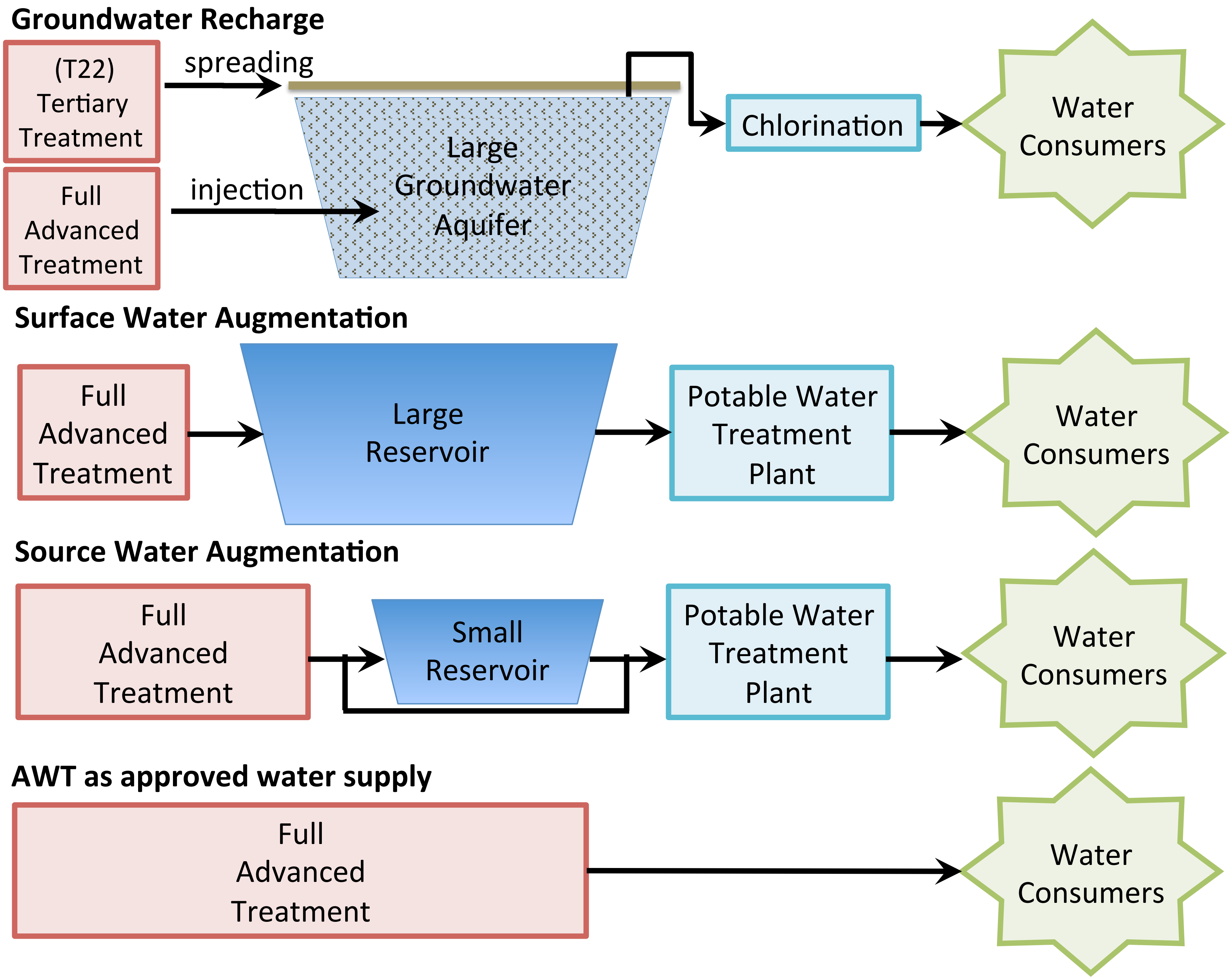
Demonstrating Redundancy and Monitoring to Achieve Reliable Potable Reuse

Shane Trussell, Ph.D., P.E., BCEE

Direct Potable Reuse in California: Specialty Seminar
September 23rd, 2015

Trussell
TECHNOLOGIES INC



Groundwater Recharge
(T22) Tertiary Treatment
spreading
Full Advanced Treatment
injection
Large Groundwater Aquifer
Chlorination
Water Consumers
Surface Water Augmentation
Full Advanced Treatment
Large Reservoir
Potable Water Treatment Plant
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Source Water Augmentation
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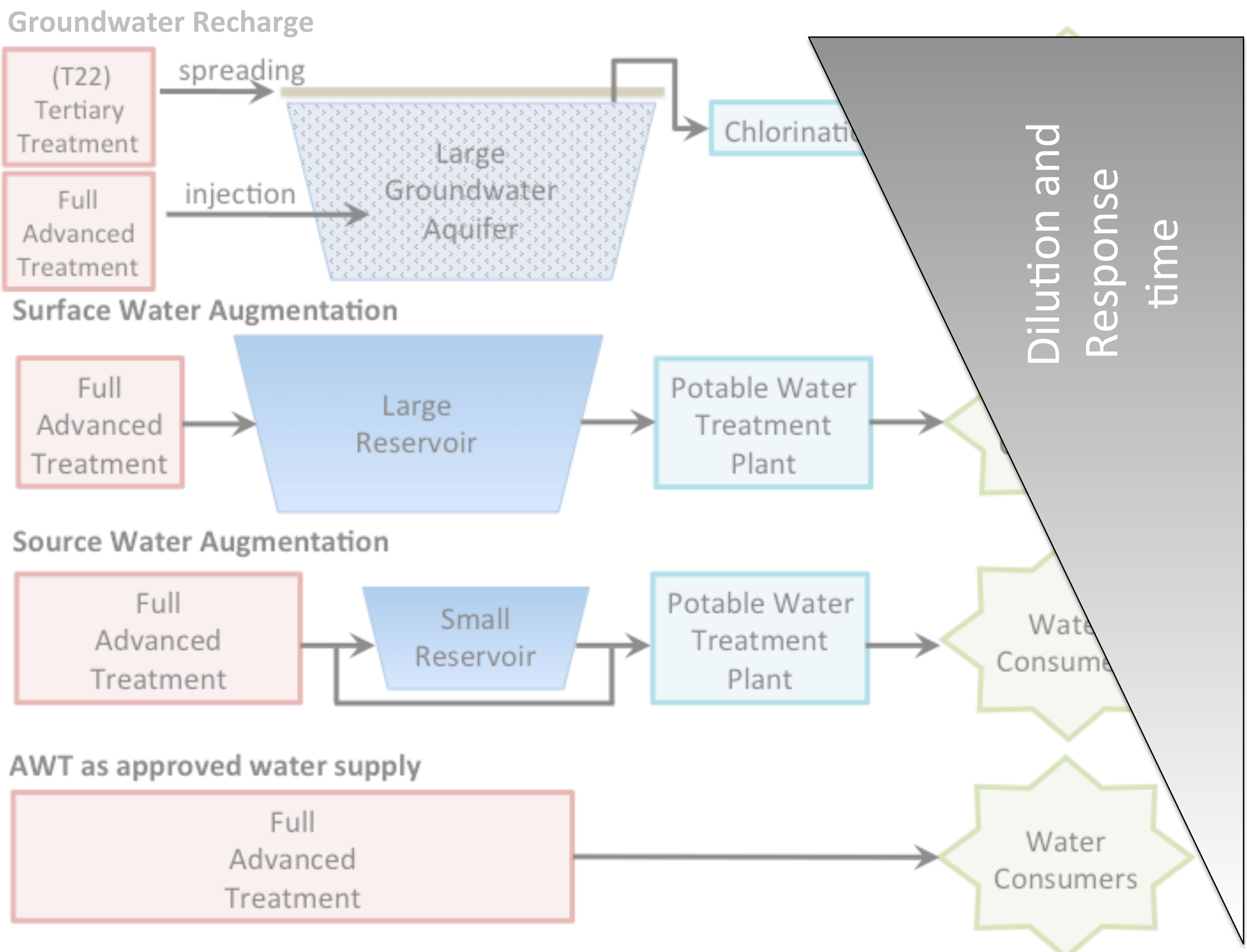
Water Consumers
AWT as approved water supply
Full Advanced Treatment
Water Consumers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Consume
AWT as approved water supply
Full Advanced Treatment
Water Consumers
Dilution and Response time

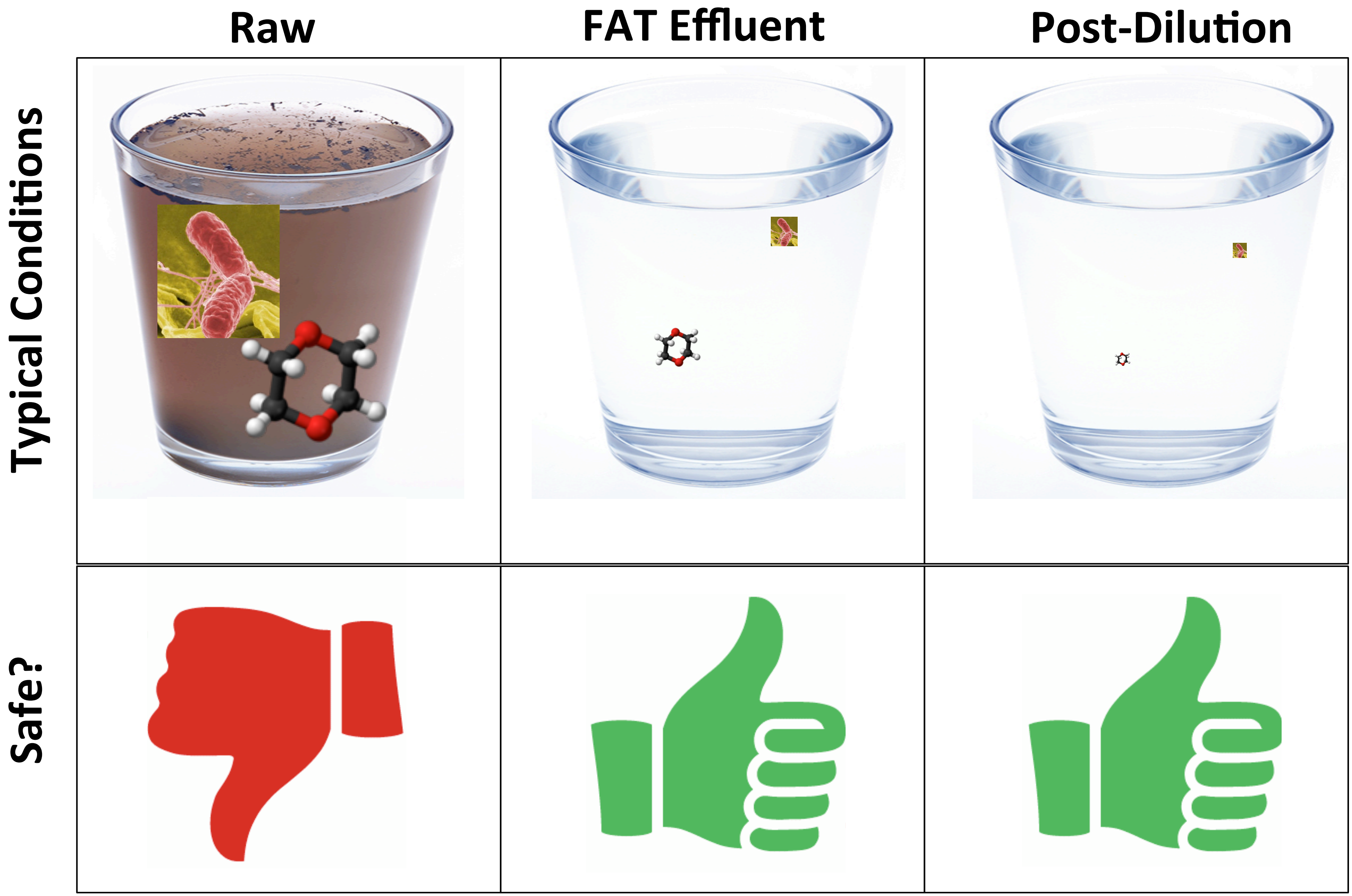
Regulations passed in 2014

Regulations in development

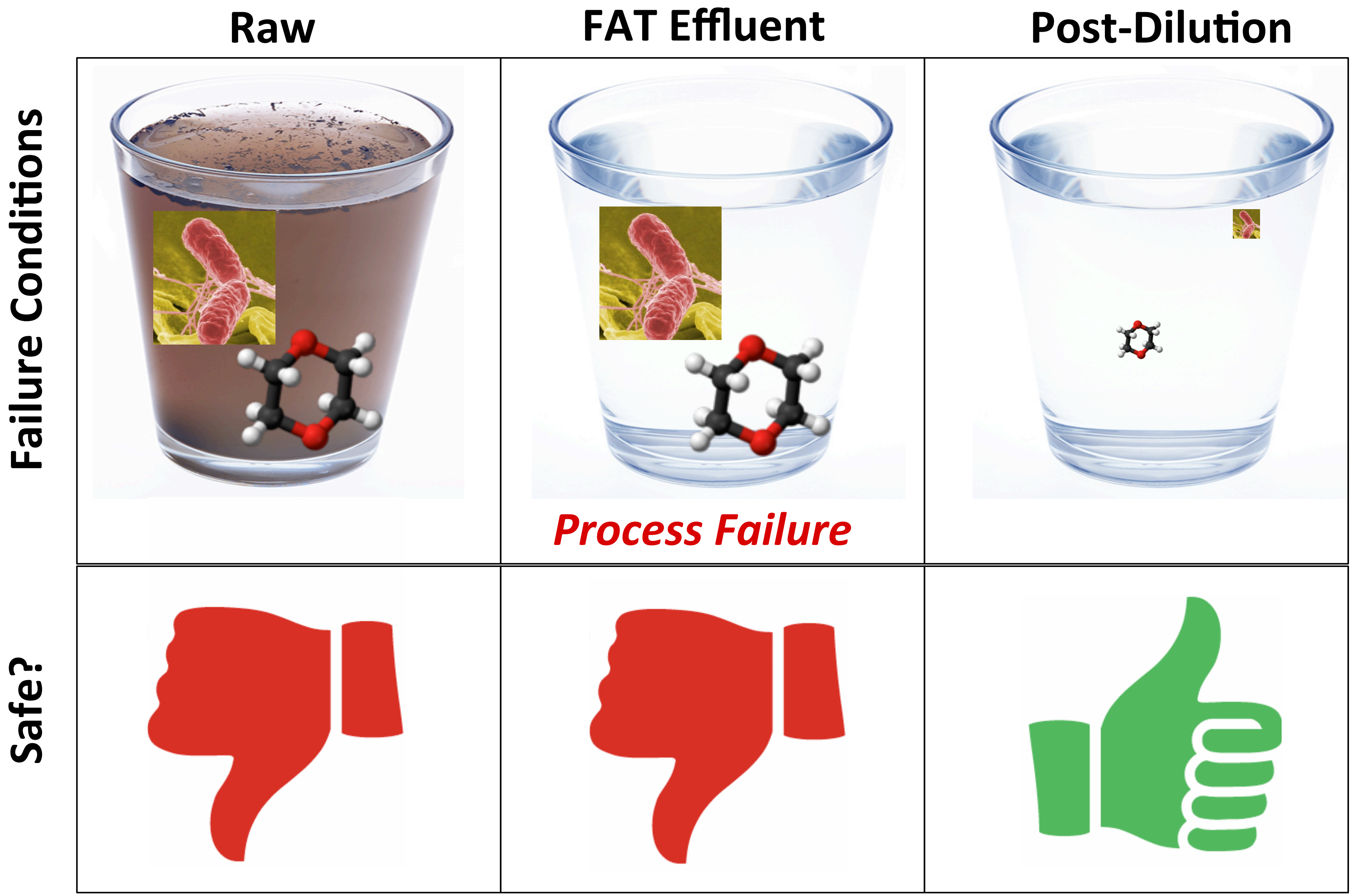
Feasibility being assessed for CA

What are the paths to reliability?

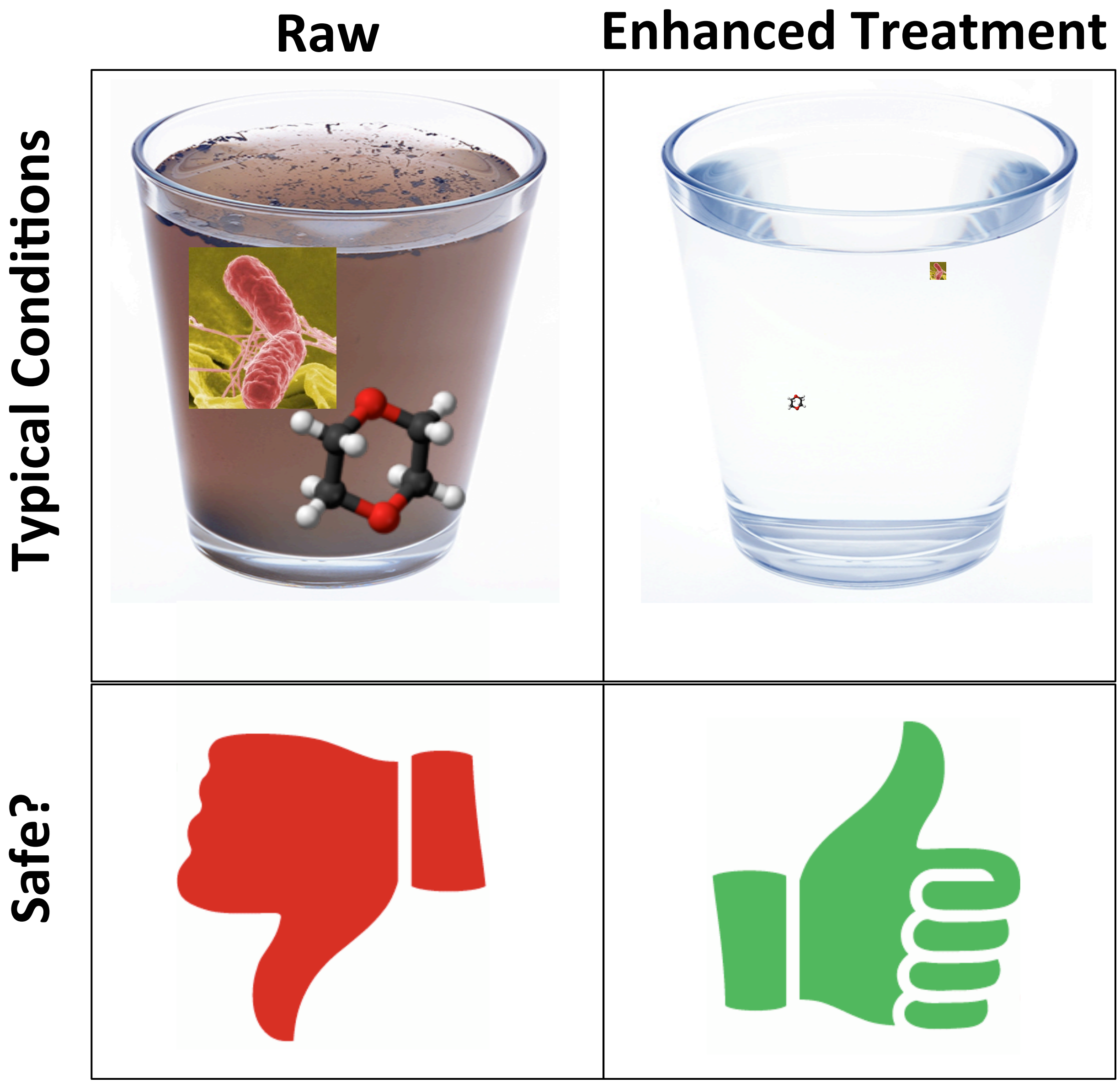
Does Dilution Work?



Does Dilution Work?



