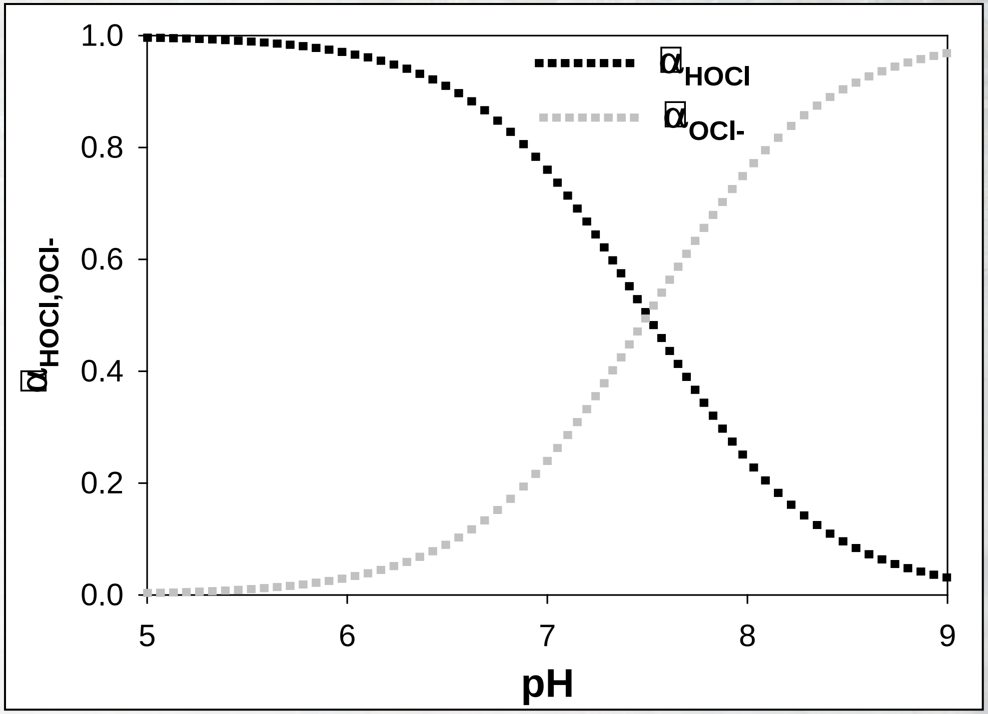
$\Rightarrow$ Cl_2 quantum yield equal to H_2O_2 quantum yield under operating conditions

This could limit Cl_2 production at high [H_2O_2]

"Free available chlorine" in aqueous solution

Key characteristics of free available chlorine (FAC):

$HOCl \leftrightarrows OCl^- + H^+$ $K_a = 10^{-7.5}$ M (i.e., pK_a = 7.5) at 25° C



$$[FAC] = [HOCl] + [OCl^-]$$

$$= \alpha_{HOCl}[FAC] + \alpha_{OCl-}[FAC]$$

$$\alpha_{HOCl} = \frac{[H^+]}{[H^+] + K_{a1}}$$

$$\alpha_{OCl-} = \frac{K_{a1}}{[H^+] + K_{a1}}$$

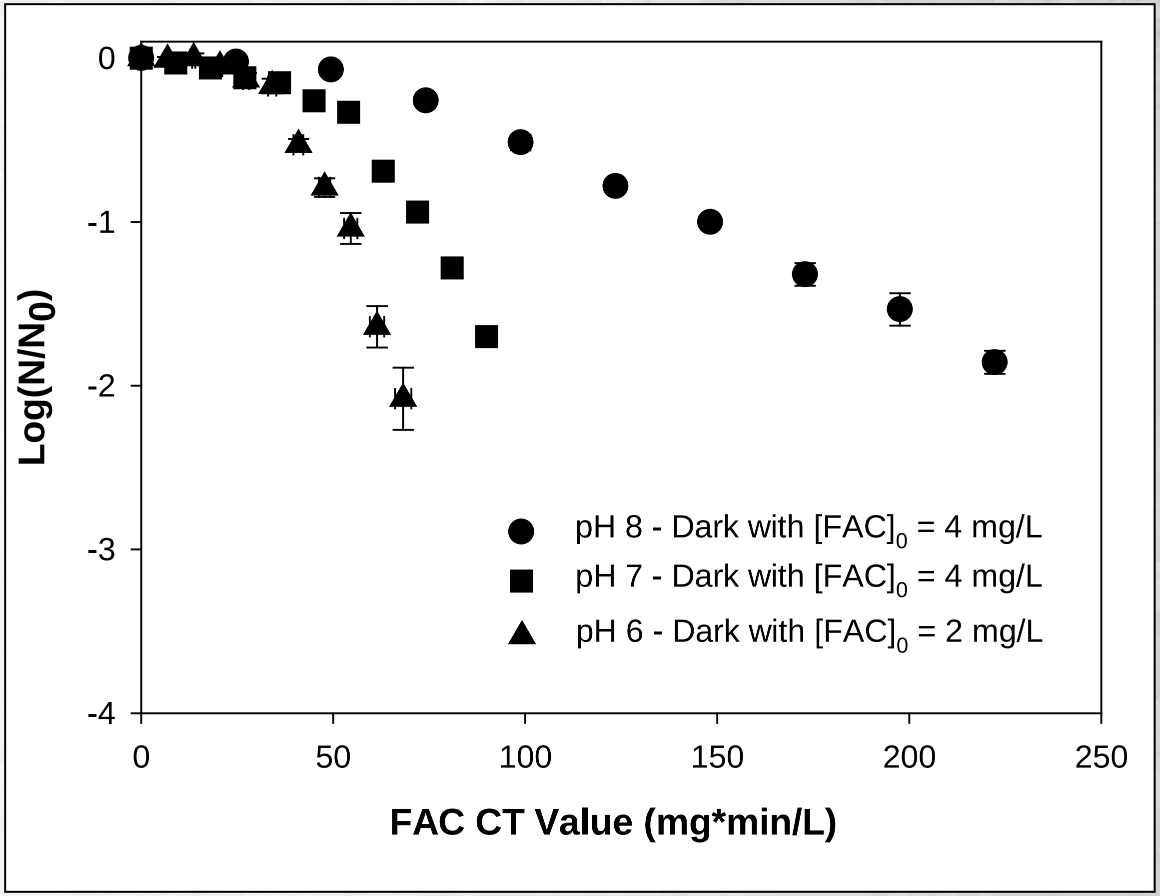
•HOCl is a much stronger oxidant than OCl-

⇒ Inactivation rates often increase with decreasing pH during chlorination processes as a consequence

B. subtilis spore inactivation - I

Inactivation by FAC alone (dark reactions):

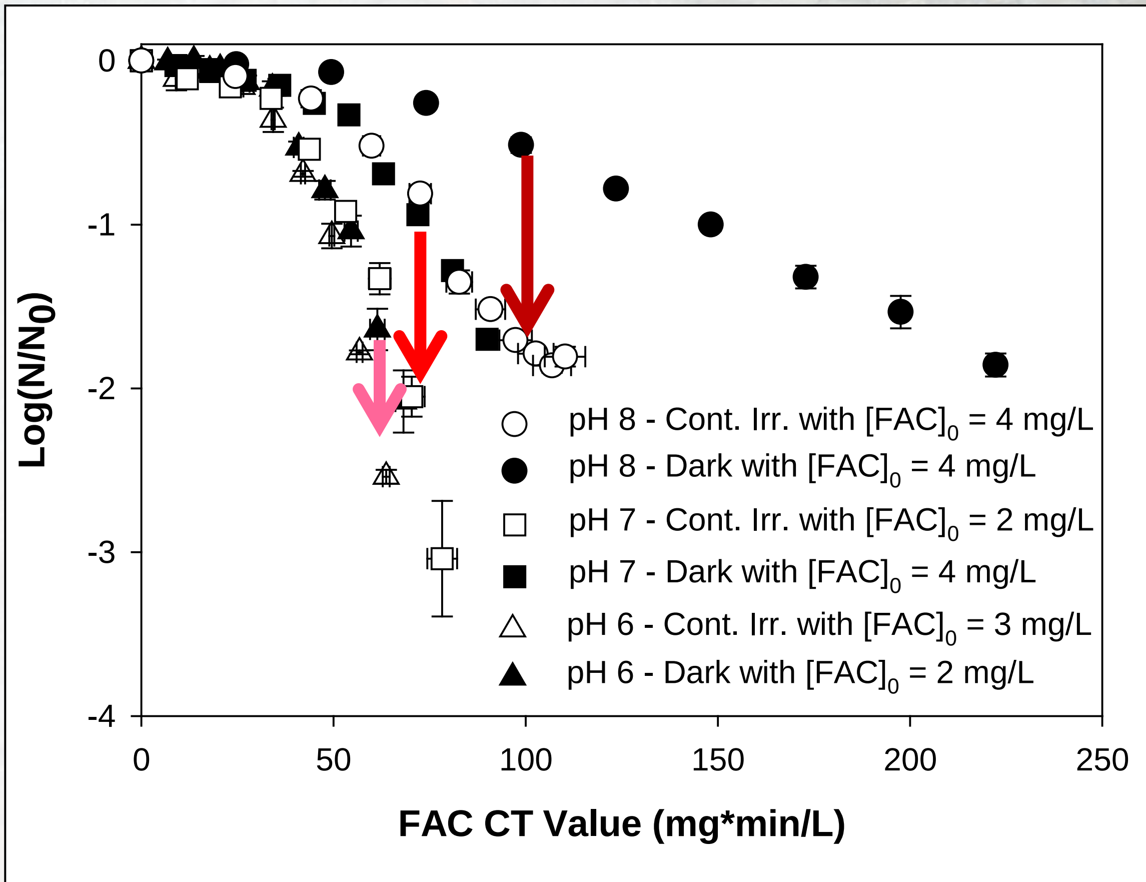
- pH 6, 7, 8; 25° C
- Inactivation rates decrease with decreasing pH on account of shift in $HOCl/OCl^-$ equilibrium toward HOCl