Enhanced treatment provides same benefit



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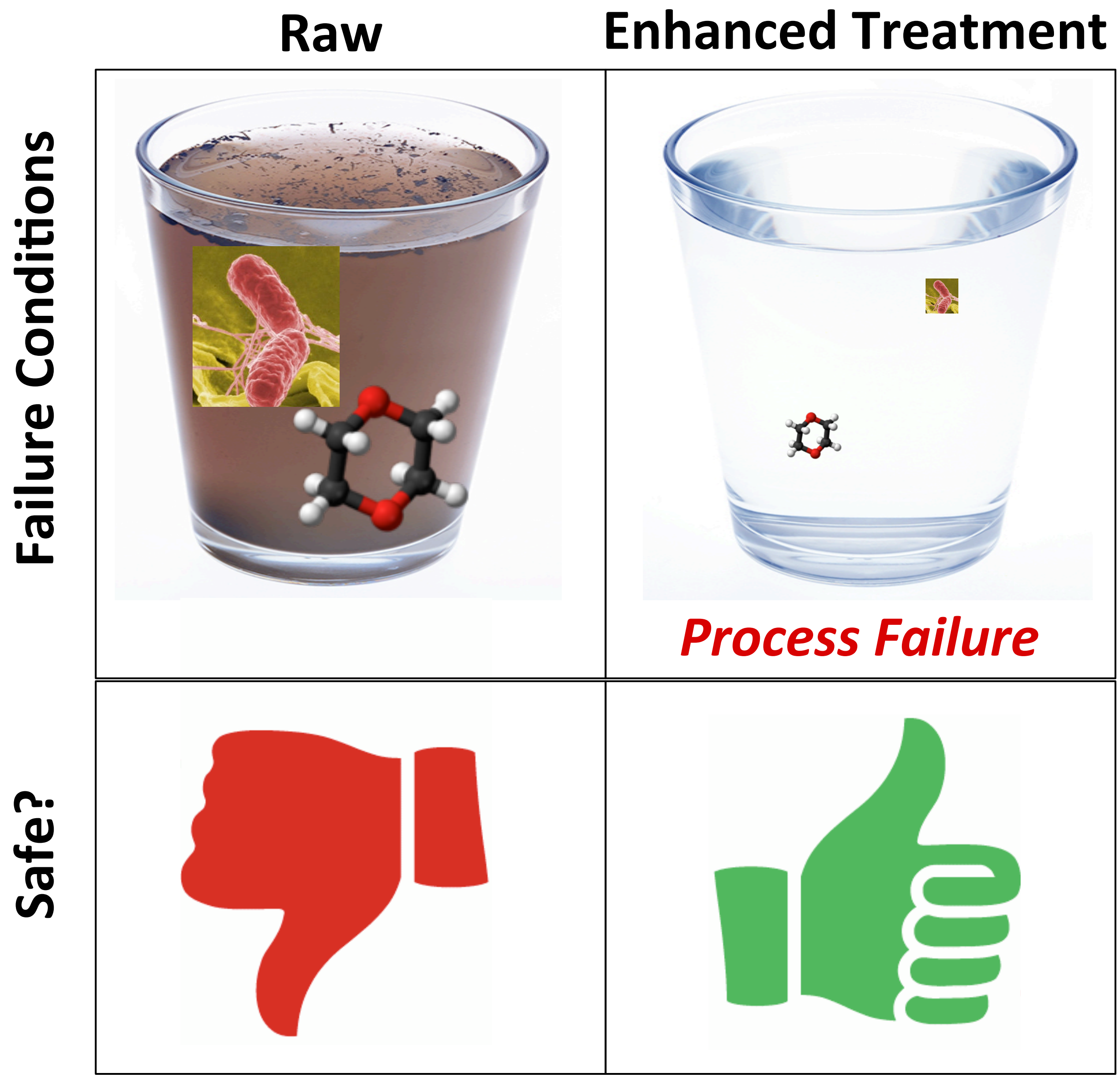
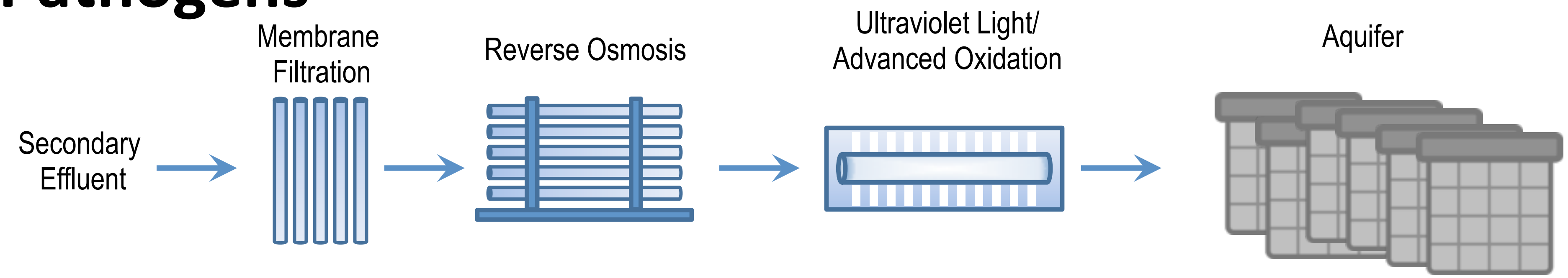



What Else Does the AWPF Concept Consider?
WEDECO

New treatment challenges for reuse

Pathogens



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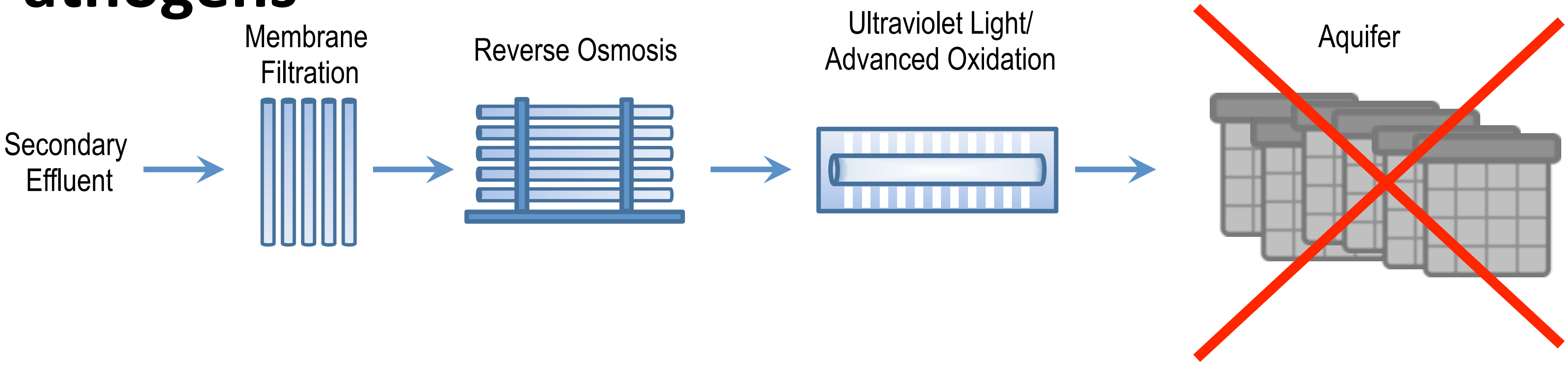

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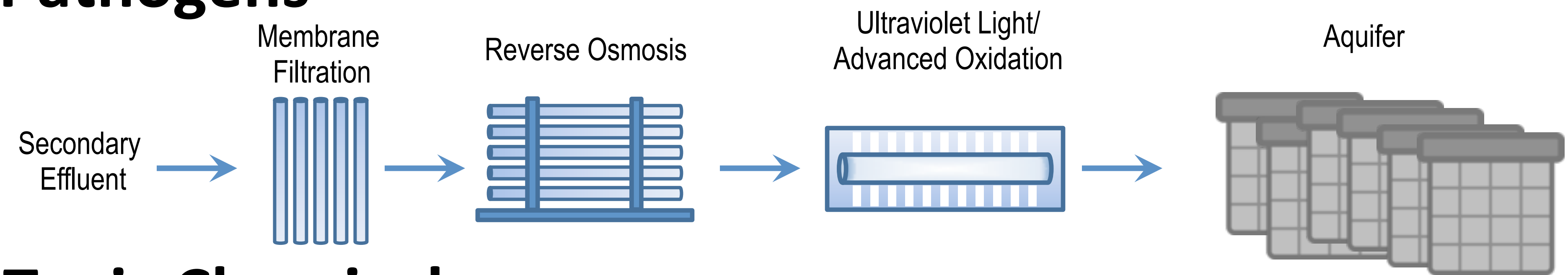
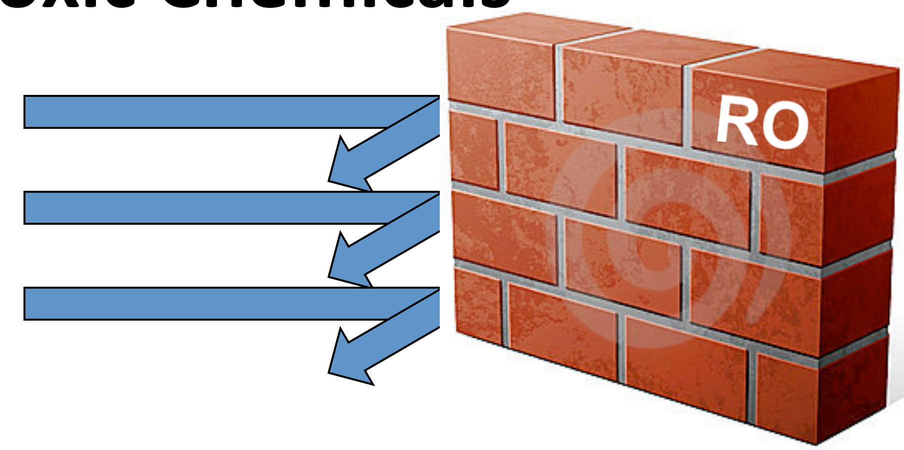


Toxic Chemicals



New treatment challenges for reuse

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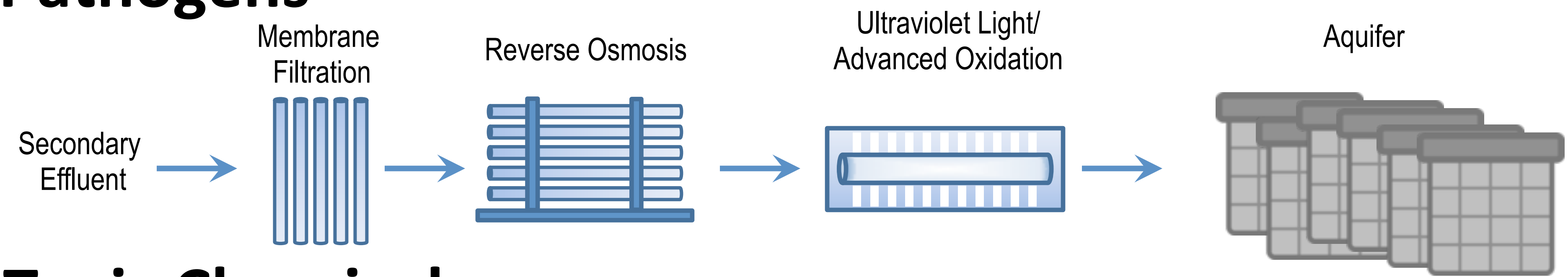

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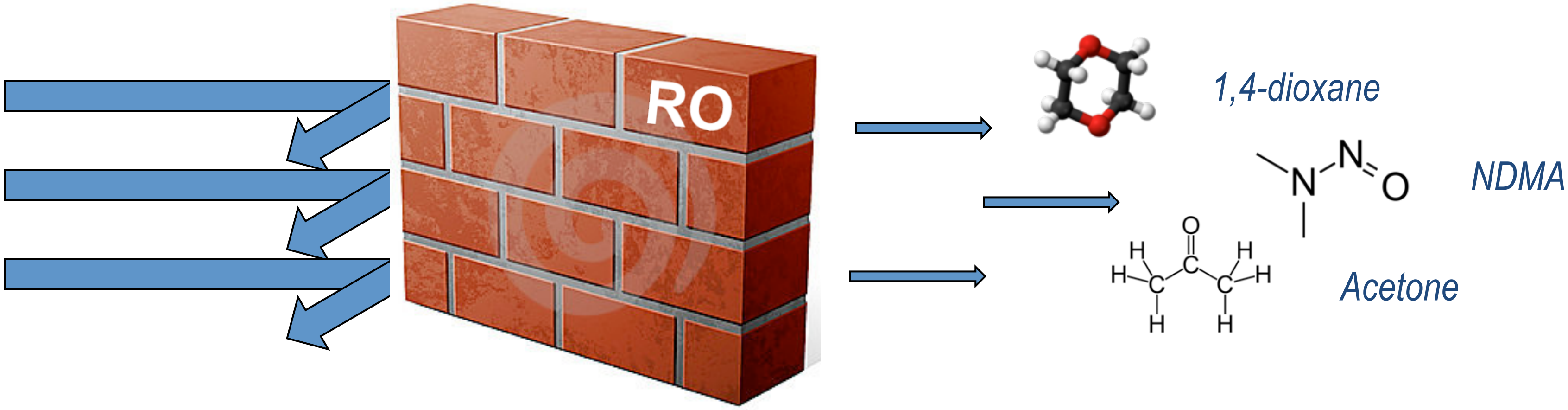

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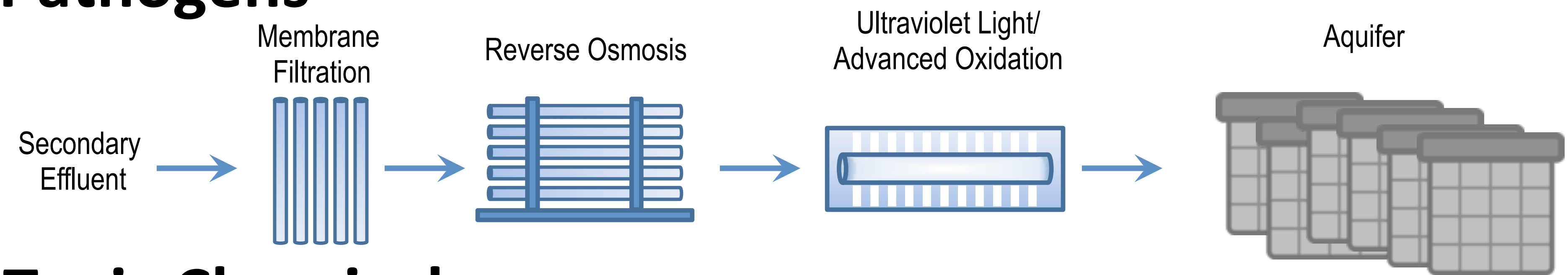

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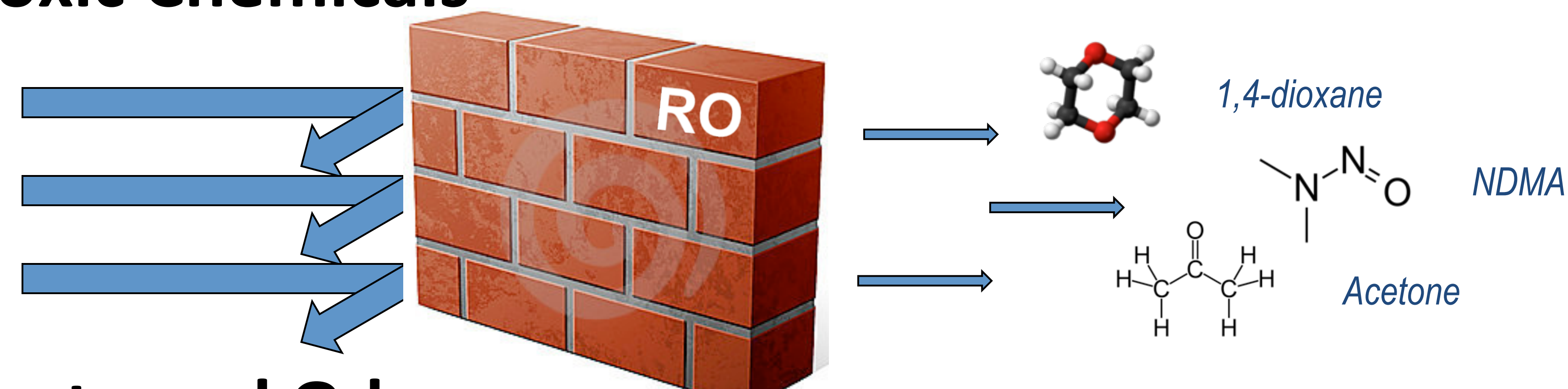
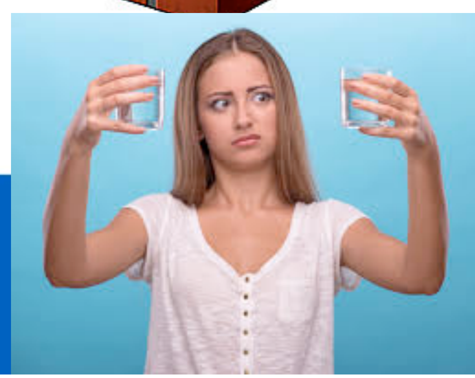
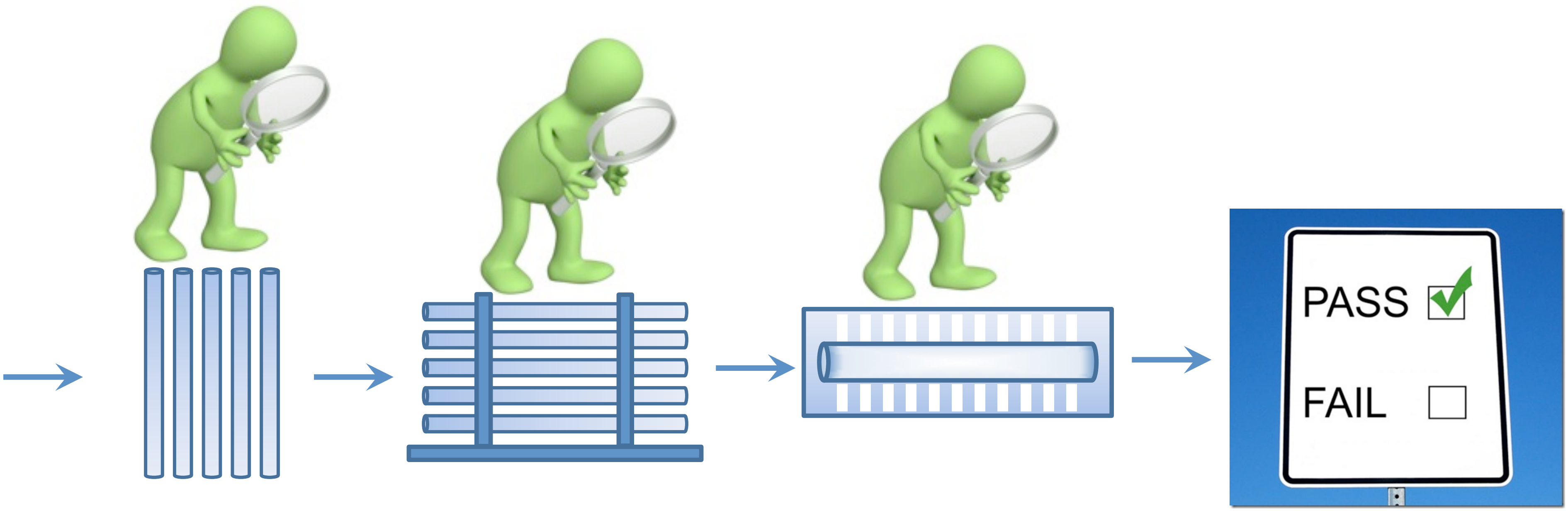


Taste and Odor



Performance monitoring is crucial



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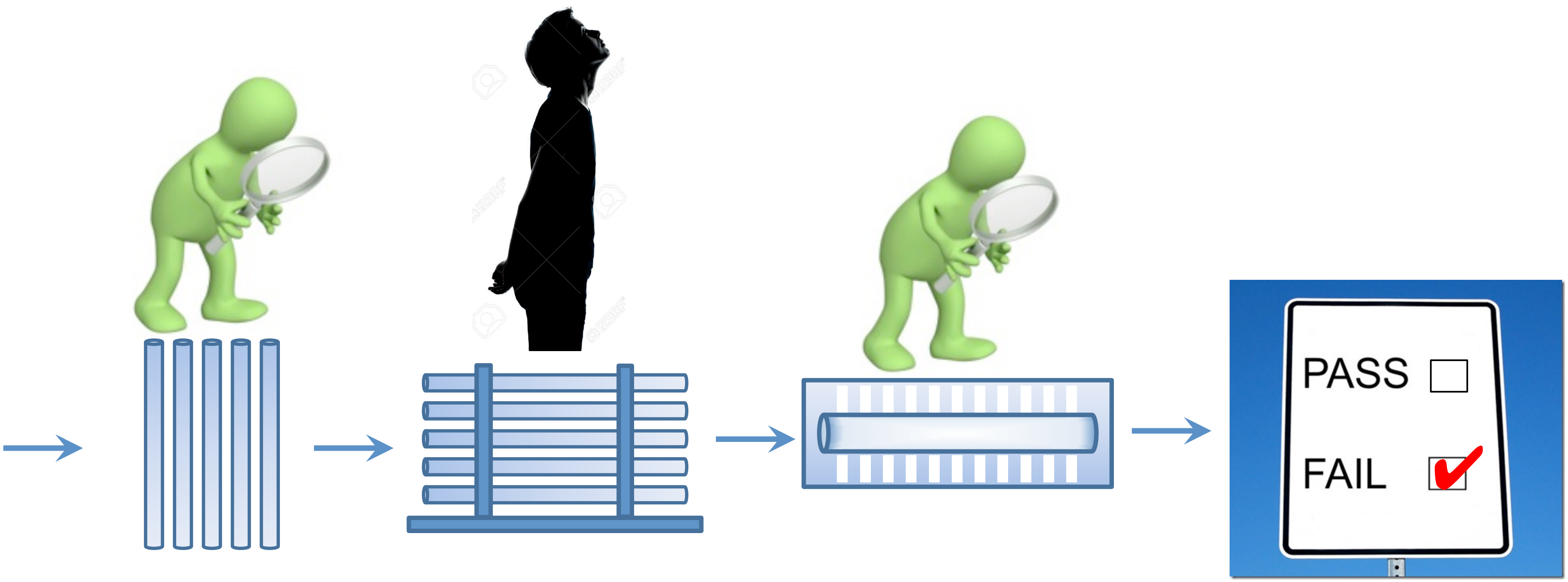


Performance must be demonstrated

WateReuse Research Project 14-12

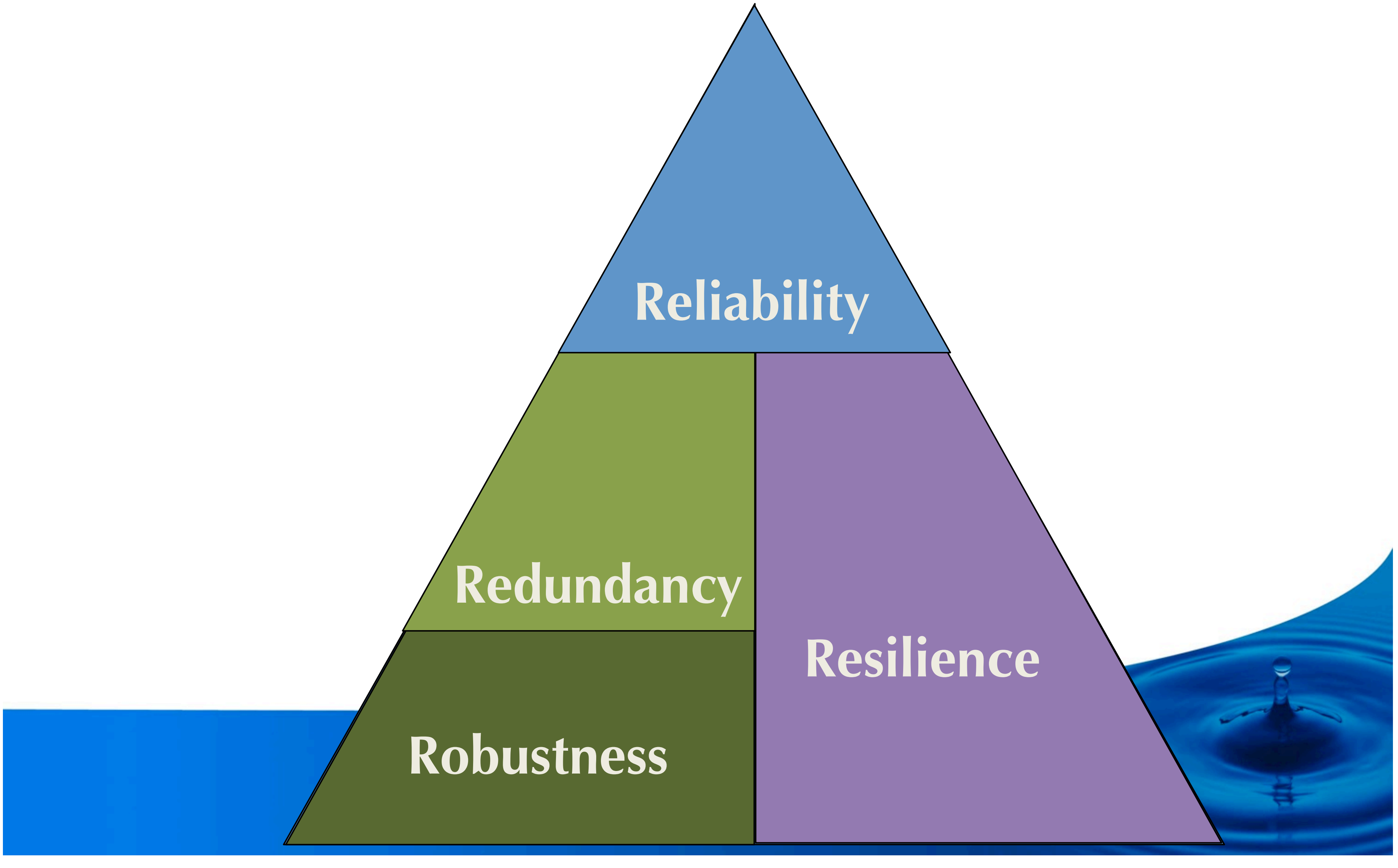
Title: Demonstrating Redundancy and Monitoring to Achieve Reliable Potable Reuse