B. subtilis spore inactivation - II

Inactivation by FAC + simulated sunlight:

- Continuous irradiation at pH 6, 7, 8; 25° C
- Substantial (> 3-fold) enhancement in inactivation rates during continuous irradiation at pH 8; less enhancement at pH < 8



- Dark reactions accelerate at lower pH; light (HO•) rates maintained at similar levels

Water Research Foundation℠

New Focus On Research

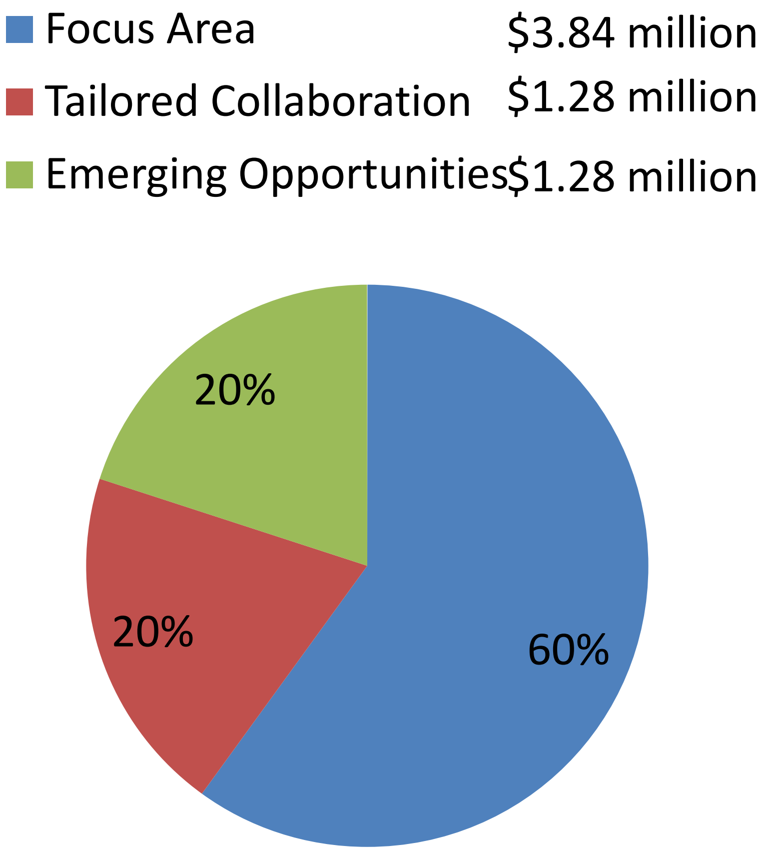
advancing the science of water

Research Programs

Focus Area Program (60% of Foundation research budget) identifies a limited number of broadly relevant subscriber issues and solves them with a targeted, multi-year research response.

The Emerging Opportunities Program (20% of Foundation research budget) enables the Foundation to respond quickly to emergent subscriber challenges and research ideas identified throughout the year.

The Tailored Collaboration Program (20% of Foundation research budget) enables the Foundation to partner with utility subscribers on research that may be more limited or regional in impact.



Utility Survey-Top Concerns

1. Asset Management
2. Utility Finance
3. Distribution System Integrity
4. Energy Management
5. Water Resources

- Chemicals of Emerging Concern
- Water Efficiency
- Disinfection By-Products
- Customer Service
- Communication

Focus Area Program

The program is developed around research focus areas—discrete, high-priority problems to be solved, or opportunities to be realized, for Subscribers and the Water Community. Focus area solutions are achievable in a defined timeframe by completing a series of research projects.

Focus Areas

Hexavalent Chromium	Water Utility Infrastructure
NDMA and Nitrosamines	Carcinogenic VOCs
Energy Efficiency and Integrated Water-Energy Planning	Water Utility Finance
Contaminants of Emerging Concern (CECs)	CECs and Risk Communication
Water Demand Forecasts and Management	Biofiltration

Hexavalent Chromium: Filling Critical Knowledge Gaps to Inform Effective Rulemaking and Customer

Objective: By 2016, develop national occurrence data, evaluate treatment technologies, quantify compliance costs, and develop effective communication tools for utilities.

Year 1 project: Impact of Water Quality on Hexavalent Chromium Removal Efficiency and Cost

Water Utility Infrastructure: Applying Risk Management Principles and Innovative Technologies to Effectively Manage Deteriorating Infrastructure

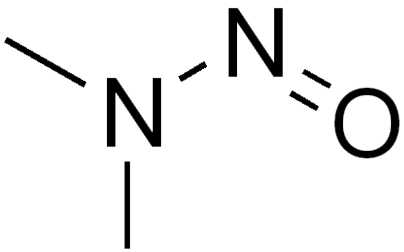
Objective: By 2017, provide utilities with tools and strategies to optimize the use of condition assessment and risk management in making infrastructure renewal decisions and the use of innovative renewal techniques.

Year 1 projects: Utility Risk Management Methodologies for Buried Assests with Improved Triple Bottom Line Understanding of Pipe Failures

Practical Condition Assessment and Failure Probability Analysis of Small Diameter Ductile Iron Pipe

NDMA and Nitrosamines: Precursor Control, Treatment Practices, and Distribution System Operations to Achieve Regulatory Compliance

Objective: By 2016, provide resources to inform rulemakers and assist utility compliance with pending regulations by understanding the occurrence, precursor formation, treatment and control, and fate of nitrosamines in distribution systems.

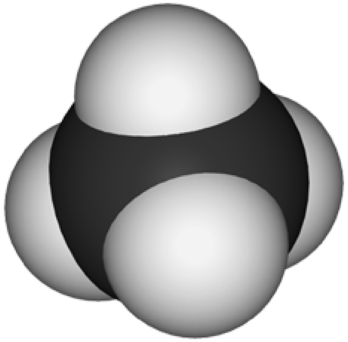


Year 1 projects: Investigating Coagulant Aid Alternatives to Poly DadMAC Polymers

Nitrosamine Occurrence Survey

Carcinogenic VOCs Contaminant Group: Filling Critical Knowledge Gaps to Inform Meaningful Regulation

Objective: By 2015, delineate co-occurrence, assess effectiveness of analytical methods, and provide treatment solutions for carcinogenic VOCs that are relevant to EPA rulemaking.



Year 1 project: Evaluation of Henry's Law Constant and Freundlich Adsorption Constant for VOC's

Water Utility Energy Efficiency and Integrated Water–Energy Planning: Developing Tools and Strategies

Objective: By 2016, provide effective strategies to reduce water utility energy consumption and cost; develop strategies for multi-sector, regional, integrated water–energy planning; and provide sound approaches for energy generation by water utilities and reduced water consumption by energy utilities.

Year 1 projects: Updated "Water and Wastewater Utilities: Characteristics and Energy Management Opportunities

Tool to Evaluate Financial, Environmental and Social Costs and Benefits of Renewable Energy Projects for Water Utilities

Water Utility Finances: Best Practices for Setting Rates, Financing Capital Improvements, and Achieving Public Support — By 2015, develop utility communication

Objective: By 2015, develop utility communication tools for governing boards and customers, critically evaluate rate-setting strategies, tap financial success factors from outside the water industry, determine impacts of utility governance and ownership on financial sustainability, and develop decision support tools for infrastructure funding

Year 1 project: Rate Approval Process Communication Strategy and Toolkit for Legislative Bodies

Contaminants of Emerging Concern in Drinking Water: Improved Cost–Benefit Analysis of Different Management Approaches

Objective: By 2016, develop robust approaches for managing CECs that consider the sources and variability of CECs; end uses of water; and the associated financial, environmental, and social costs/benefits.