WATEREUSE

Project Goal

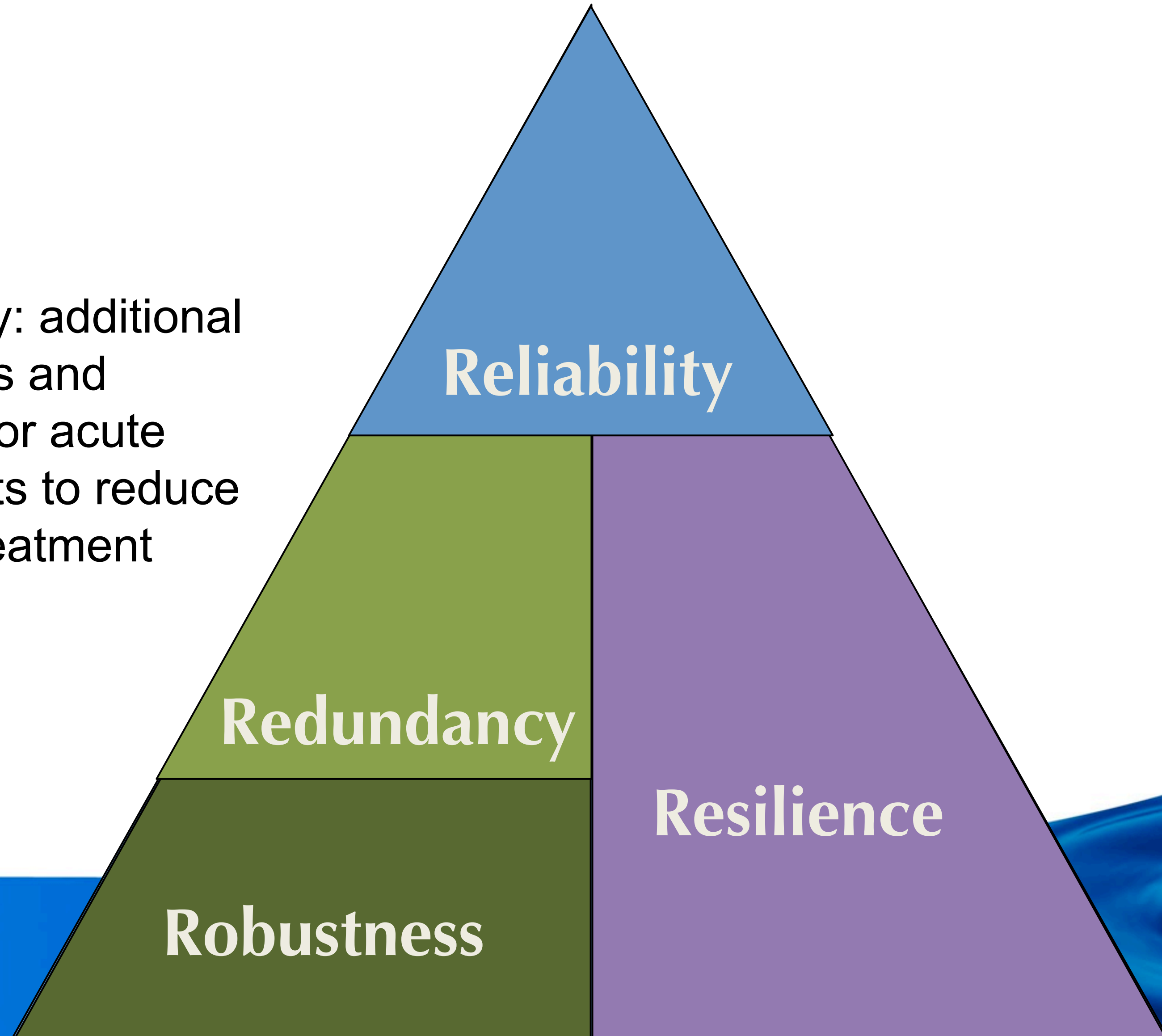
To leverage industry "state of the art" to demonstrate how a combination of treatment redundancy and enhanced monitoring techniques can *reliably* achieve potable reuse treatment objectives

AWPF Concept Built on Reliability

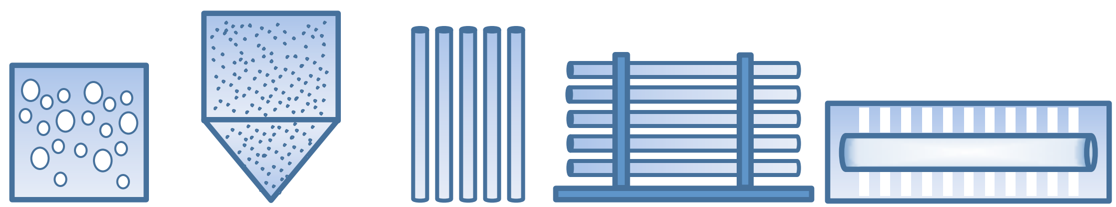


AWPF Concept Built on Reliability

- Redundancy: additional log removals and monitoring for acute contaminants to reduce impact of treatment anomalies

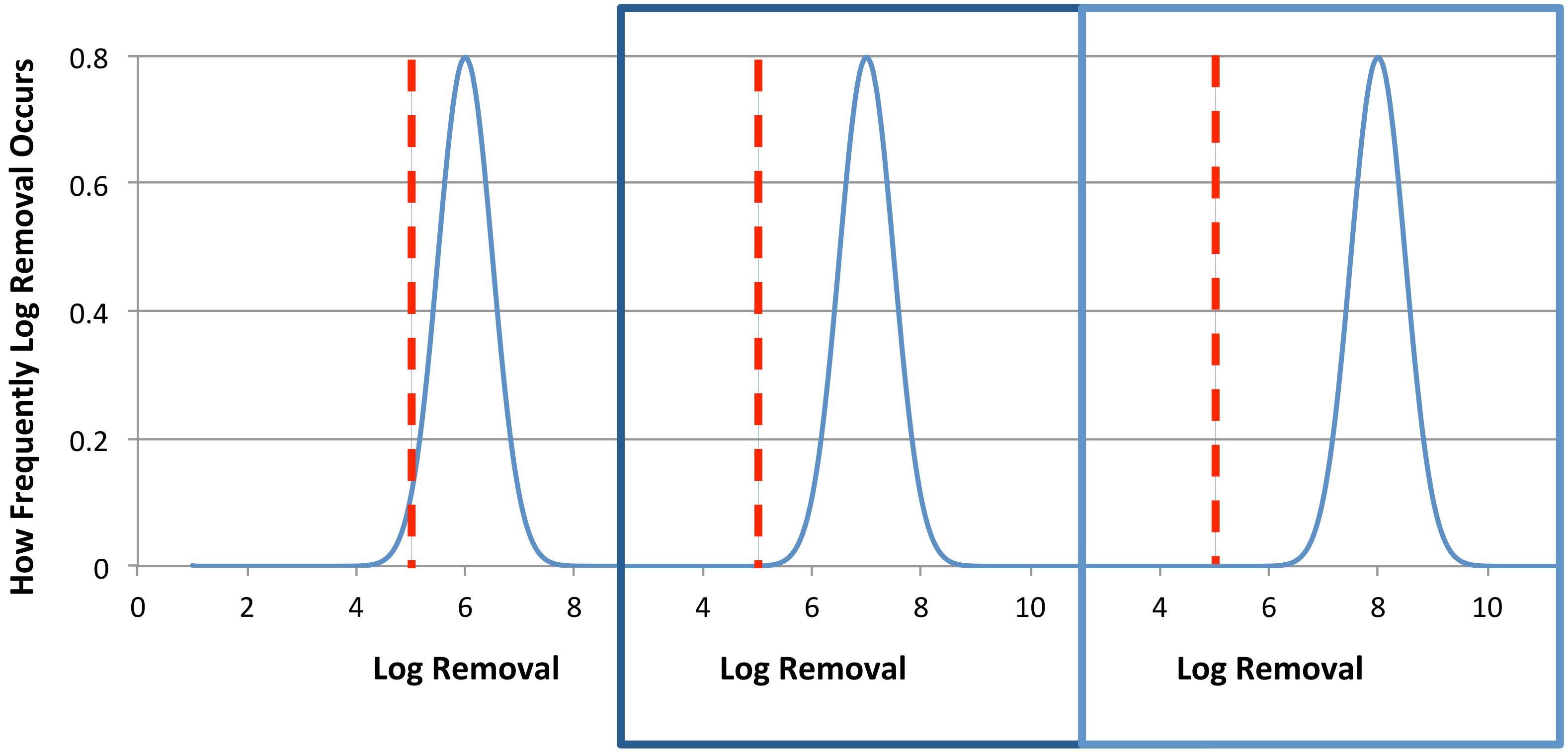


Treatment Redundancy



	3ry	O_3	BAC	MF	RO	UV/AOP	Total	Minimum
Virus	2	6	-	-	1-2	6	**15-16**	12
Crypto	1	2-4	-	4	1-2	6	14-17	10
Giardia	2	6	-	4	1-2	6	19-20	10

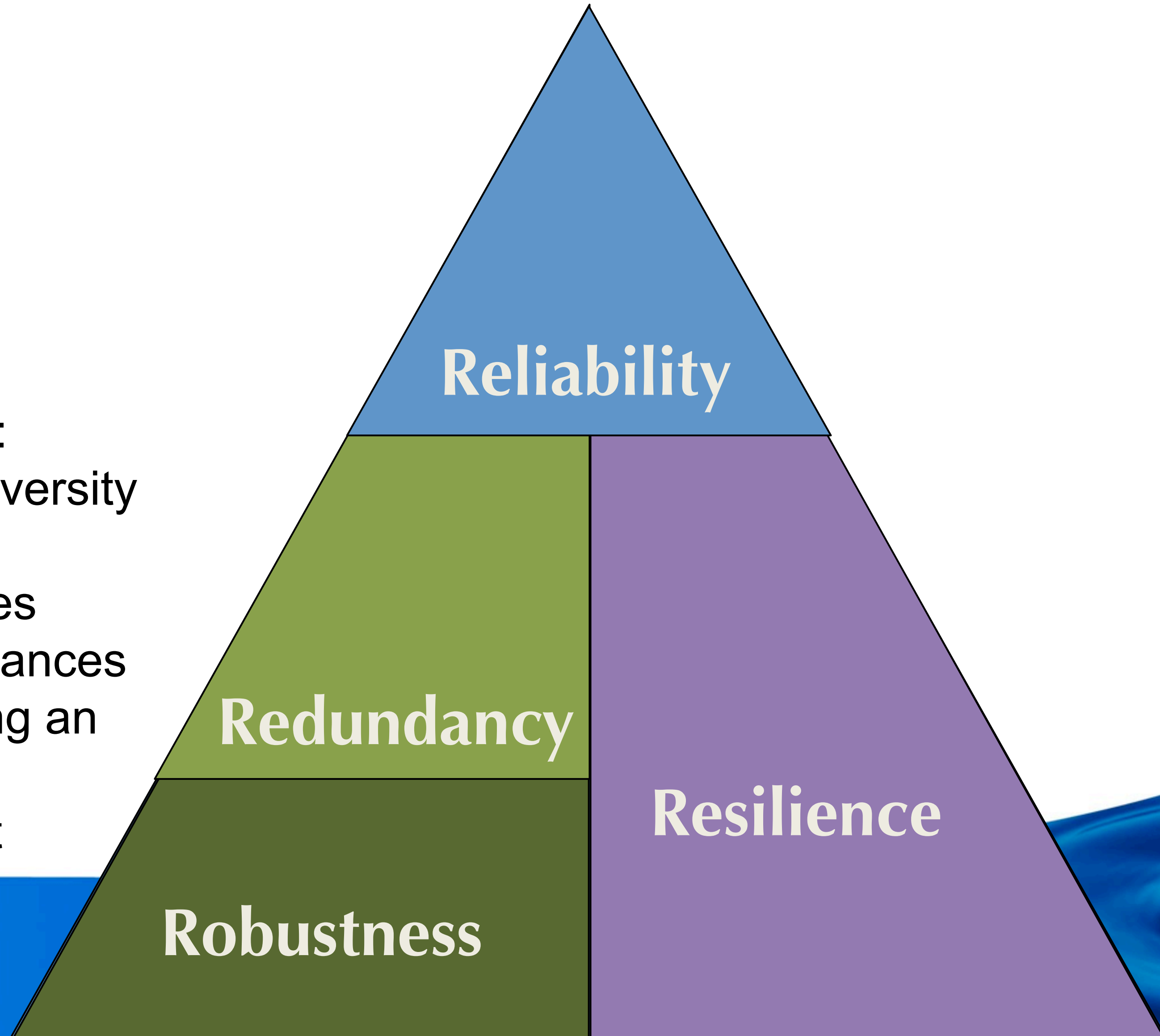
Redundancy: Greater than Minimum



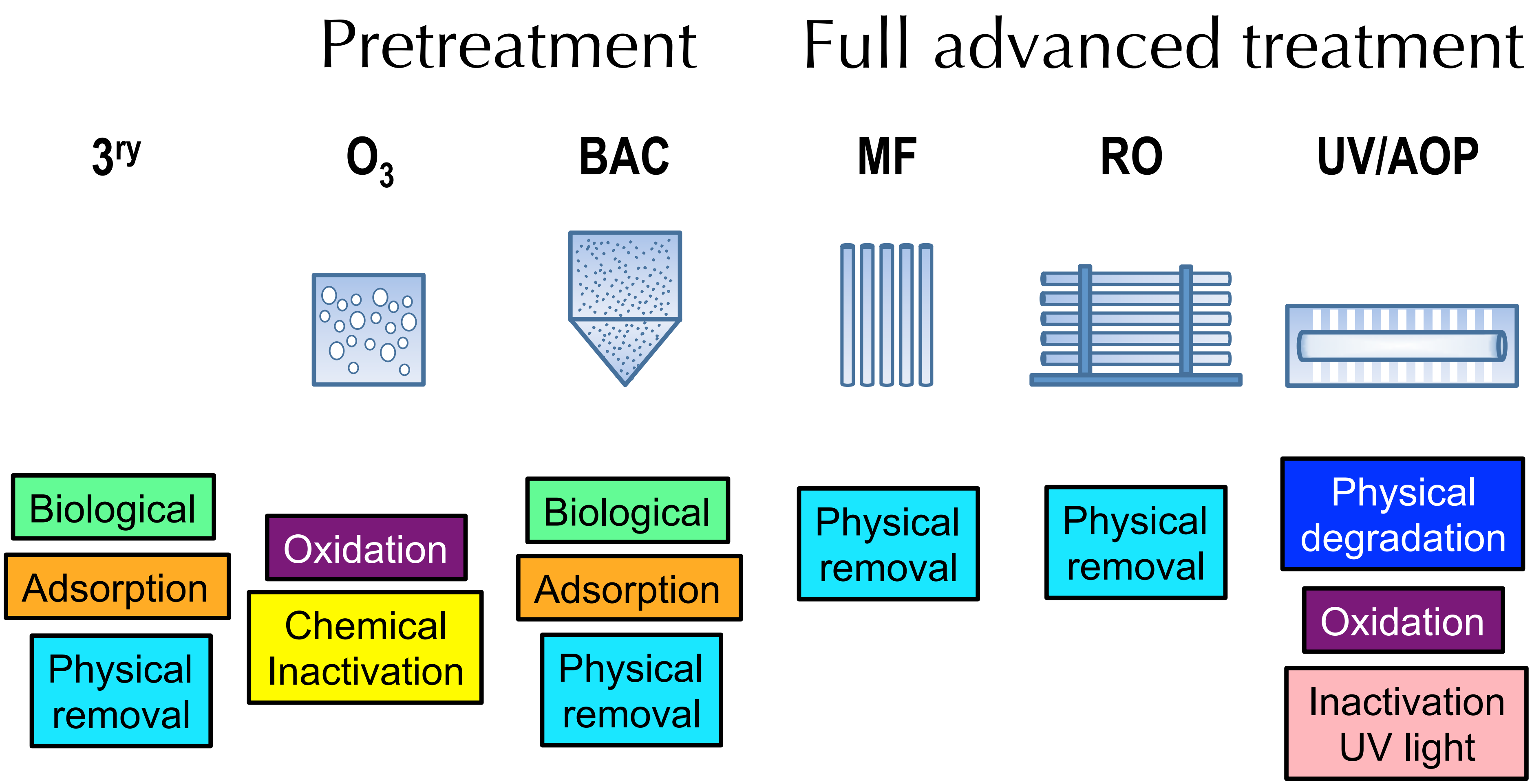
Failure to achieve 5-log?	<u>6-log</u>	<u>7-log</u>	<u>8-log</u>
	2.3%	0.003%	0.0000001%

AWPF Concept Built on Reliability

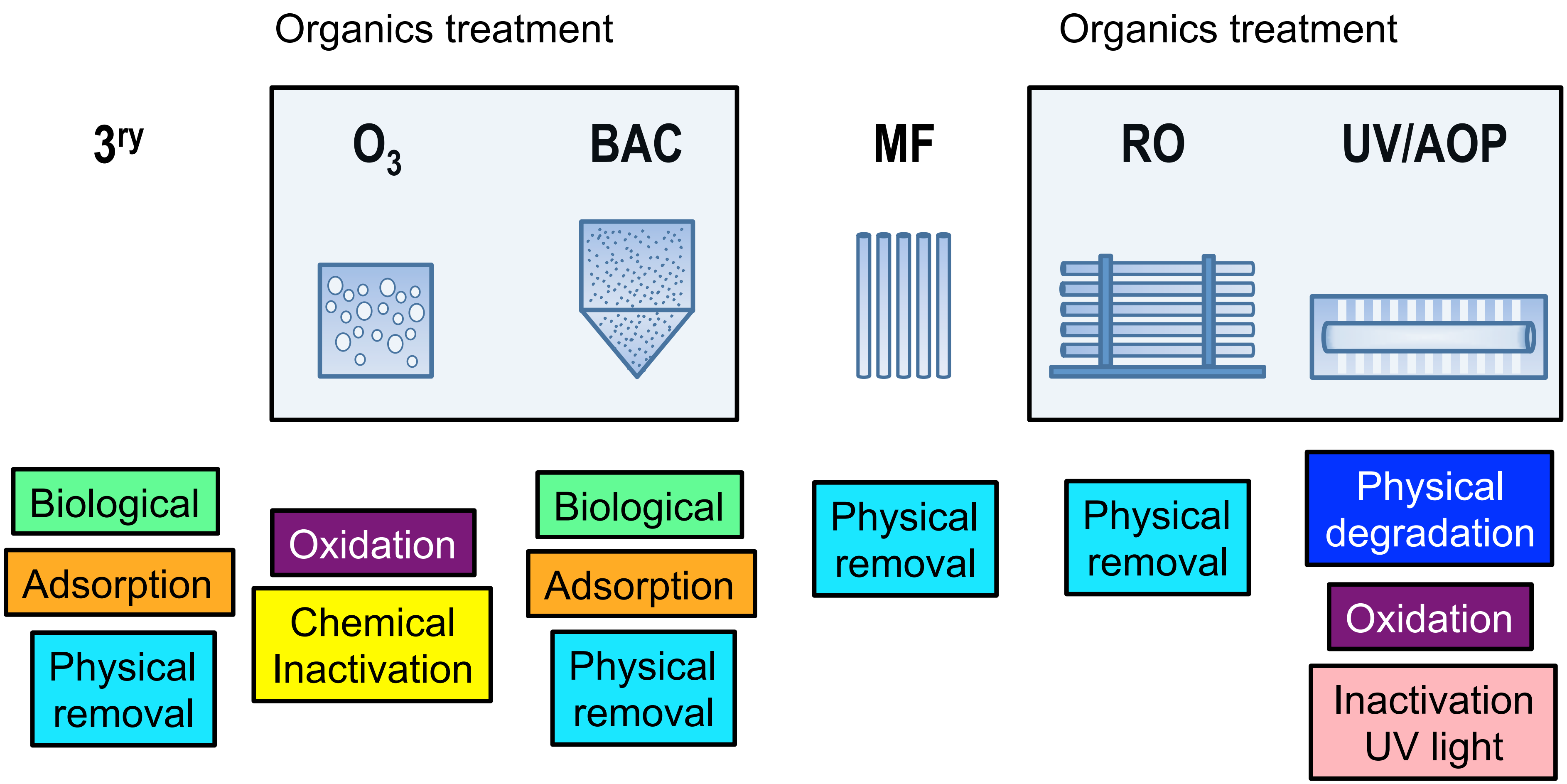
- Robustness: increased diversity of treatment process types improves chances of attenuating an unknown contaminant



Robustness: Incorporating more strength

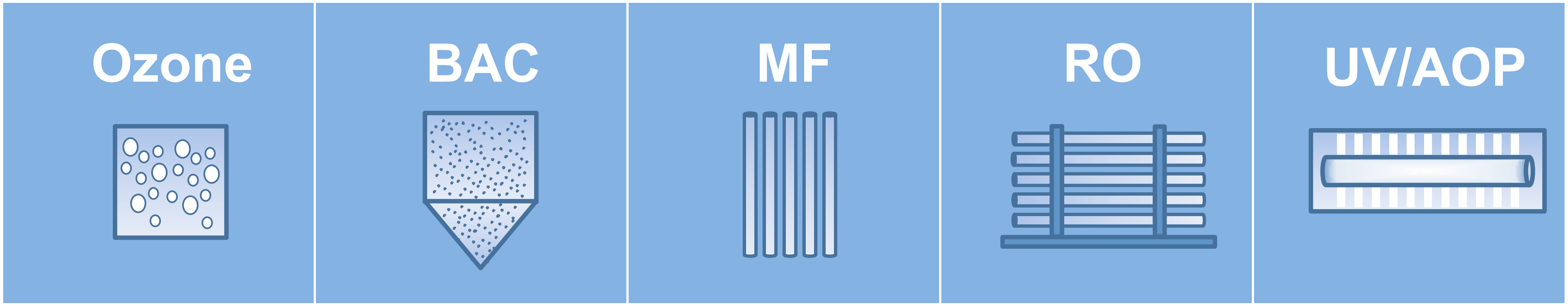


Robustness:
Proactively mitigates next “unknown”



MEASURING RELIABILITY

Measuring Reliability



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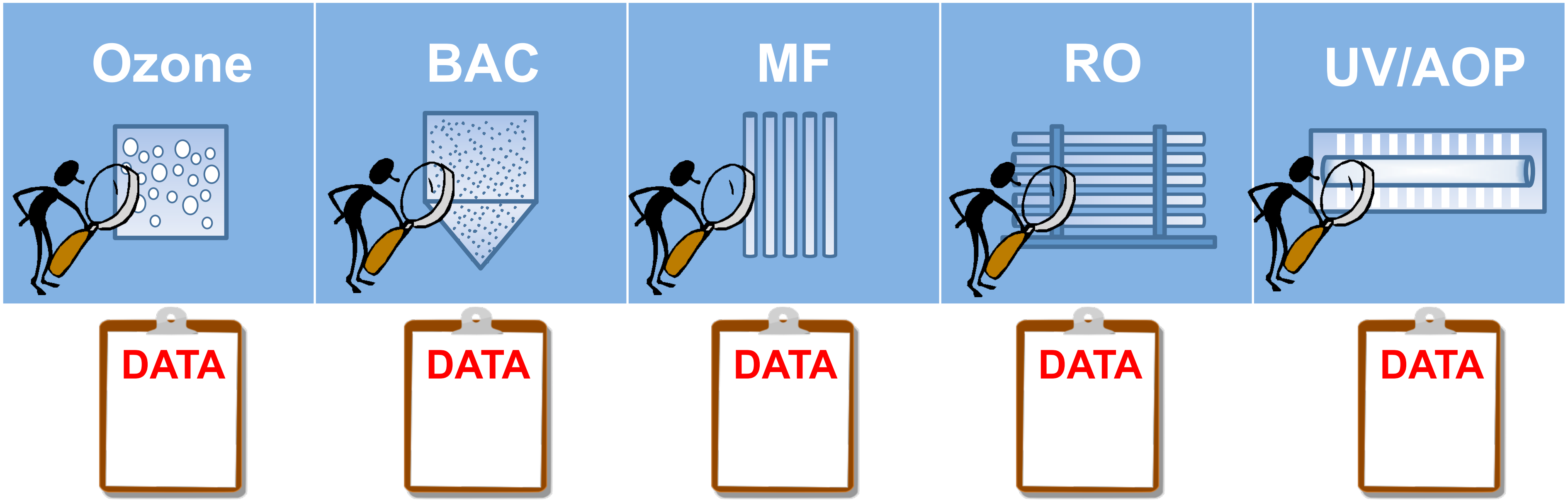

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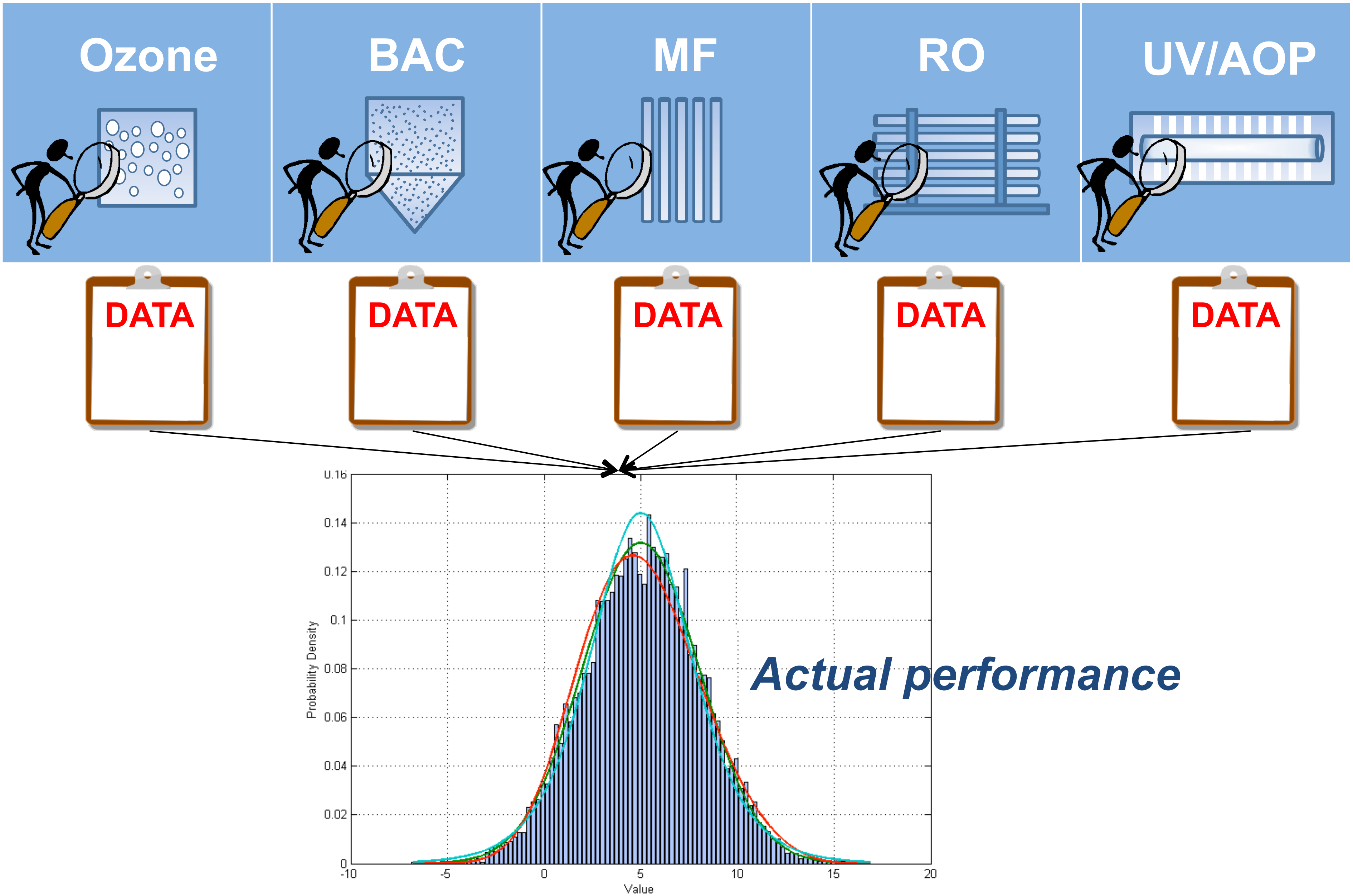

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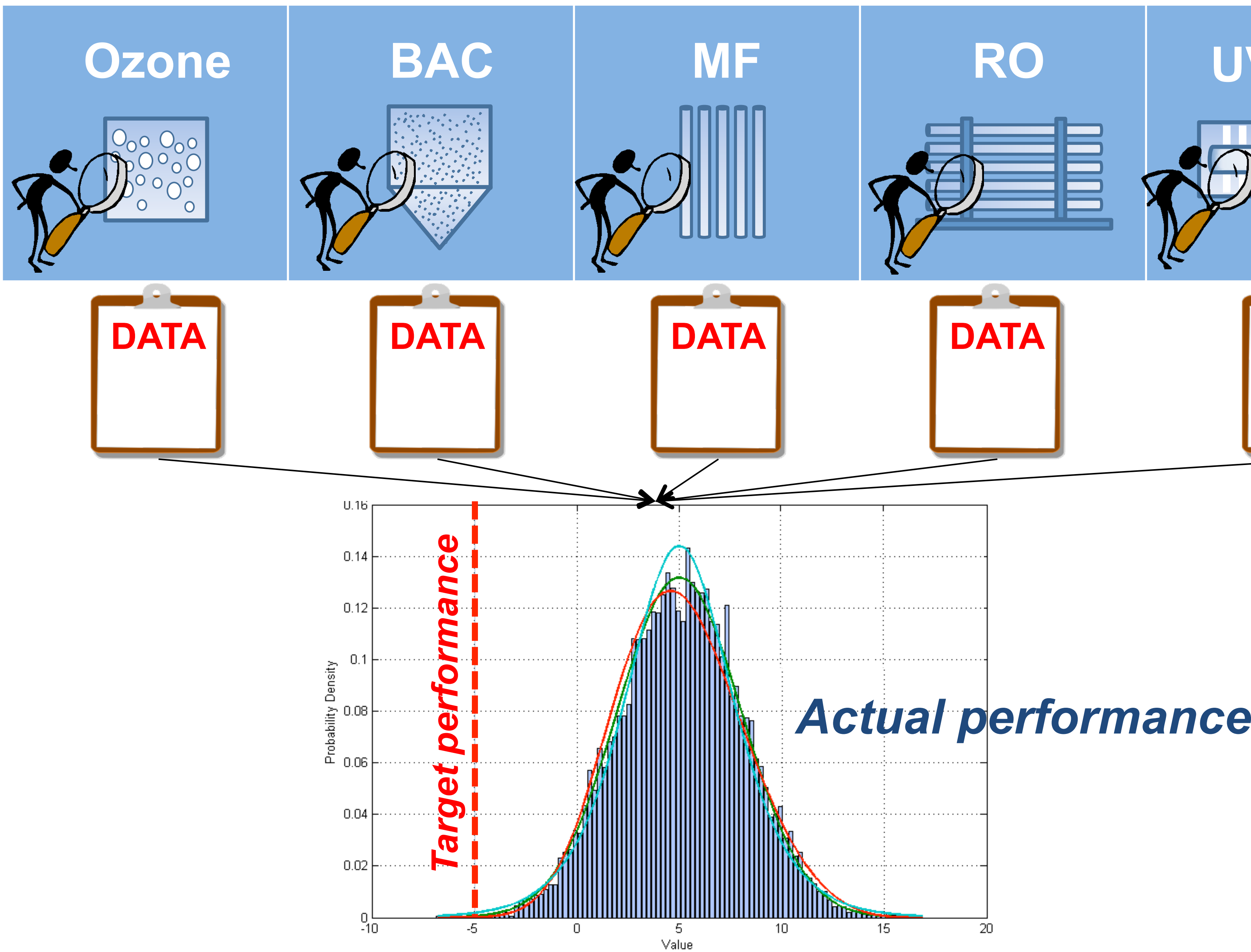
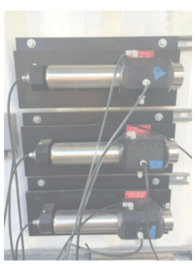


Performance Monitoring Data

	Ozone	BAC	MF	RO	UV/AOP
Critical Control Points	DO_3 (x3)	--	Turb. (Eff) PDT	Δ TOC Δ Cond.	UV Intensity Power UVT

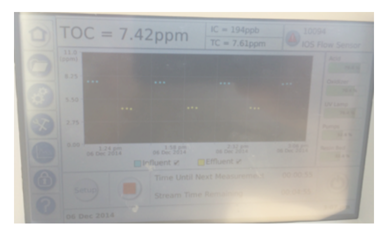
HACH

ROSEMOUNT Analytical

Kuntze INSTRUMENTS

GE Power & Water
Water & Process Technologies
Analytical Instruments





Data Management

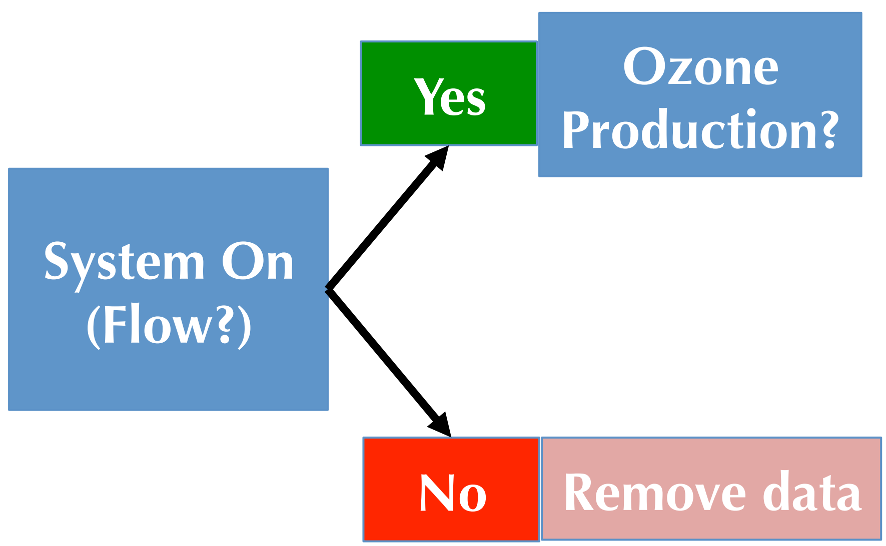
Meters

Local Storage And Control

SCADA/Central Storage

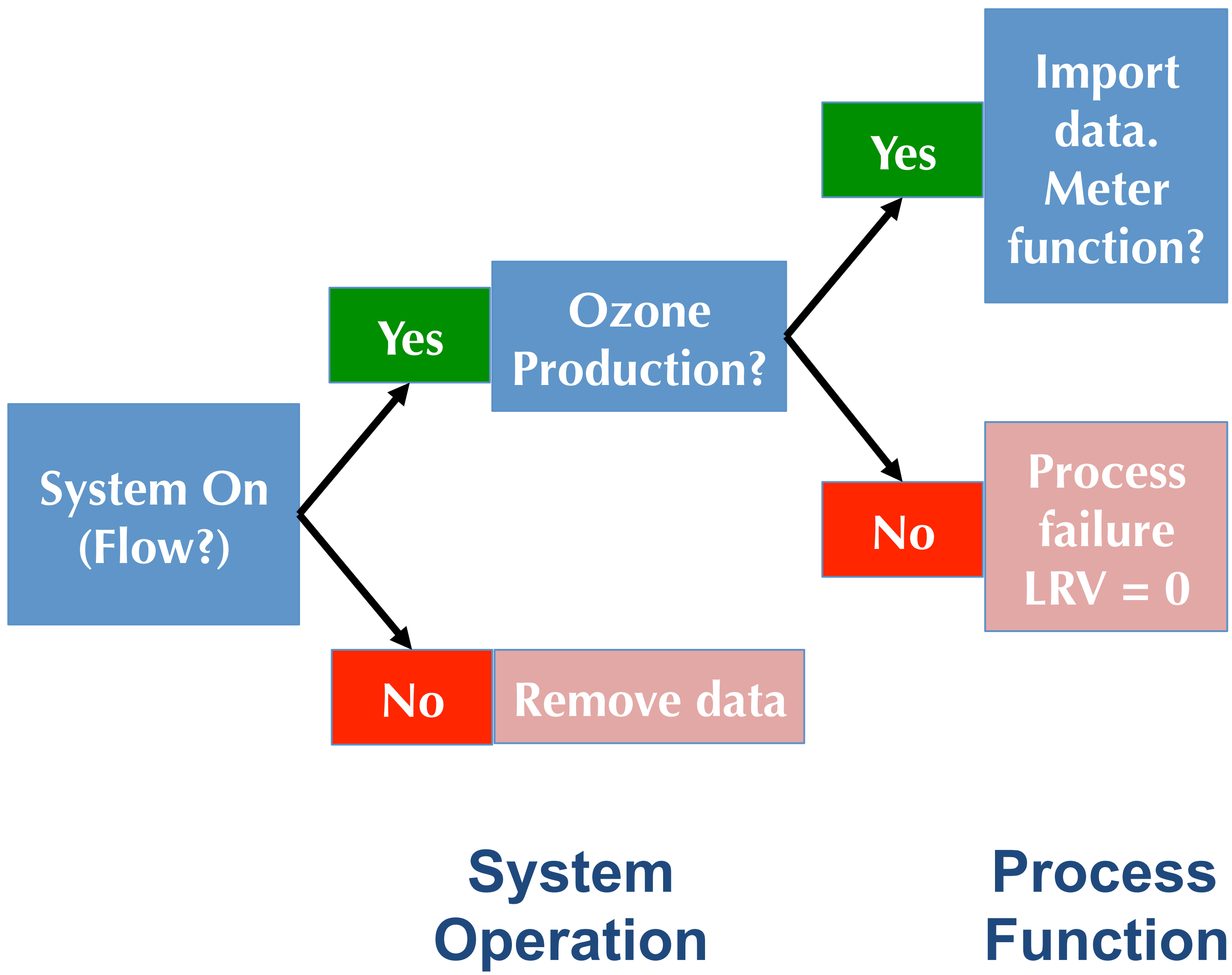
Performance Analysis

Data Analysis

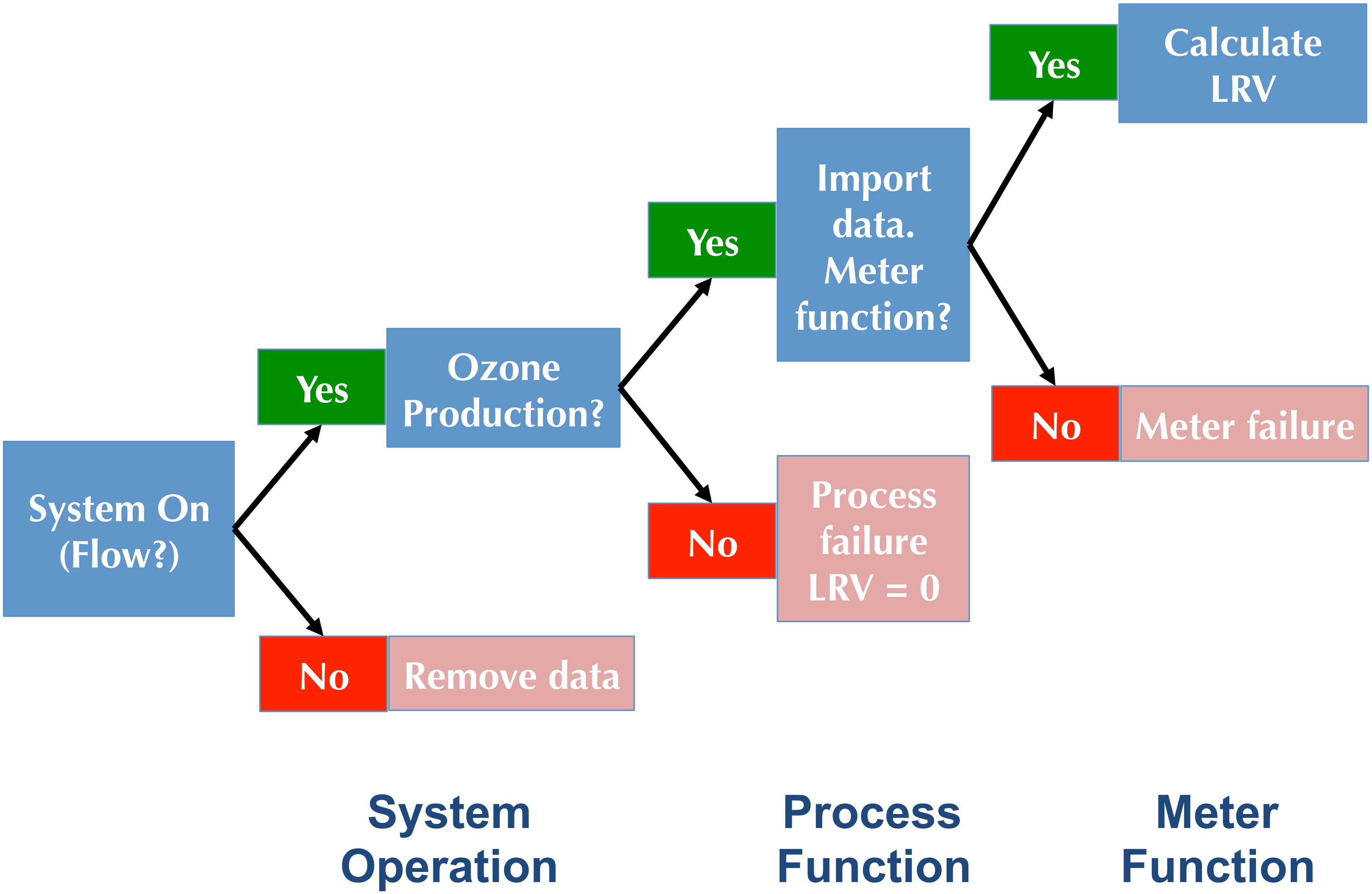


System Operation

Data Analysis



Data Analysis



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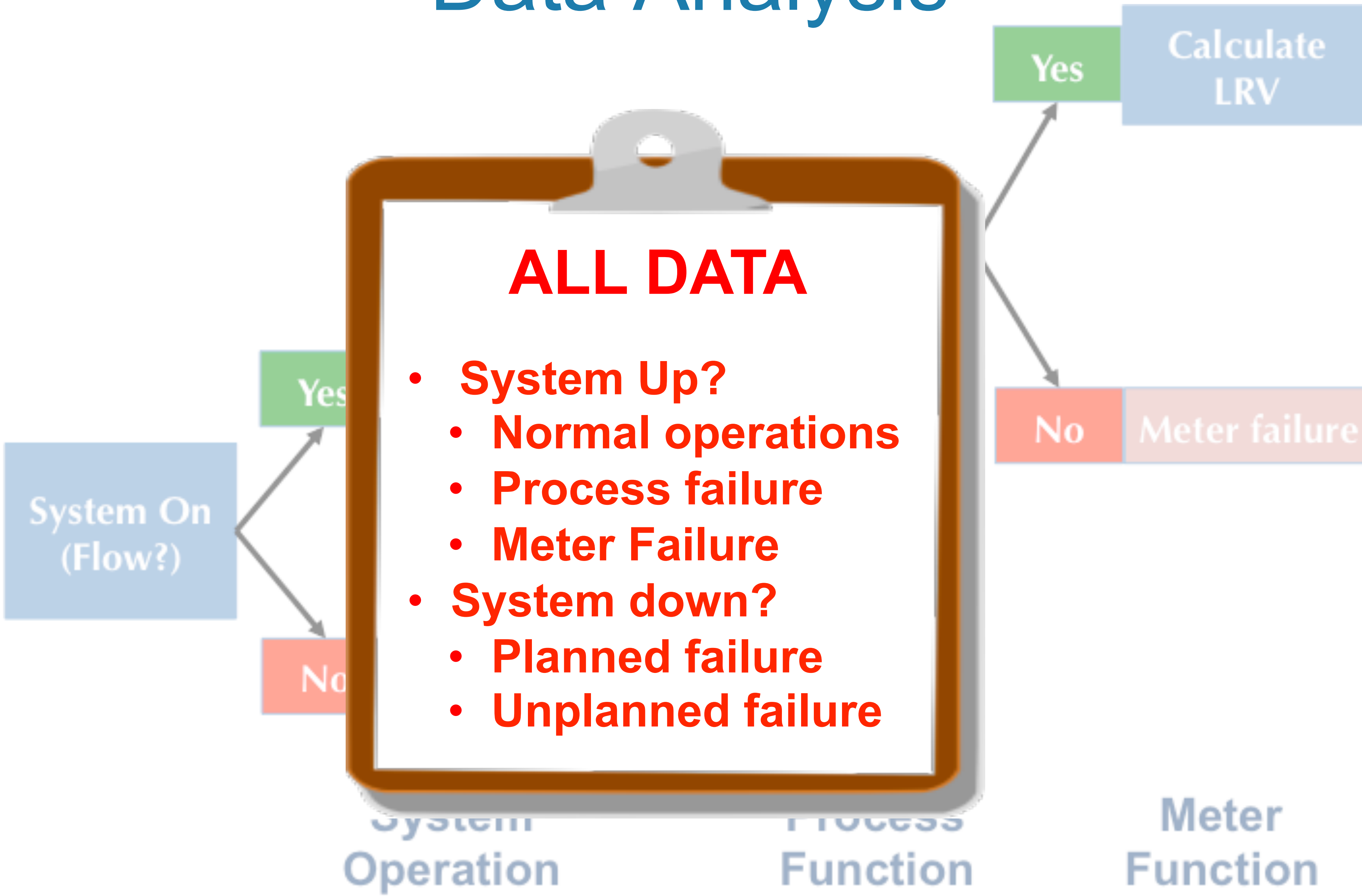