Year 1 project: Watershed Sources of Contaminant of Emerging Concern and Relative Risk of (Human) Exposure

Contaminant Risk Communication: Developing Core Messages and Engaging Critical Stakeholders

Objective: By 2014, develop core messages for water utilities to communicate the relative and often uncertain risk of contaminants to different audiences and initiate dialogue among key stakeholder groups to foster agreement on related issues and solutions.

Year 1 projects: Core Messages for Priority Contaminants of Emerging Concern

Broadening the National Dialogue on CECs and Public Health

Water Demand: Improving the Accuracy of Forecasts and Management

<u>Objective</u>: By 2016, increase the accuracy of both short-term and long-term demand forecasting and quantify the interdependencies between changing use, rate structure, and utility financial stability.

<u>Year 1 project</u>: Evaluating the Effects of the Recent Economic Recession on Water Demand

Biofiltration: Defining Benefits, Overcoming Unintended Consequences, and Developing Utility Guidance

Objective: By 2017, determine biofiltration effectiveness at removing CECs and other contaminants, define benefits and communicate to key stakeholders, develop strategies to mitigate unintended consequences of biofiltration, and provide utility guidance on optimizing biofiltration.

Year 1 project: Development of a Biofiltration Knowledge Base

On-Line Proposal Submission

Knowledge Portals

- **Extensive, topic-specific, online resource areas**
  - Synthesized information
  - Executive Toolkits
  - Links to third-party resources
  - Subscriber discussion forums
  - Industry news feeds
  - FAQs
  - Presentations
  - Webcasts
  - Infographics
- **Beneficial to subscribers and other audiences** (professionals, media and general public)

Knowledge Portals

- Asset Management
- DBPs
- Energy Management
- Microbials
- Utility Finance
- Distribution System Integrity
- Advanced Treatment
- Customer Service
- Water Resources
- Desalination & Reuse
- Water Efficiency
- Chemicals of Emerging Concern
- Climate Change