OZONE | BAC | MF | RO | UV/AOP

Forms of Reliability

Mechanical Reliability

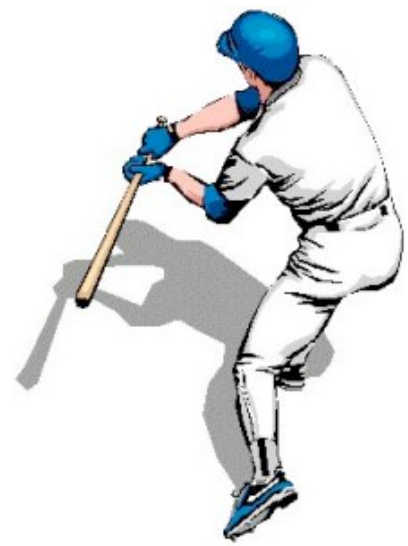
How frequently system is running as designed

Inherent Reliability

Quality of water produced when system is running properly

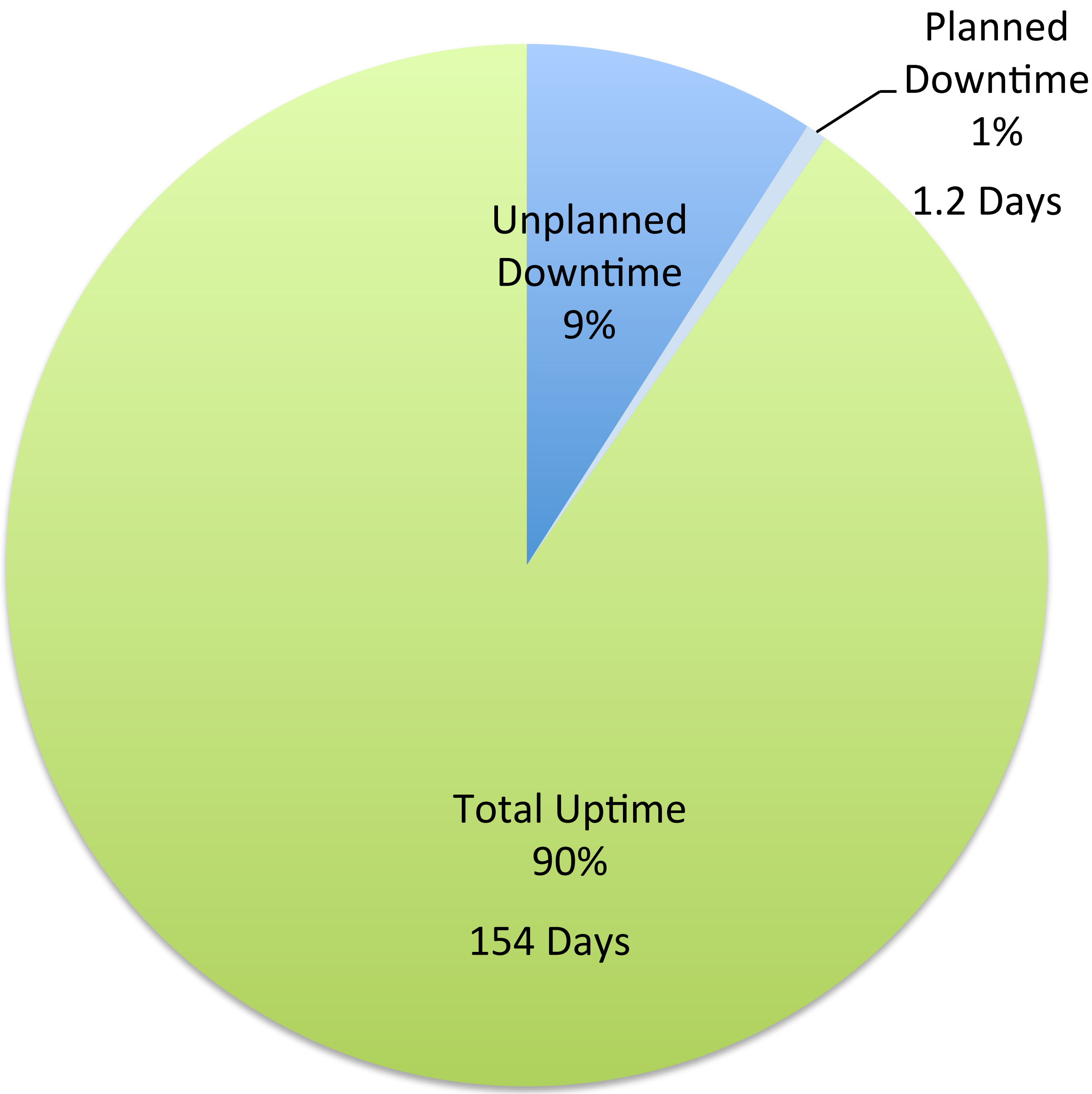
System Up

System Down



System Performance

Mechanical Reliability



Demo plant not designed with standby

Ozone Performance Calculation

Inputs

- Temperature
- Dissolved O_3 Meters (x3)
- Contact Time

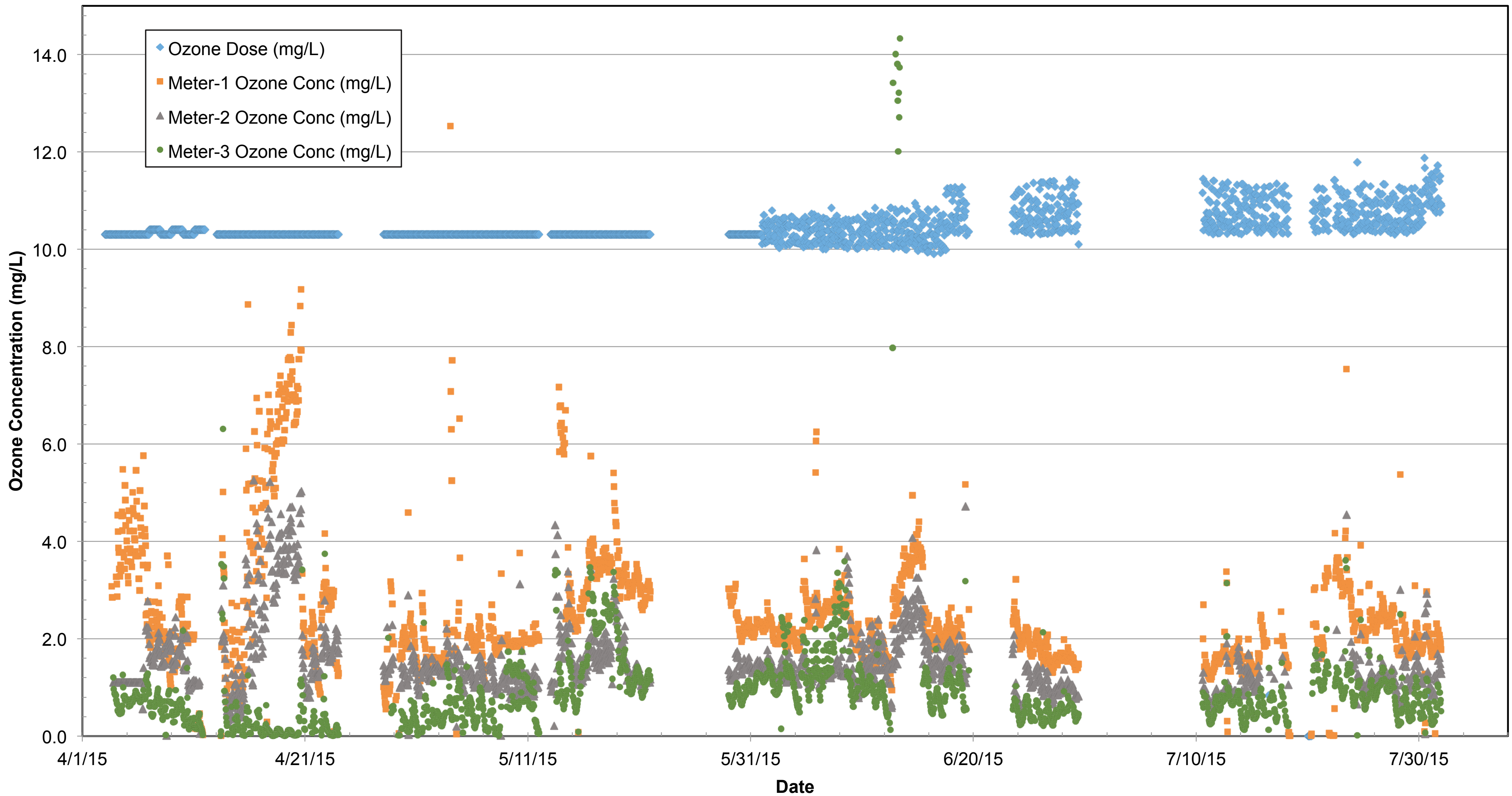
Calculations

- Determine total CT value

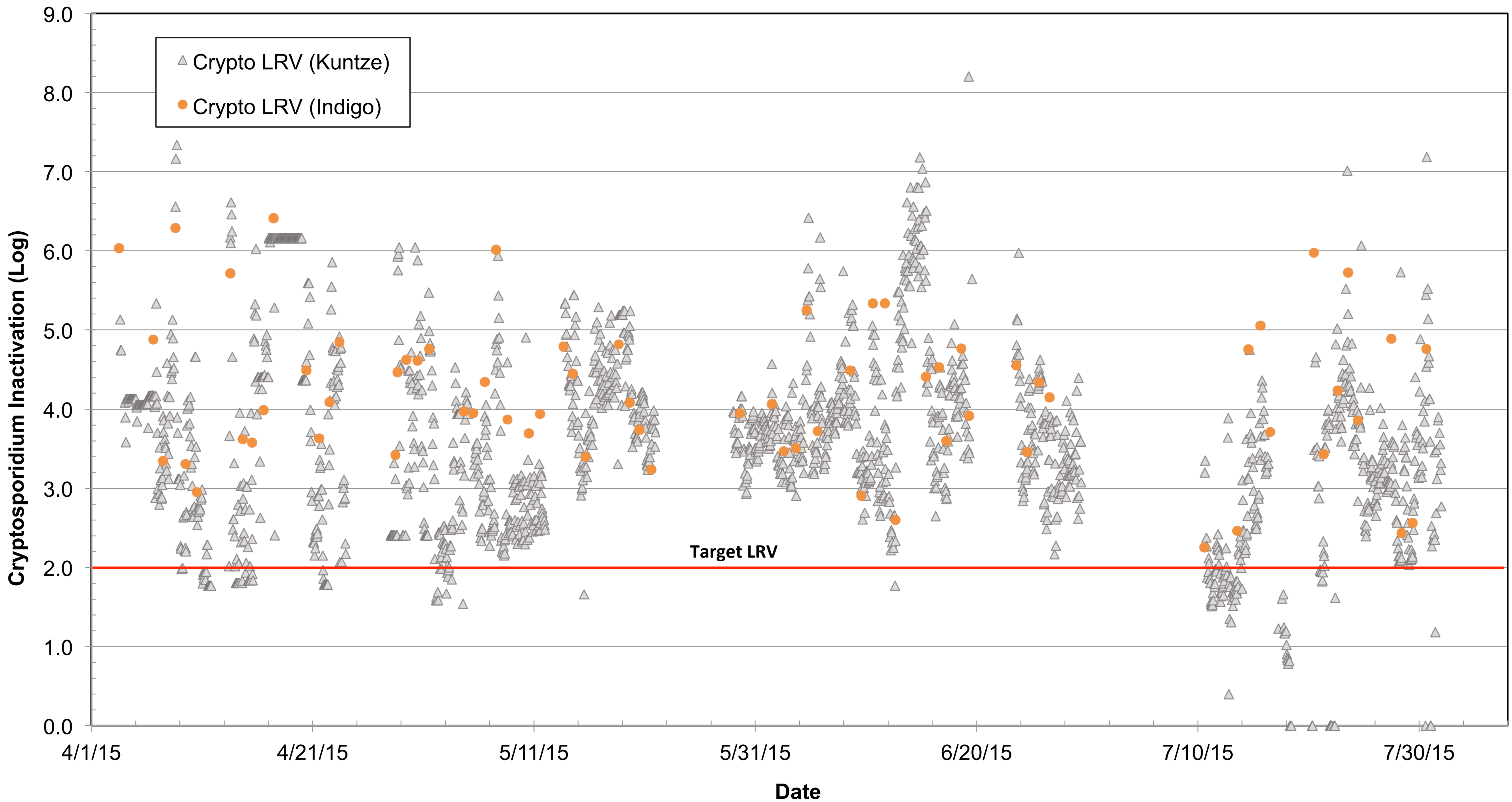
Assign LRV

- Use info from SWTRs to assign Crypto LRV
- If Crypto LRV $\geq$ 1, Giardia and virus = 6

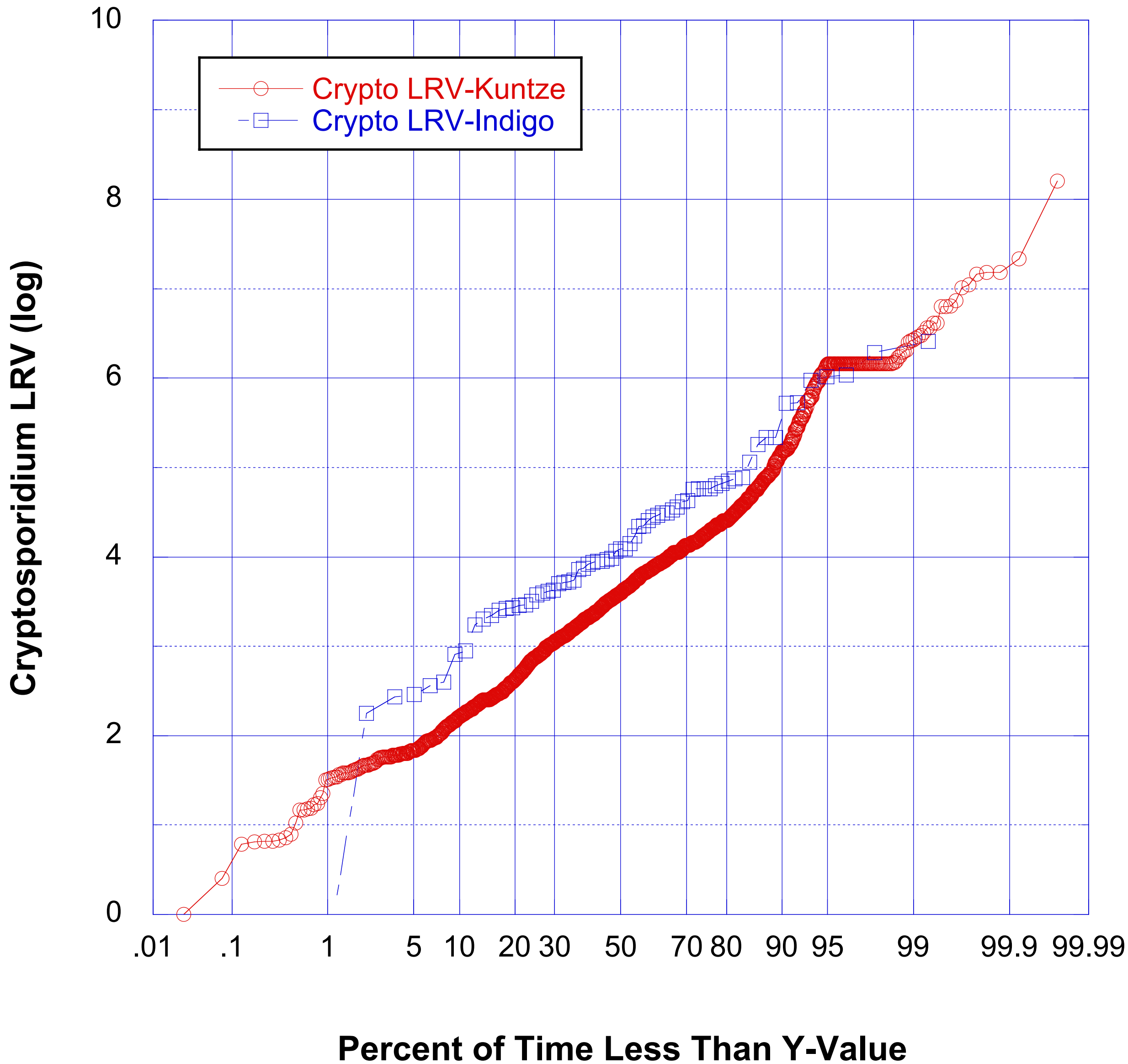
Ozone Performance Data



Ozone Performance Data

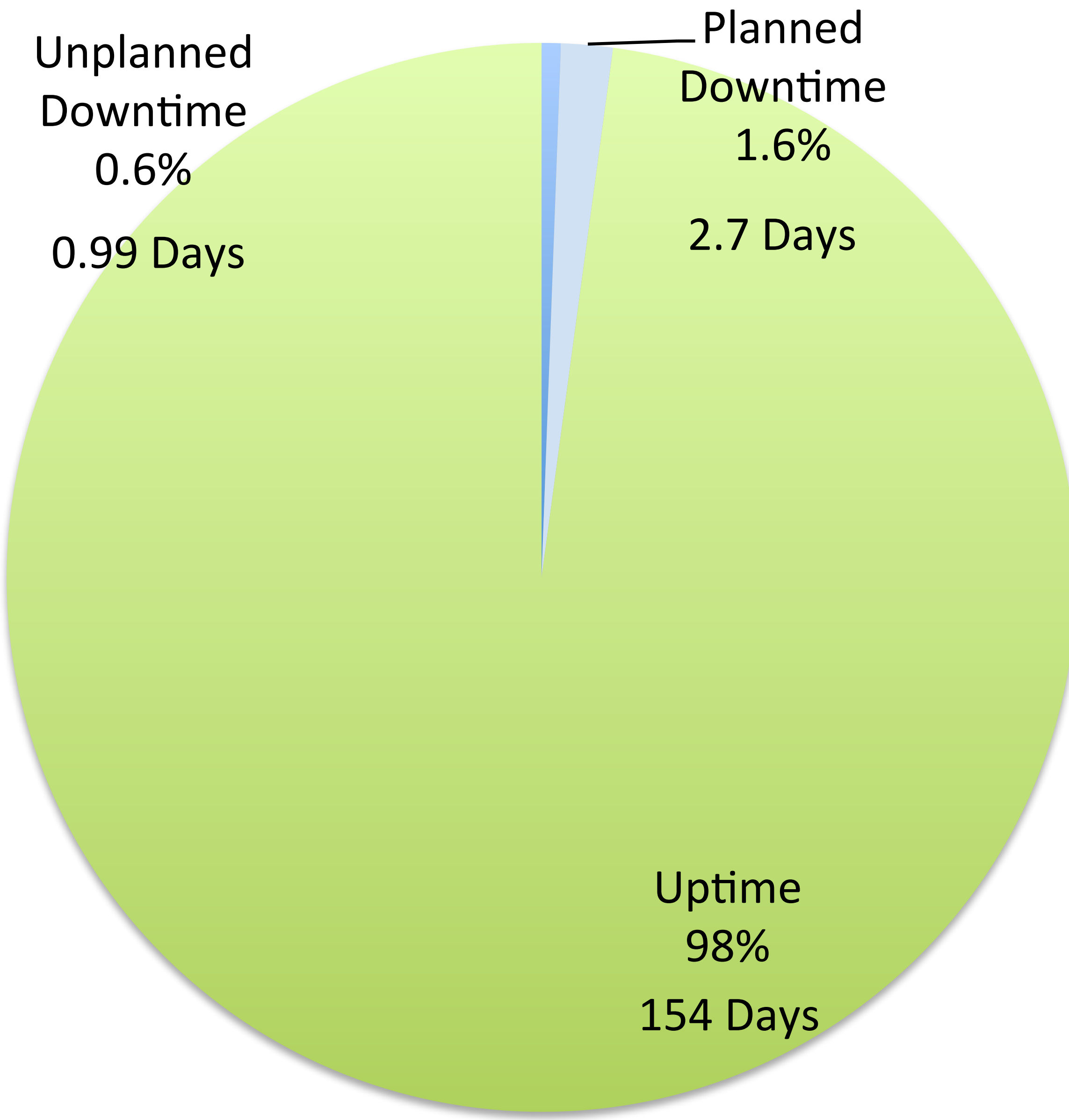


Ozone Performance Curve

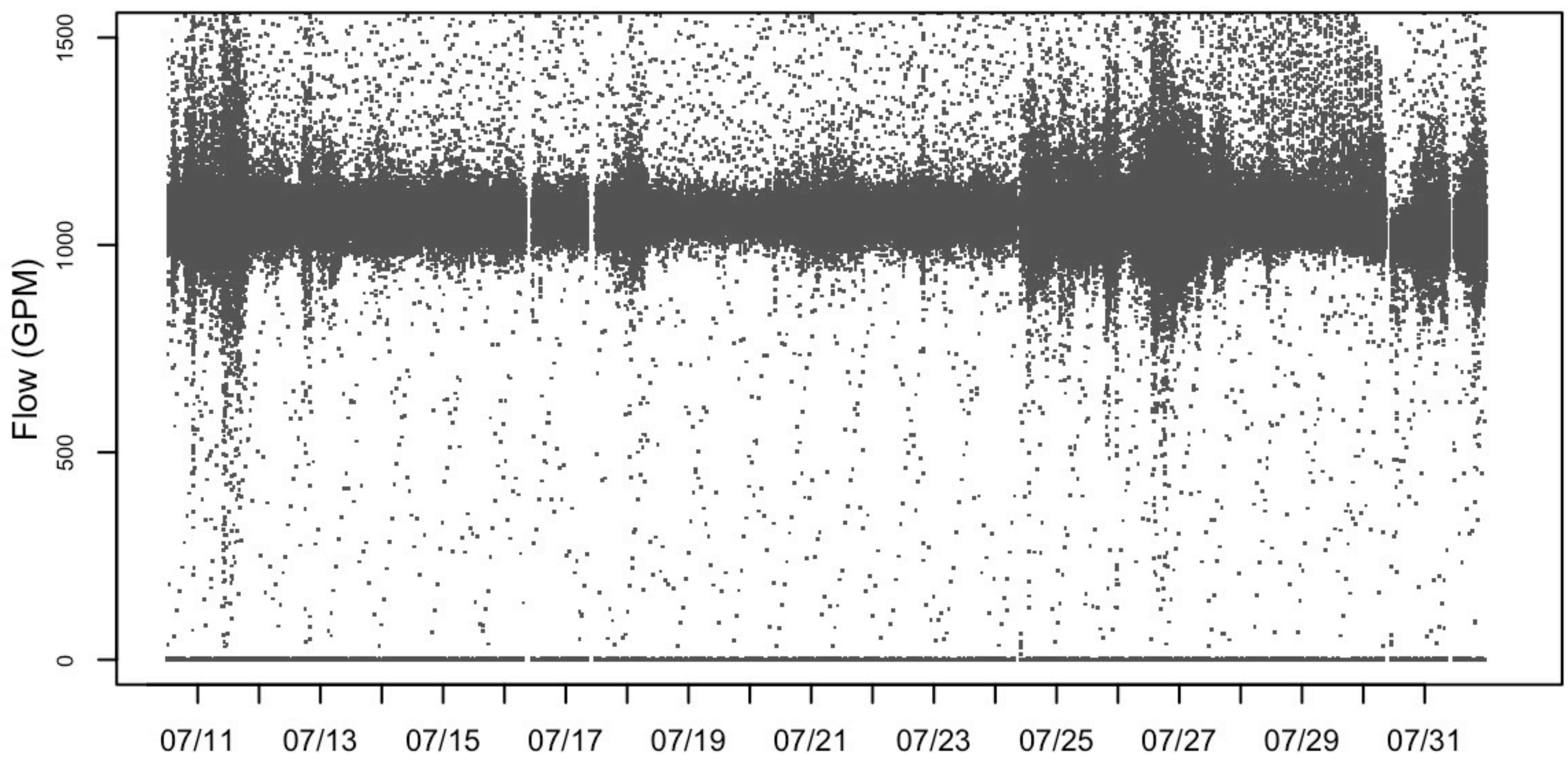



WEDECO
OZONE
BAC
MF
RO
UV/AOP

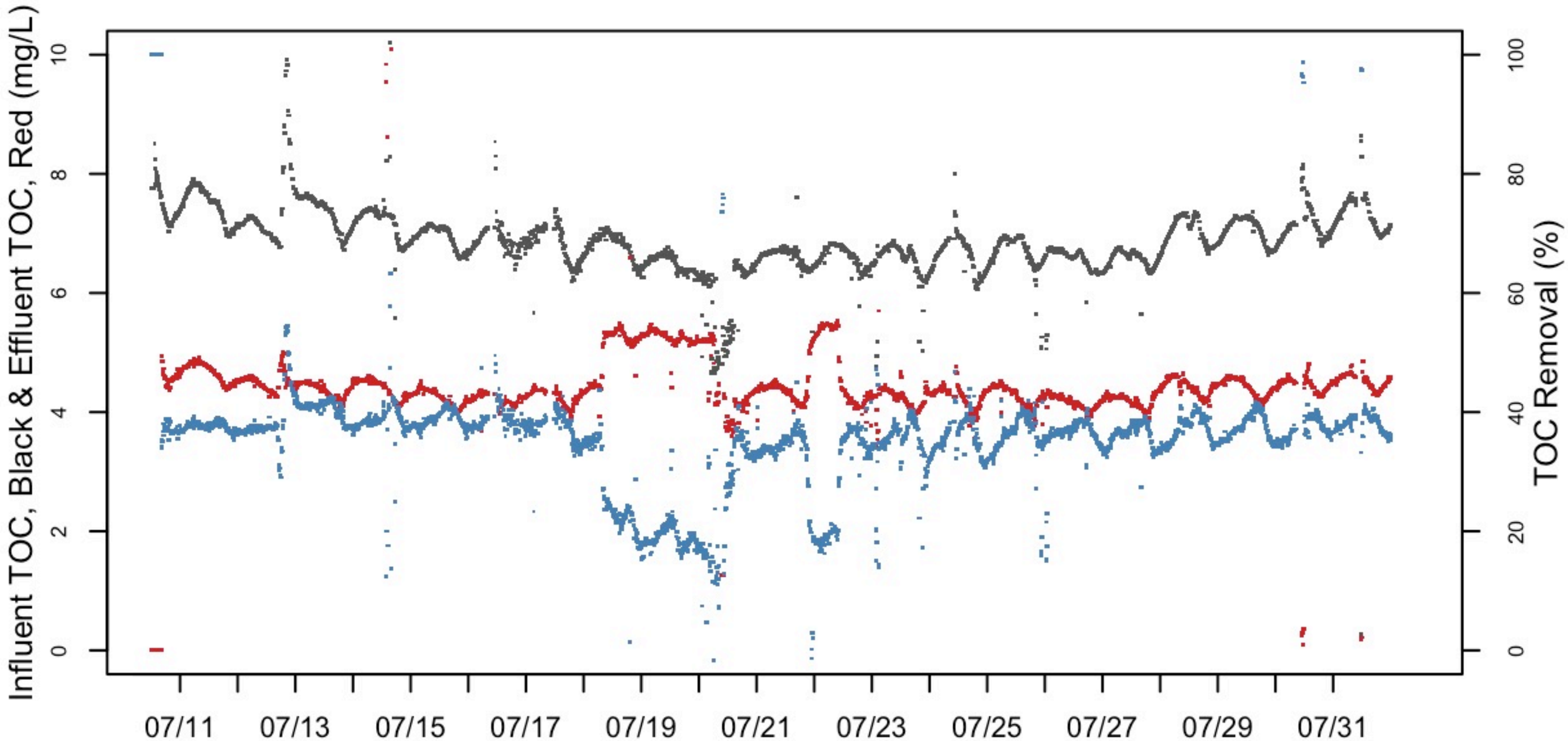
Mechanical Reliability



BAC Performance Data

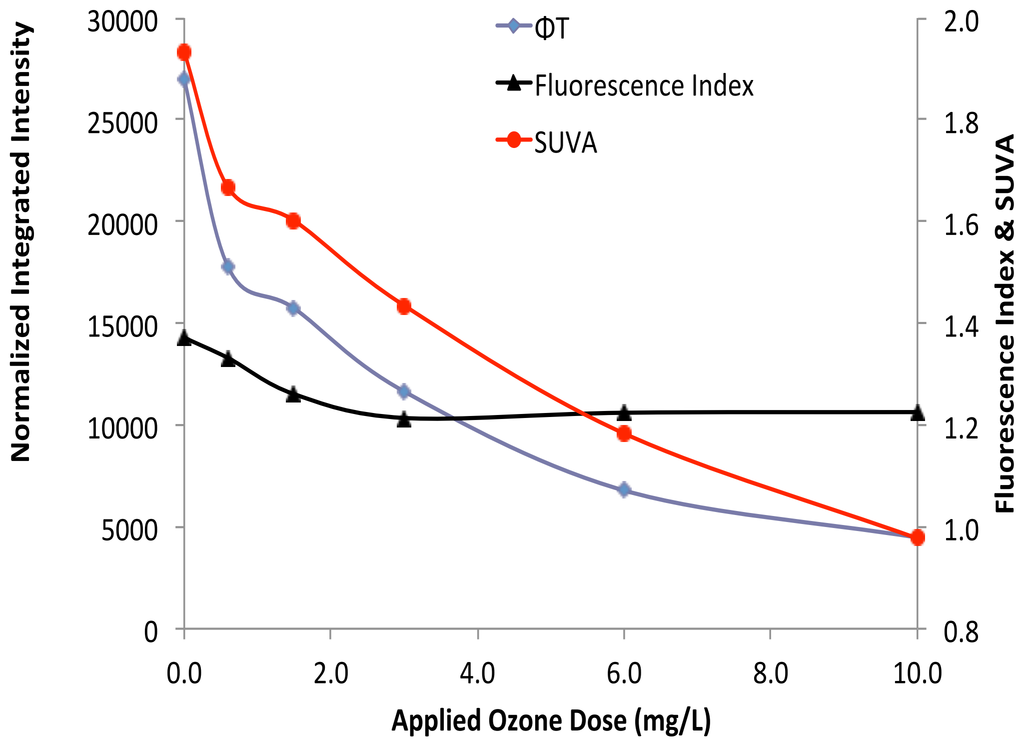


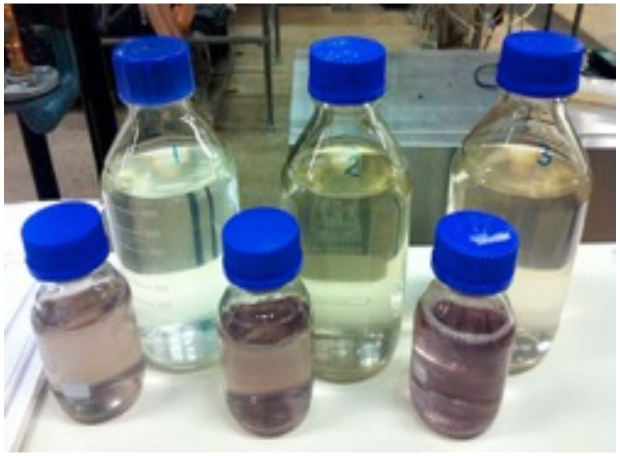
BAC Performance Data

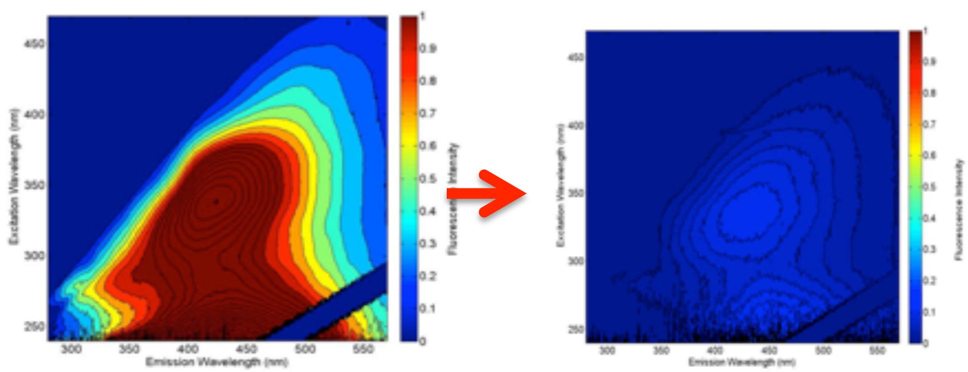


Transformation of Organic Matter by Ozone

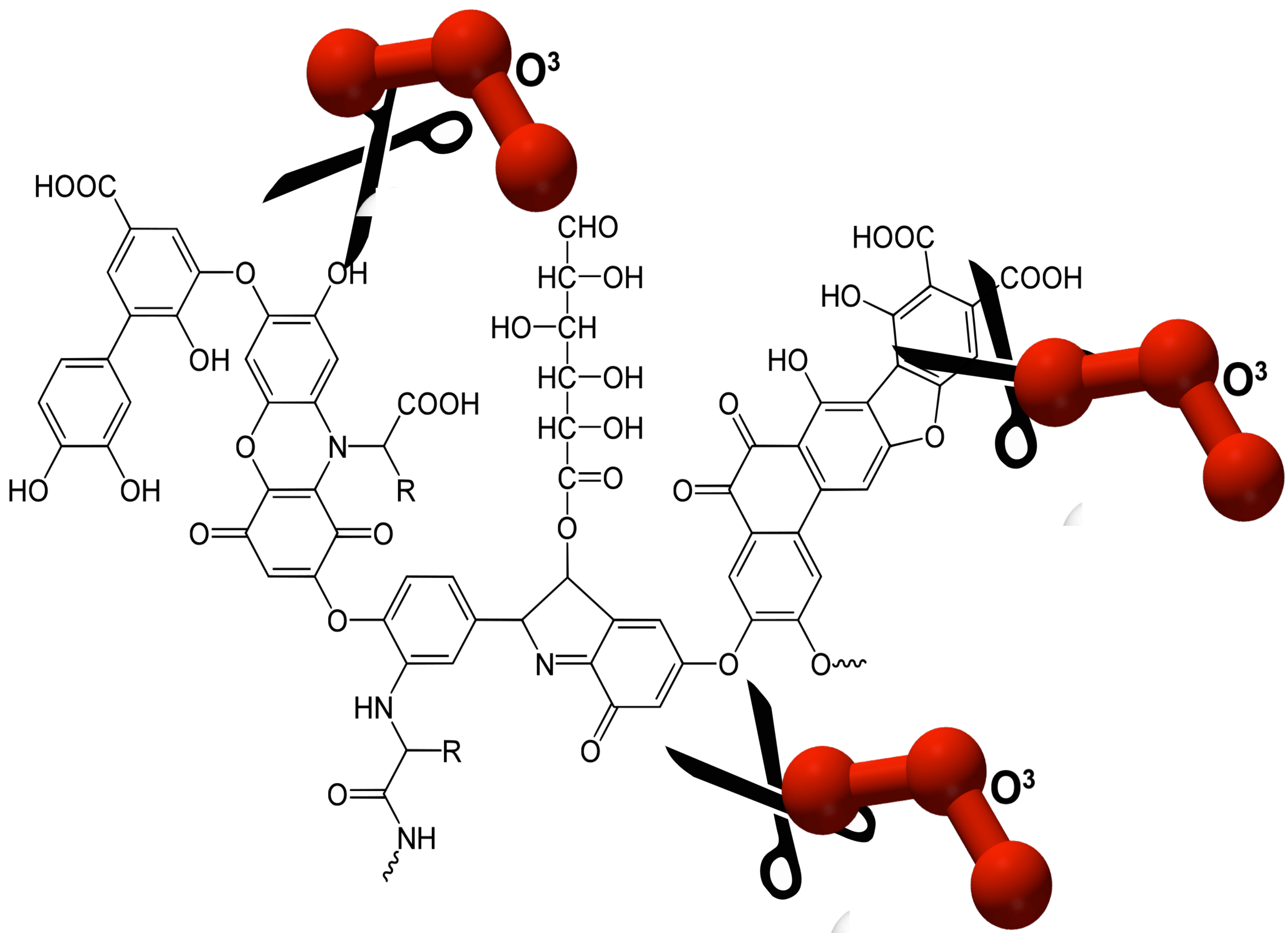
- Ozone oxidizes EfOM
- Quantifiable decrease in:
  - UVT
  - Fluorescence
  - Color
- Breaks down large MW and produces smaller MW, more polar, and more hydrophilic type organics



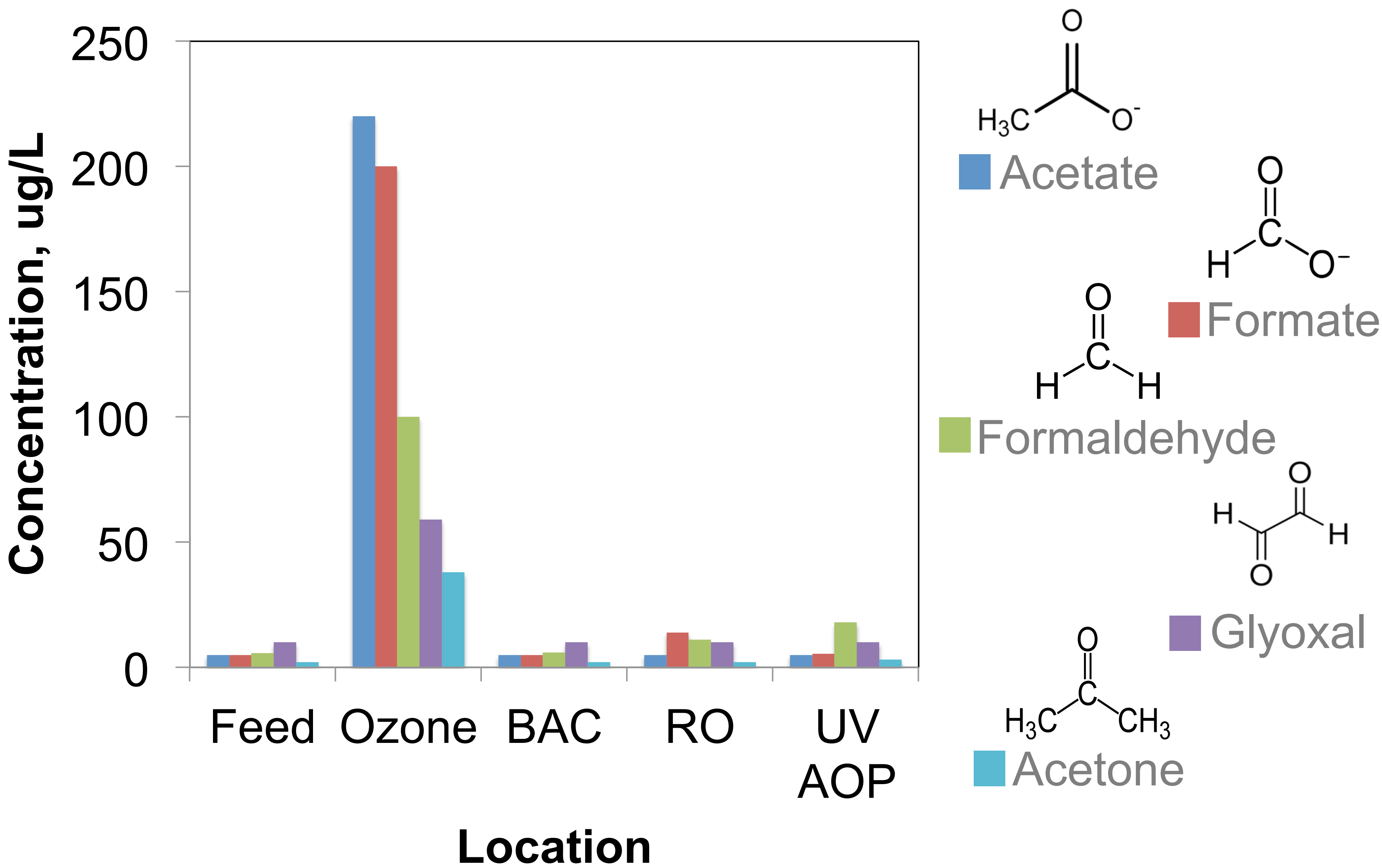




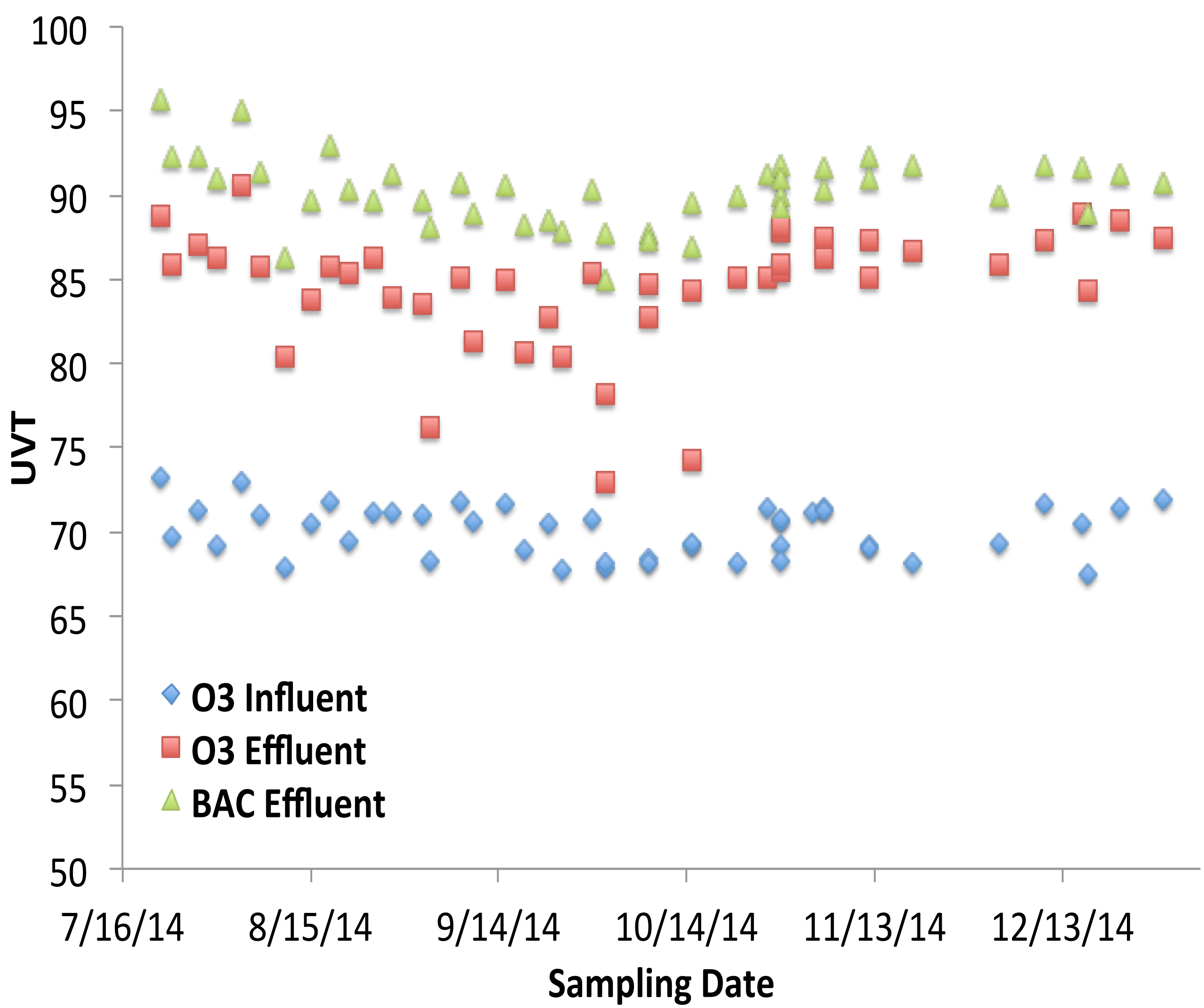
What does ozone do to TOC?