Alice Fulmer

Chemicals of Emerging Concern

Dr. Djanette Khiari

Disinfection By-Products

Frank Blaha

Asset Management

Dr. Grace Jang

Microbials & Distribution System Integrity

Dr. Hsiao-Wen Chen

Advanced Treatment

Jennifer Warner

Water Resources

Dr. Jian Zhang

Distribution System Integrity

Jonathan Cuppett

Utility Finance

Dr. Kenan Ozekin

Climate Change

Linda Reekie

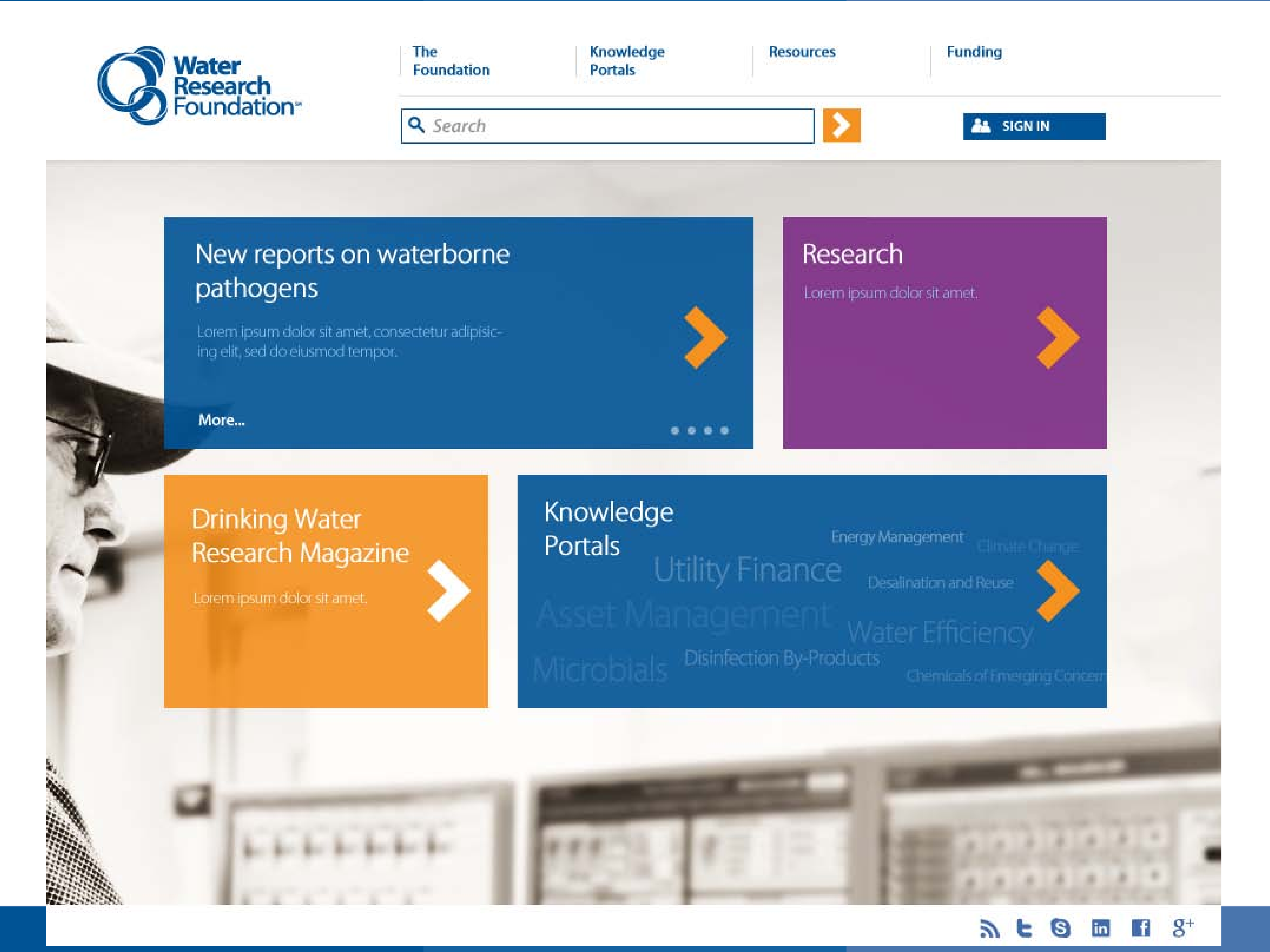
Customer Service & Energy Management

Mary Smith

Microbials

Maureen Hodgins

Water Efficiency



Water Research Foundation
The Foundation
Knowledge Portals
Resources
Funding
Search
SIGN IN
New reports on waterborne pathogens
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More...
Research
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Drinking Water Research Magazine
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Knowledge Portals
Energy Management
Climate Change
Utility Finance
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Asset Management
Water Efficiency
Microbials
Disinfection By-Products
Chemicals of Emerging Concern

Water Research Foundation

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Knowledge Portals: Energy Management

- Asset Management
- Microbials
- Utility Finance
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- Disinfection By-Products

Reports (12) | Webcast (7) | Case Studies (2) | Project Updates (0) | Web Tools (0)

Energy Management lorem ipsum dolor sit amet, consectetuer adipiscing elit, sed diam nonummy nibh euismod tincidunt ut laoreet dolore magna aliquam. sed diam nonummy nibh euismod tincidunt ut.

Executive Tool Kit

Energy Management

Energy efficiency in water treatment

Energy efficiency in water conveyance and distribution

Energy efficiency in water conveyance and distribution

Energy efficiency in water treatment

External Resources

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FAQs

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Emerging Opportunities Program (EO)

The EO Program provides a defined mechanism for the Foundation to move quickly on time-critical research. The program also enables the Foundation to commit co-funding for subscriber-relevant research ideas developed by approved partner organizations and to fund selected, urgent internal projects as needed.

Time-sensitivity

Type of impact

Extent of issue

Identifiable research solution.

EO Program

- Trace Level Chromium-6 Occurrence and Analysis: Reviewing and Testing the State of the Science
- Rates and Revenues: Water Utility Leadership Forum on Challenges of Meeting Revenue Gaps
- Seismic Performance of Water Infrastructure
- Lead and Copper Rule Targeted Unsolicited Research
- Investigating the Presence of HAAs and THMs in Sodium Hypochlorite Feedstocks Used for Drinking Water Disinfection.

Tailored Collaboration Program(TC)

The TC Program helps to fund projects that address issues important to subscribers on a regional or national level. Under this program utility subscriber or group of subscribers can obtain matching funds for a research idea that they have developed

2012 Approved TC Projects

The Seasonal Patterns of NDMA Precursors in Water Sources and their Removal at Drinking Water Treatment Plants. (#4444)

Energy Recovery from Pressure Reducing Valve Stations Using In-Line Hydrokinetic Turbines. (#4447)

Optimizing Biofilter Conditions for Improved Manganese Removal and Retention. (#4448)

Seawater Desalination Energy Consumption Modeling. (#4446)

Sources, Fate and Treatment of Hexavalent Chromium. (#4449)