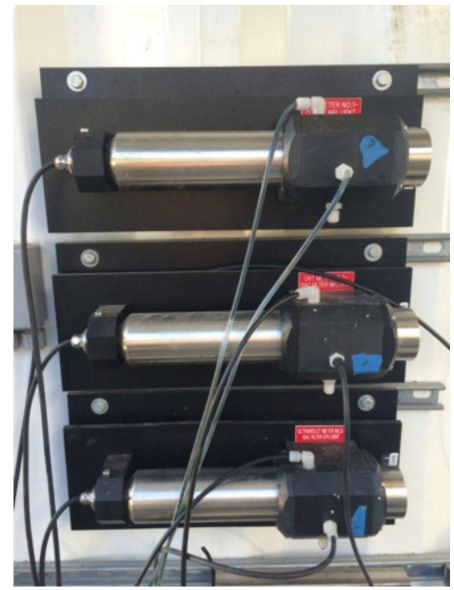


Oxidation Byproducts Are Yummy!

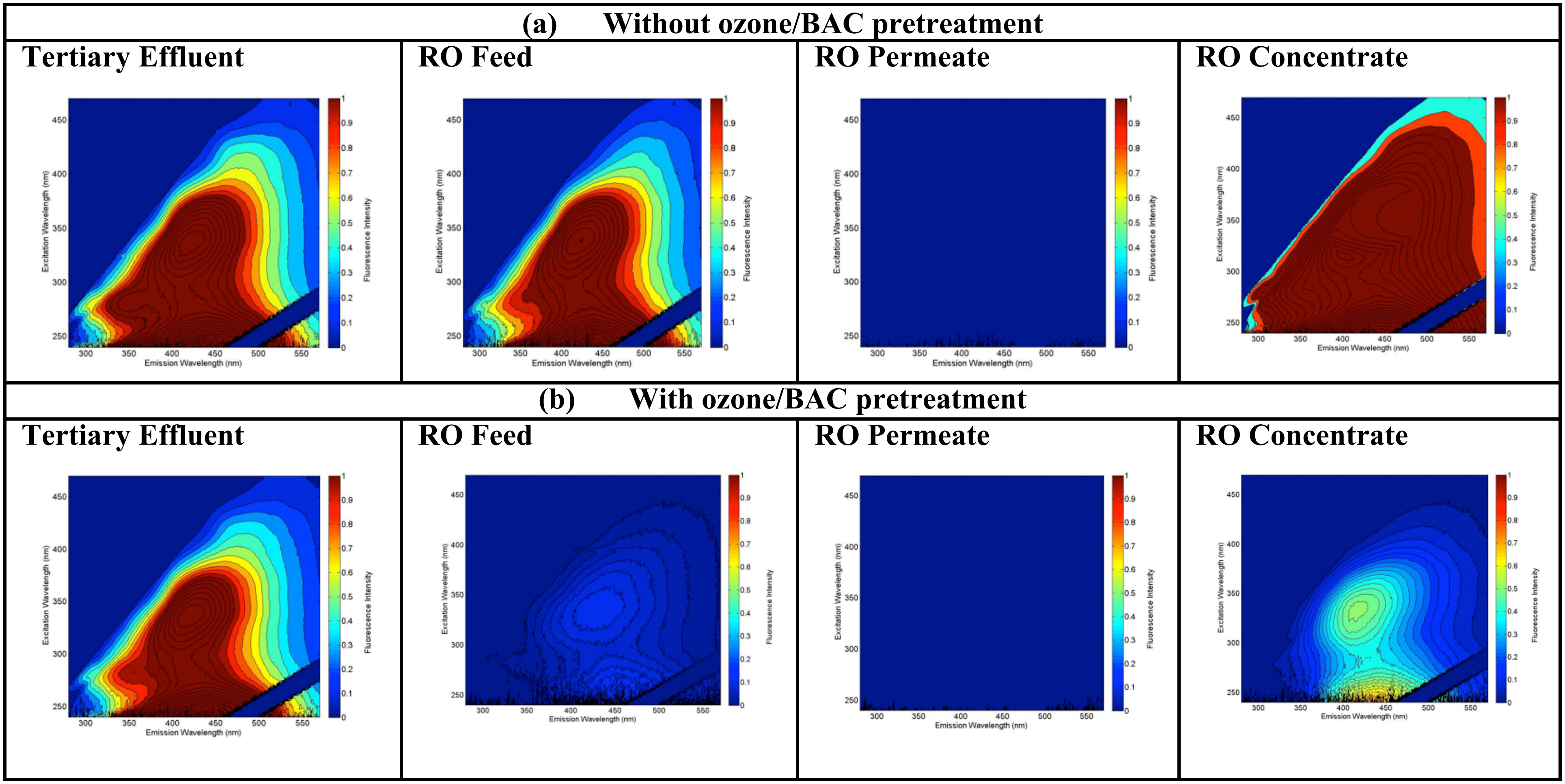


Process Monitoring by UVT Meters



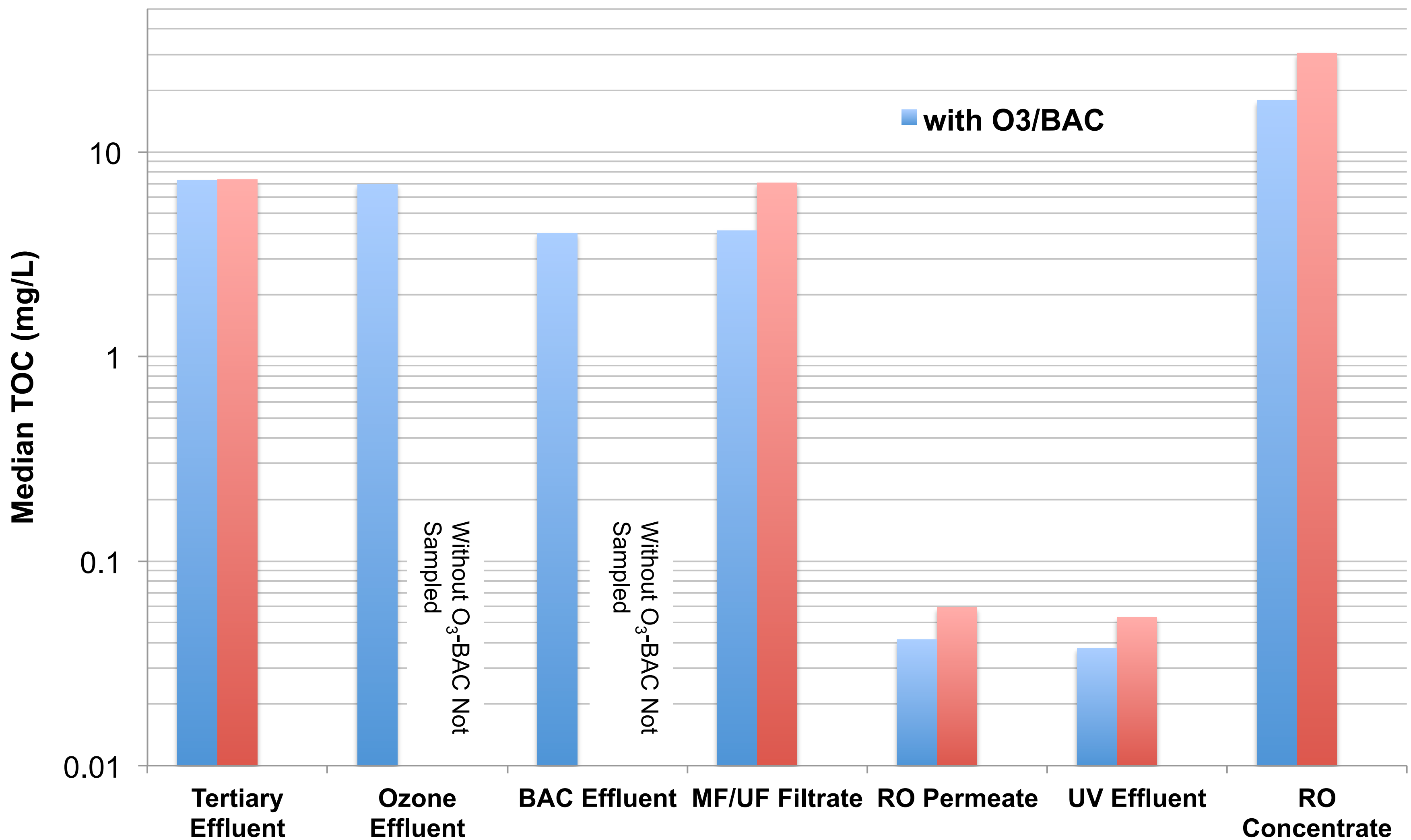


EfOM Transformation by Fluorescence

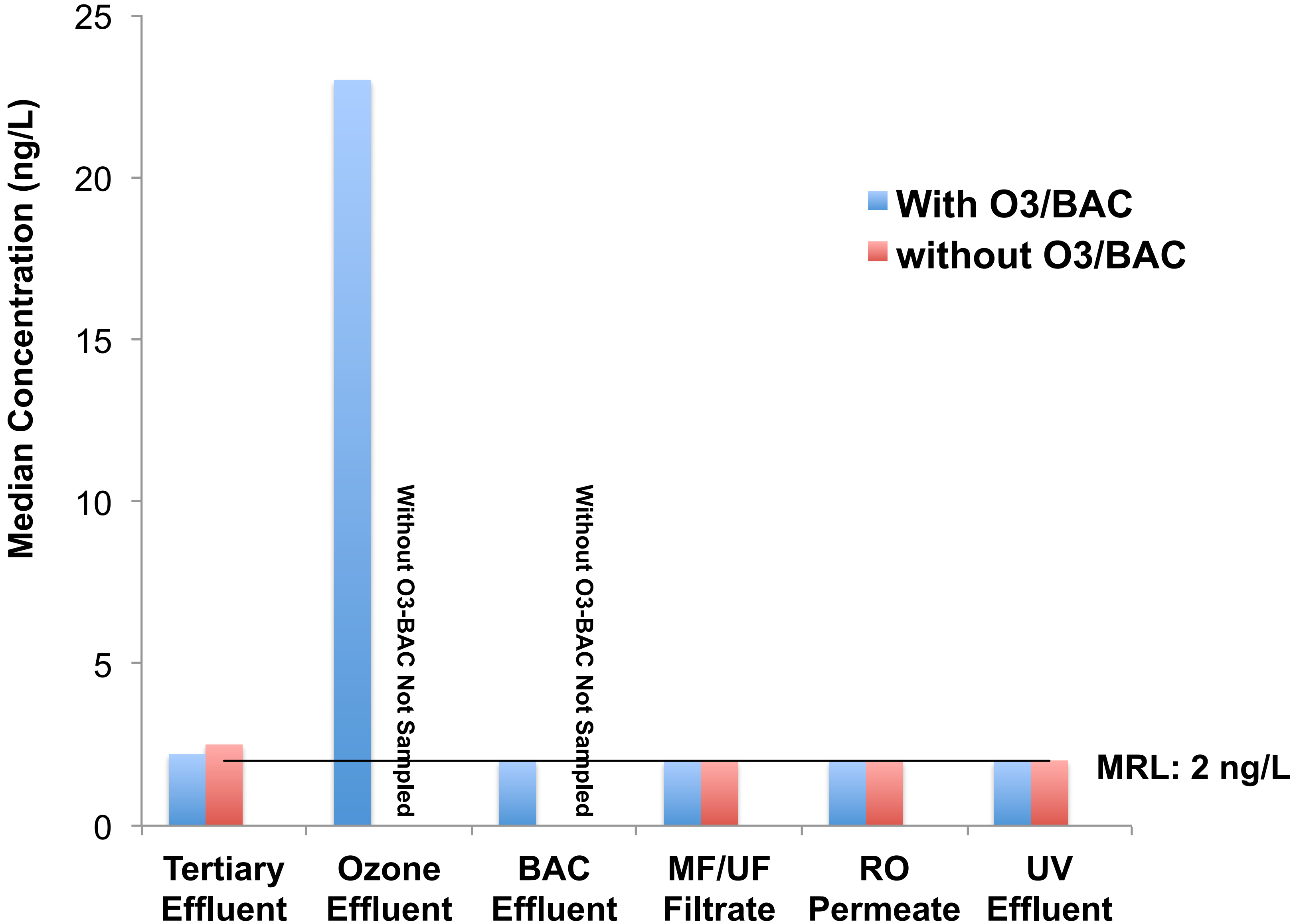


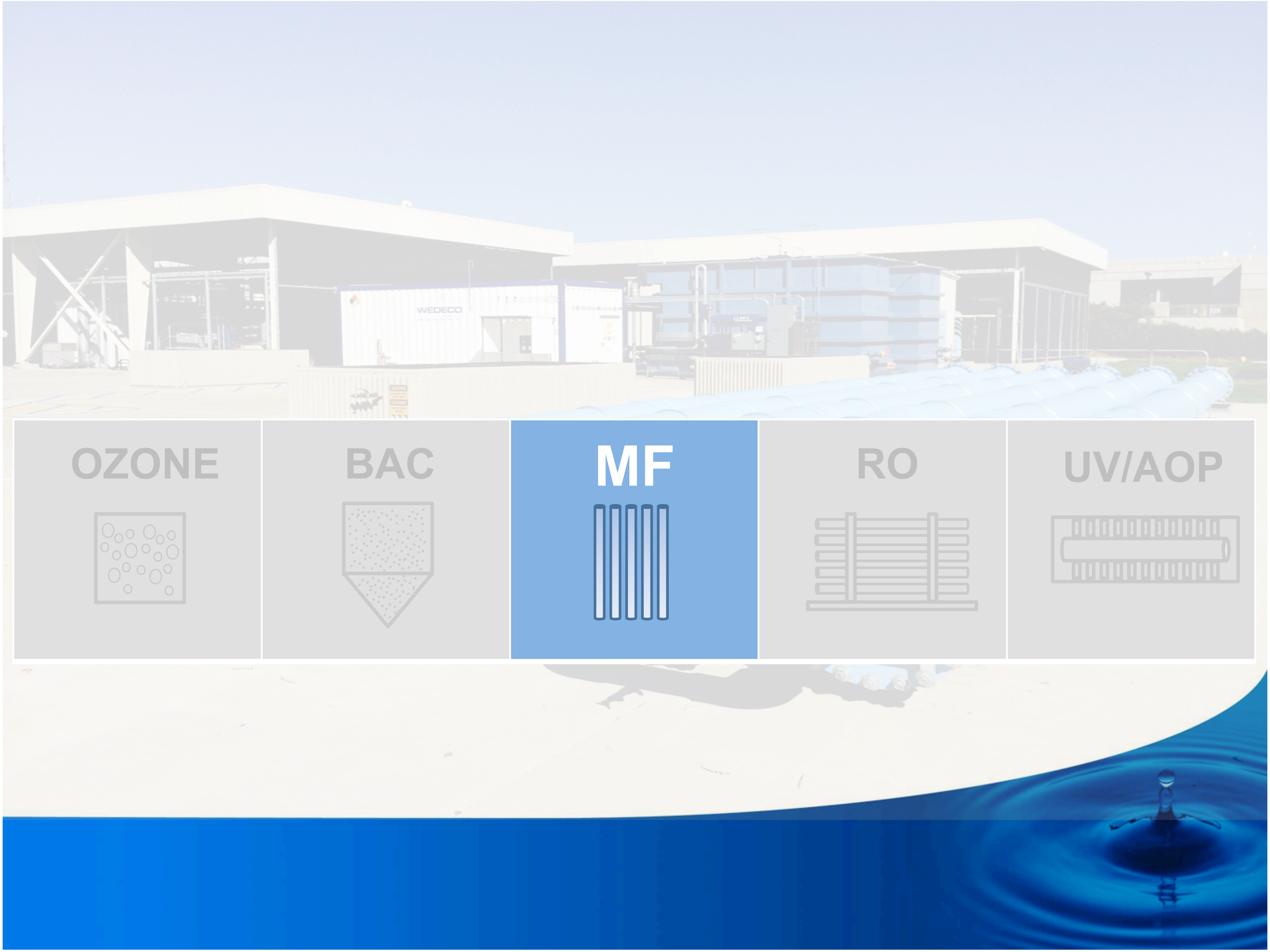
- RO concentrate shows less fluorescence than the feed water (tertiary effluent) and contains **40% less TOC**

Reduction in Feed TOC Benefits Product Water Quality



NDMA Formation and Removal




OZONE
BAC
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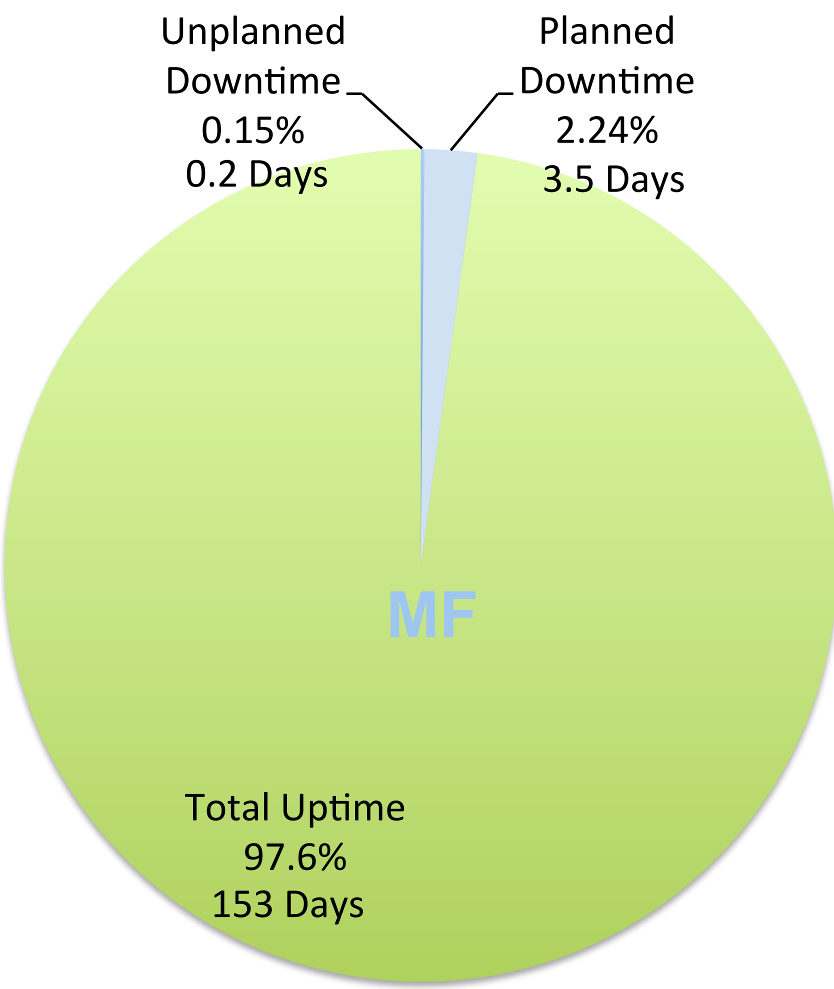
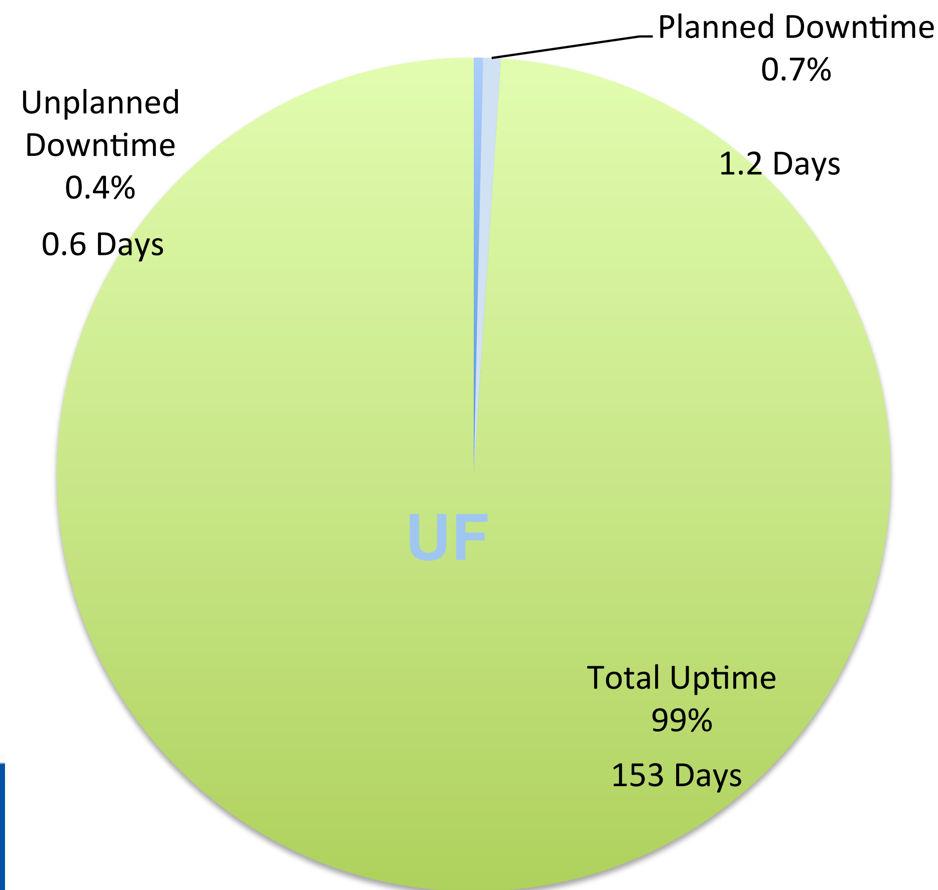
Mechanical Reliability