2012 Pending TC Projects

Biological Treatment of Nitrates in Well Water

Pretreatment of Low Alkalinity Organic-Laden Surface Water Prior to a Coagulation-Ultrafiltration Membrane Process

Leveraging Data from Non-Destructive Examinations to Help Select Ferrous Water Mains for Renewal

Development of an Effective Asbestos Cement Distribution Pipe Management Strategy for Utilities

New e-Communications Products

Water Current *(Water Research Update)*

- Foundation news and resources and important industry announcements
- Open – subscribers and non-subscribers encouraged to subscribe

Research on Tap *(Bookshelf)*

- Research results and resources, webcasts, workshops, project updates
- *S*ubscribers, regulators and other partners

News Splash *(Subscriber Alerts)*

- *A*lert subscribers to breaking Foundation and industry news
- *S*ubscribers, regulators and other partners

WATER CURRENT

WATER CURRENT
Water Research Foundation E-Newsletter

Important News From WaterRF

Exciting Changes Coming in 2012
Happy New Year and welcome to the inaugural edition of Water Current — our revitalized monthly newsletter that will highlight important Foundation announcements and industry news. The launch of the Water Current is just one of many valuable improvements happening at the Foundation throughout 2012.

To learn more, click here to view a very short video about our new communication efforts and Web resources debuting in the coming months.

EO Research Program Completes Successful First Year
In its fledgling year, the Foundation's Emerging Opportunities (EO) program successfully launched research on a wide variety of high-priority issues in the amount of $1.2M. A total of 19 projects were funded, covering such topics as analyzing and removing hexavalent chromium, controlling lead and copper release in the distribution system, complying with the new Stage 2 Disinfection By-Products Rule, and responding to the earthquakes in New Zealand and Japan. (Read More)

Attend Foundation Presentations at the Utility Management Conference
Water Research Foundation project results will be presented during two sessions at the 2012 AWWA/WEF co-sponsored Utility Management Conference in Miami. "An Industry Survey of Best Practices and Performance Metrics Related to the 10 Attributes" and "Who Are Our CEOs? A Profile of American Utilities' Leadership" will be

January 2012

Subscribers:
Webcast Registration Now Open

Development of a Bench-Scale Test to Predict the Formation of Nitrosamines
Wednesday, Feb 1
2–3:30 pm ET
By: Stuart W. Krasner

Subscribers are talking about our Webcasts:

"Webcast well done. ...sparked good discussion for our group afterwards..."
Gary Burlingame, Philadelphia Water

"The Webcast presentation and Q&As were most interesting and informative..."
Barry Usagawa, Honolulu Board of Water Supply

Foundation Webcasts
Live and On Demand

More than 125 subscribers have recently viewed

NEWS SPLASH

NEWS SPLASH

Important News for Water Research Foundation Subscribers

February 6, 2012

Water Research Foundation (WaterRF) Awarding $500,000 in Grants for Research on Aging Water Infrastructure Projects

(February 6, 2012, Denver, CO) — The Water Research Foundation (WaterRF) is issuing Request for Proposals (RFP) that generate science and engineering knowledge to improve and/or evaluate promising innovative technologies and techniques to reduce the cost and improve the effectiveness of operation, maintenance, management, and replacement of deteriorating water infrastructure.

The $500,000 in grants to be issued in 2012 represents the third year of a four-year research program collaboration between WaterRF and Water Environment Research Foundation (WERF). The program is funded by the U.S. Environmental Protection Agency (EPA) through its Innovation and Research for Water Infrastructure for the 21st Century program.

Aging and deteriorating water infrastructure is a priority for EPA. A 2008 Clean Water Needs Survey estimated that more than $298 billion in capital investments in water utilities will be needed over the next 20 years. WaterRF and WERF collaborated on a successful proposal to work on this research program under which WaterRF focuses on potable water infrastructure and WERF focuses on wastewater and stormwater infrastructure.

WaterRF intends to fund as many high-impact potable water projects as possible under this RFP. The RFP and complete instructions are available on the Foundation's website. Collaboration with water utilities is encouraged. For a summary of research projects currently underway, please click here. WaterRF will allocate funds in a manner that proposed research outcomes will be of immediate and beneficial use to the water community. Gaps identified and research questions from the U.S. EPA Research Plan (2007) should be considered when proposing research projects.

Contact Frank Blaha, Senior Research Manager (303.347.6244 or fblaha@waterrf.org) for additional information. All proposals are due to WaterRF offices by 5:00 p.m. Mountain Time, Tuesday, March 6, 2012.

RESEARCH ON TAP

RESEARCH ON TAP
Water Research Foundation Results and Resources

Tap Into Foundation Resources

Welcome to the inaugural edition of Research on Tap—previously known as "Bookshelf"

Research on Tap is a monthly publication presenting information and links to new reports, project updates, and upcoming Webcasts and workshops from the Water Research Foundation.

Research Reports and Resources

Printed Reports:

4063 Formation of Halonitromethanes and Iodo-Trihalomethanes in Drinking Water

4223 Energy Efficiency Best Practices for North American Drinking Water Utilities

4283 Comparing Conventional and Pelletized Lime Softening Concentrate Chemical Stabilization

4176 Developing a Roadmap and Vision for Source Water Protection for U.S. Drinking Water Utilities

Special Reports:

Conclusions on the Waterborne Pathogen (WBP) Action (Available under Special Reports/Report series from the Global Water Research Coalition)

Interim Deliverables:

4312 An Operational Definition of Biostability for Drinking Water: Case Studies and Literature Review

January 2012

How to Gain Access to Foundation Resources

Foundation reports and resources are always free to subscribers, but do require a login and password.

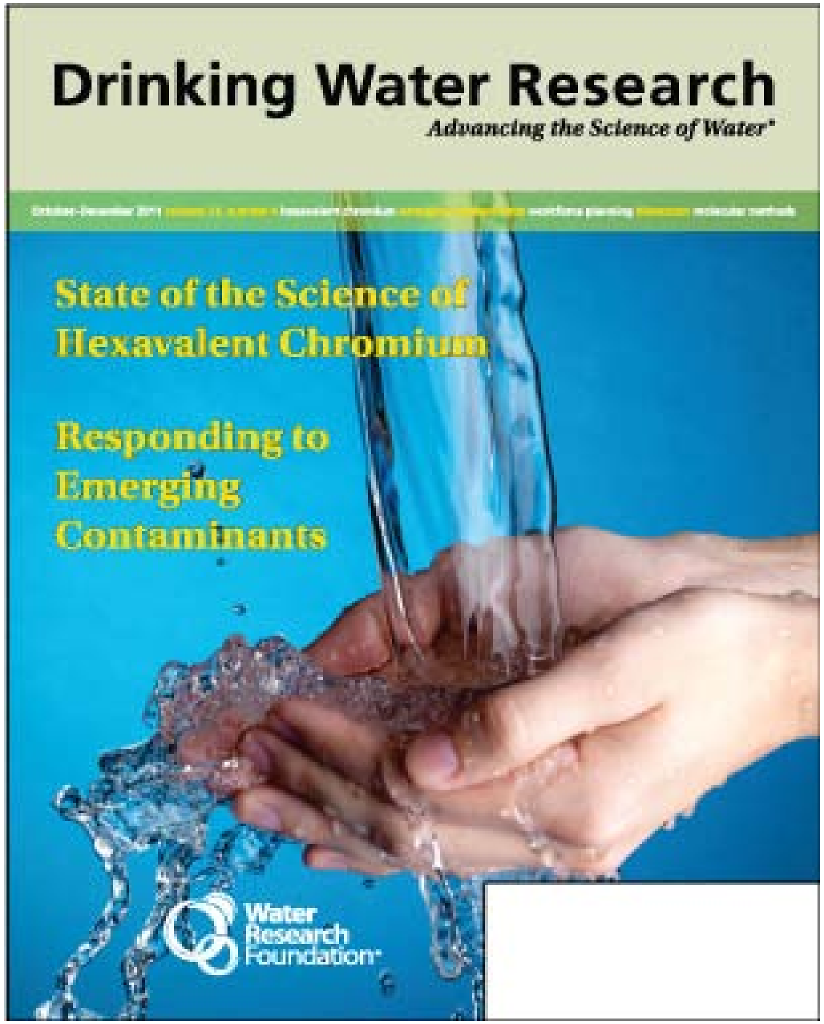
If you are a subscriber who has forgotten your password, simply click here to have your login information emailed to you. You can also contact Earlinda Mahoney for assistance at emahoney@WaterRF.org or 303.347.6243.

Exciting Changes in 2012

This revitalized publication is just one of the many improvements happening at the Foundation in 2012.

To learn more, click here to view a very short video about our new communication efforts and Web resources debuting in the coming months.

Drinking Water Research



Published quarterly – mailed to staff in database

Water Research Foundation℠

Thank You

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advancing the science of water