MF/UF Performance Calculation

Performance Criteria

- If filtrate Turbidity < 0.15 NTU over 24-h period
- Use daily membrane integrity test to determine LRV

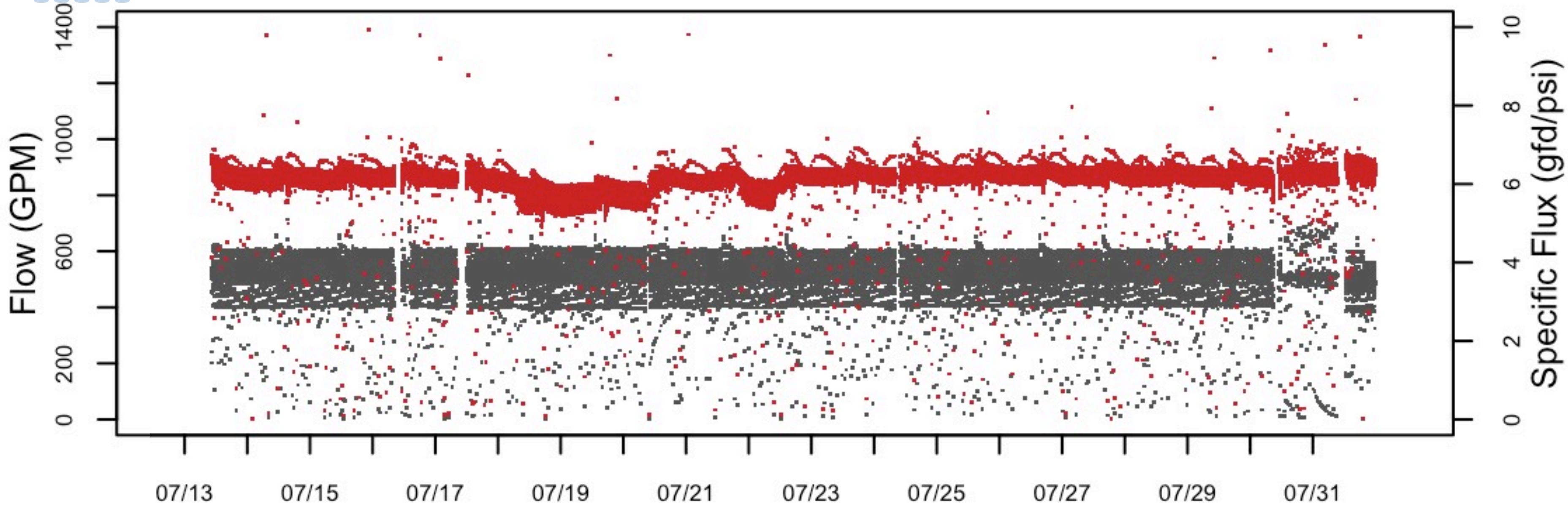
Assign LRVs

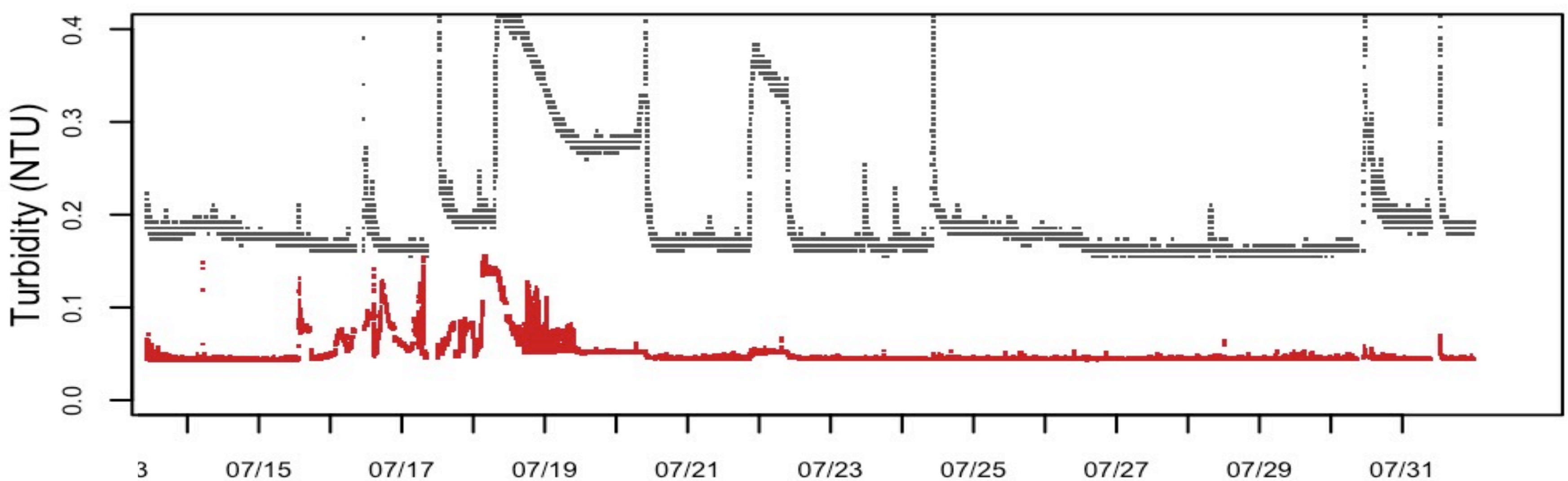
- Crypto: determine LRV based on EPA calculations

$$LRV = \log\left(\frac{Q_p \bullet ALCR \bullet P_{atm}}{\Delta P_{test} \bullet V_{sys} \bullet VCF}\right)$$

- Giardia: assume equivalent to Crypto LRV
- Virus: assign LRV = 0 (or do study)

MF Performance Data





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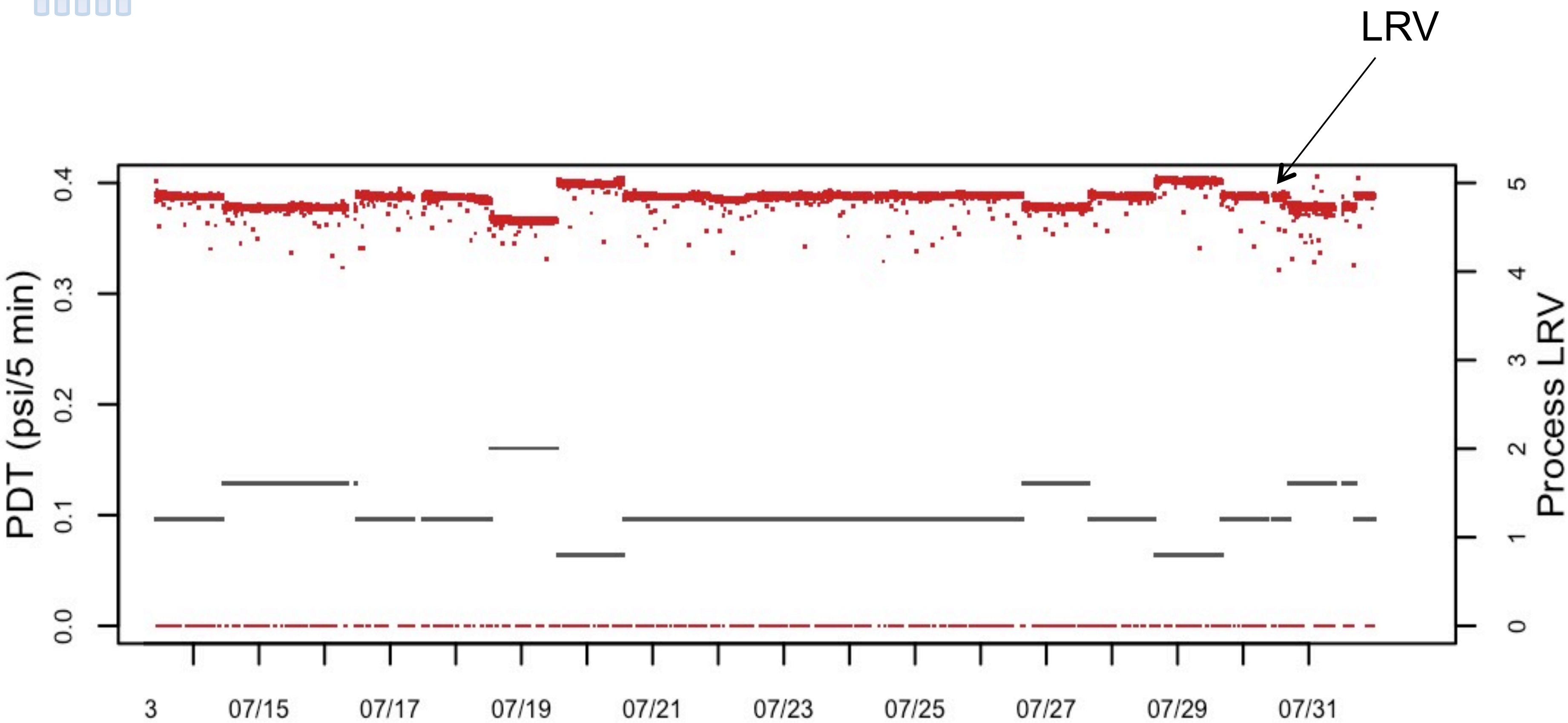
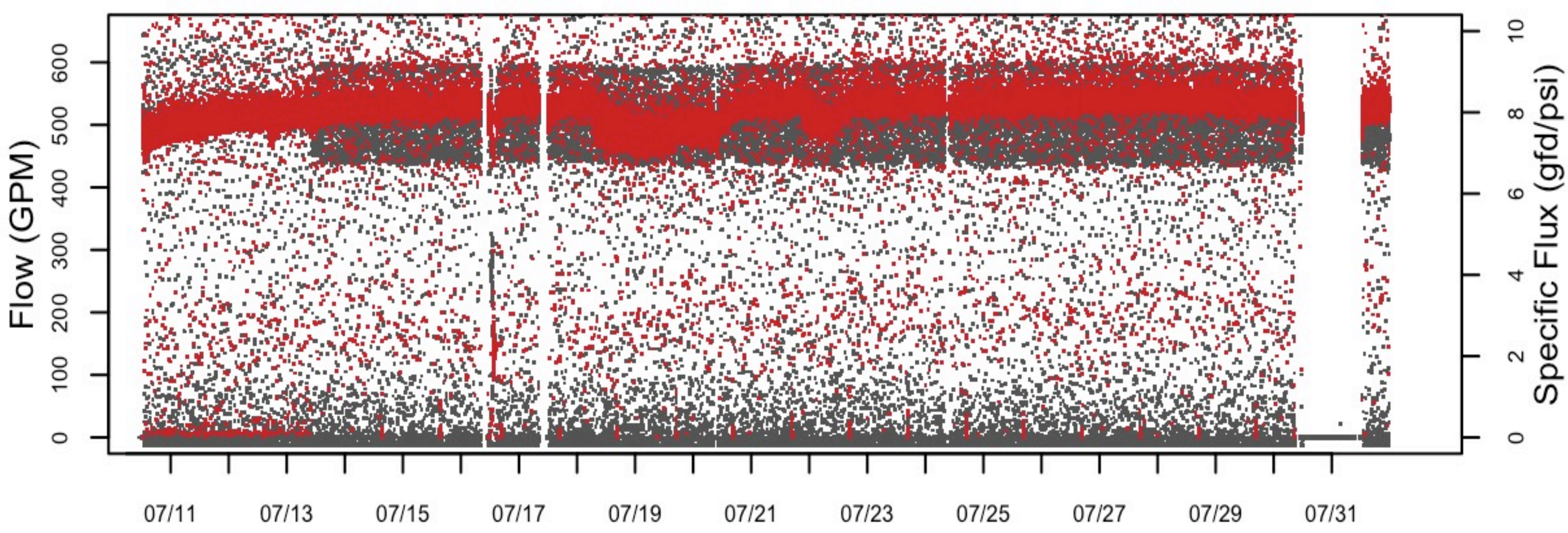


MF

UF Performance Data



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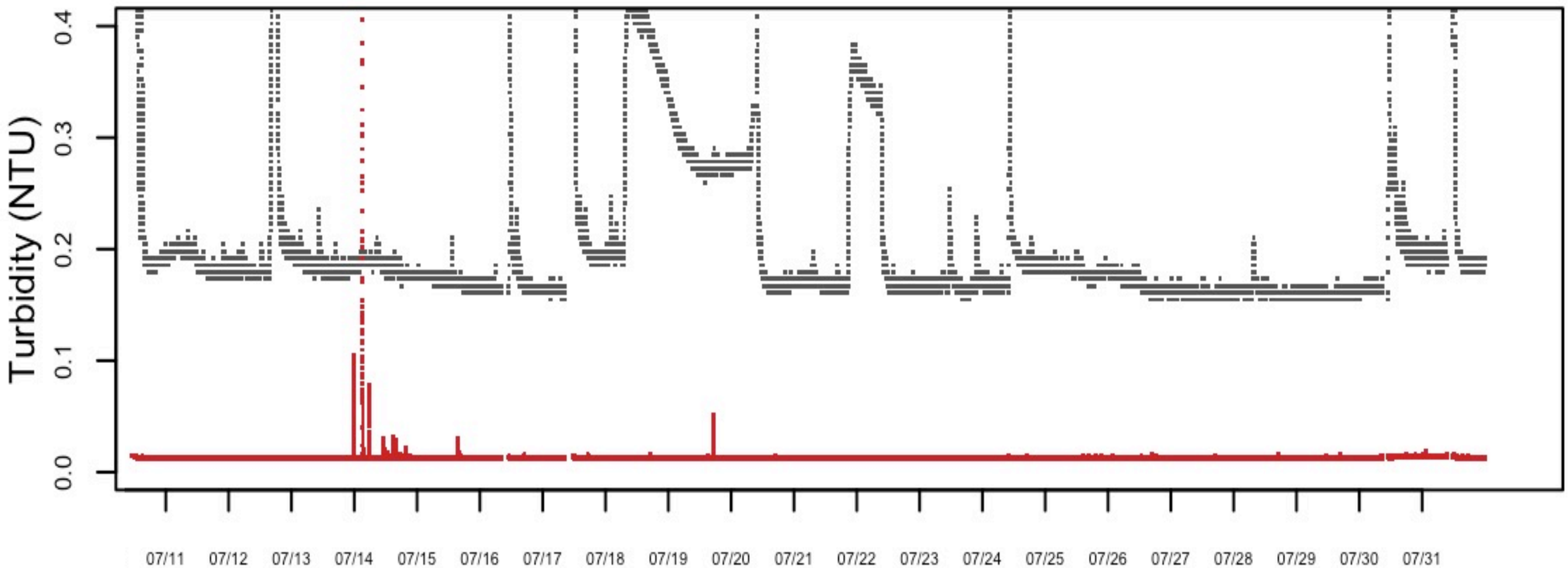

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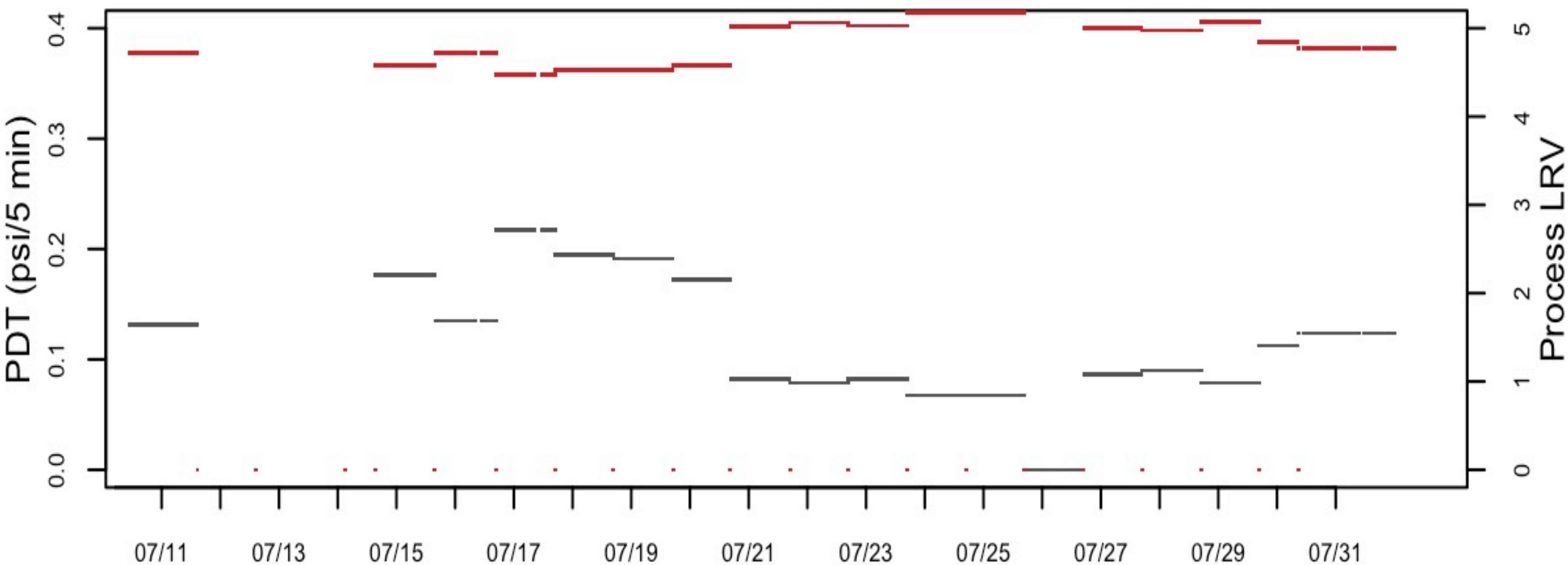
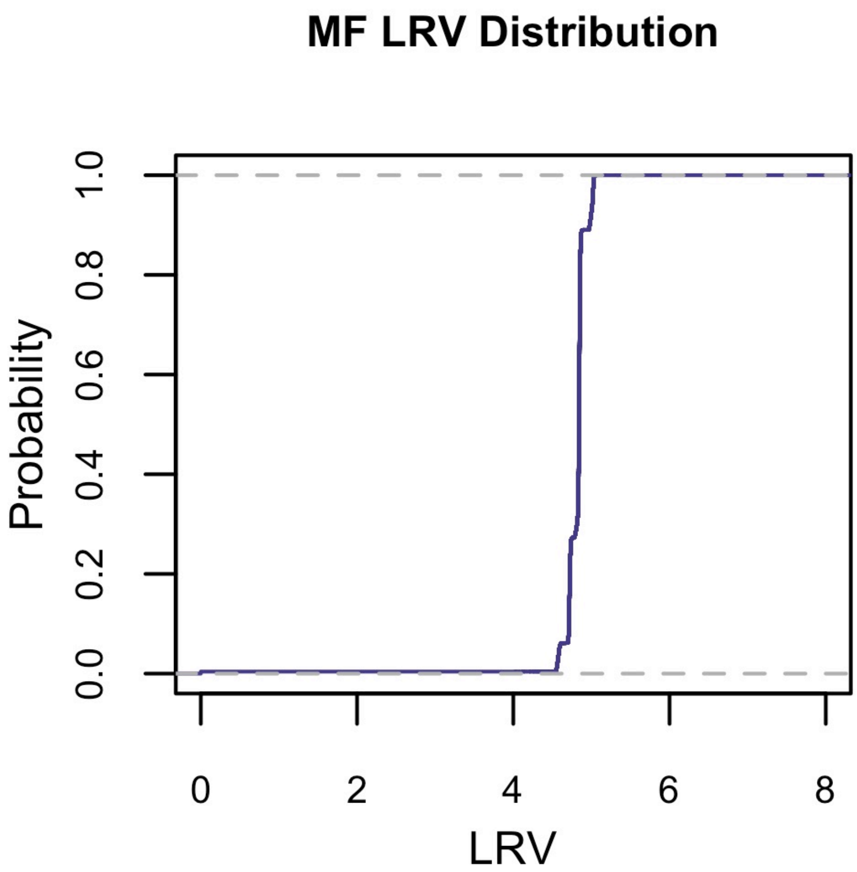
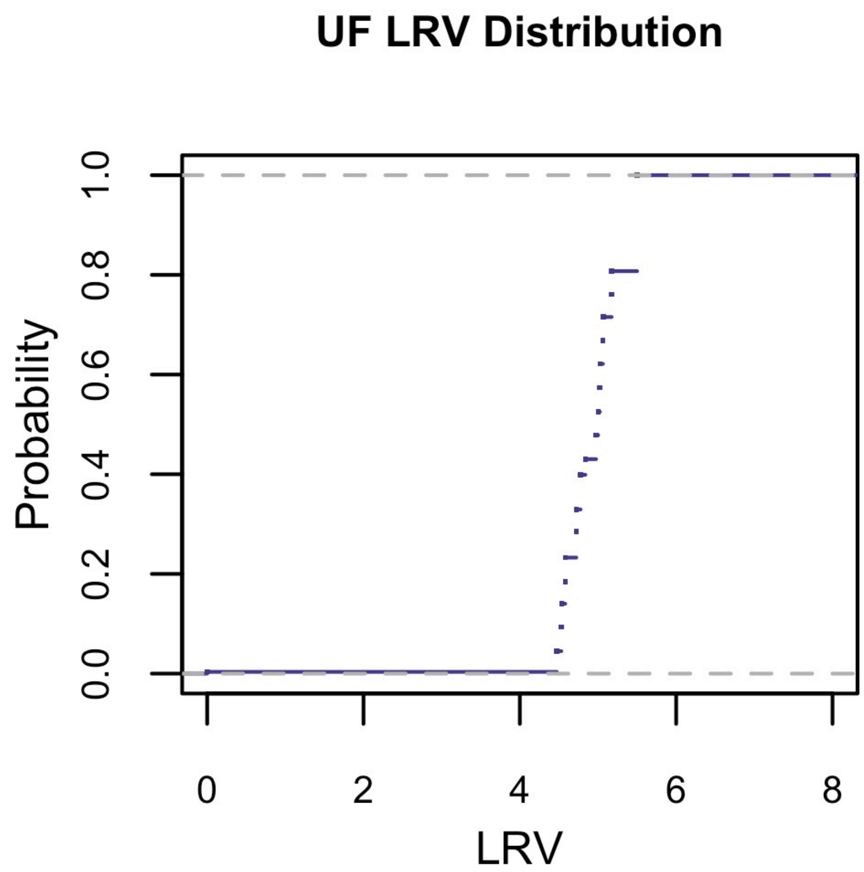
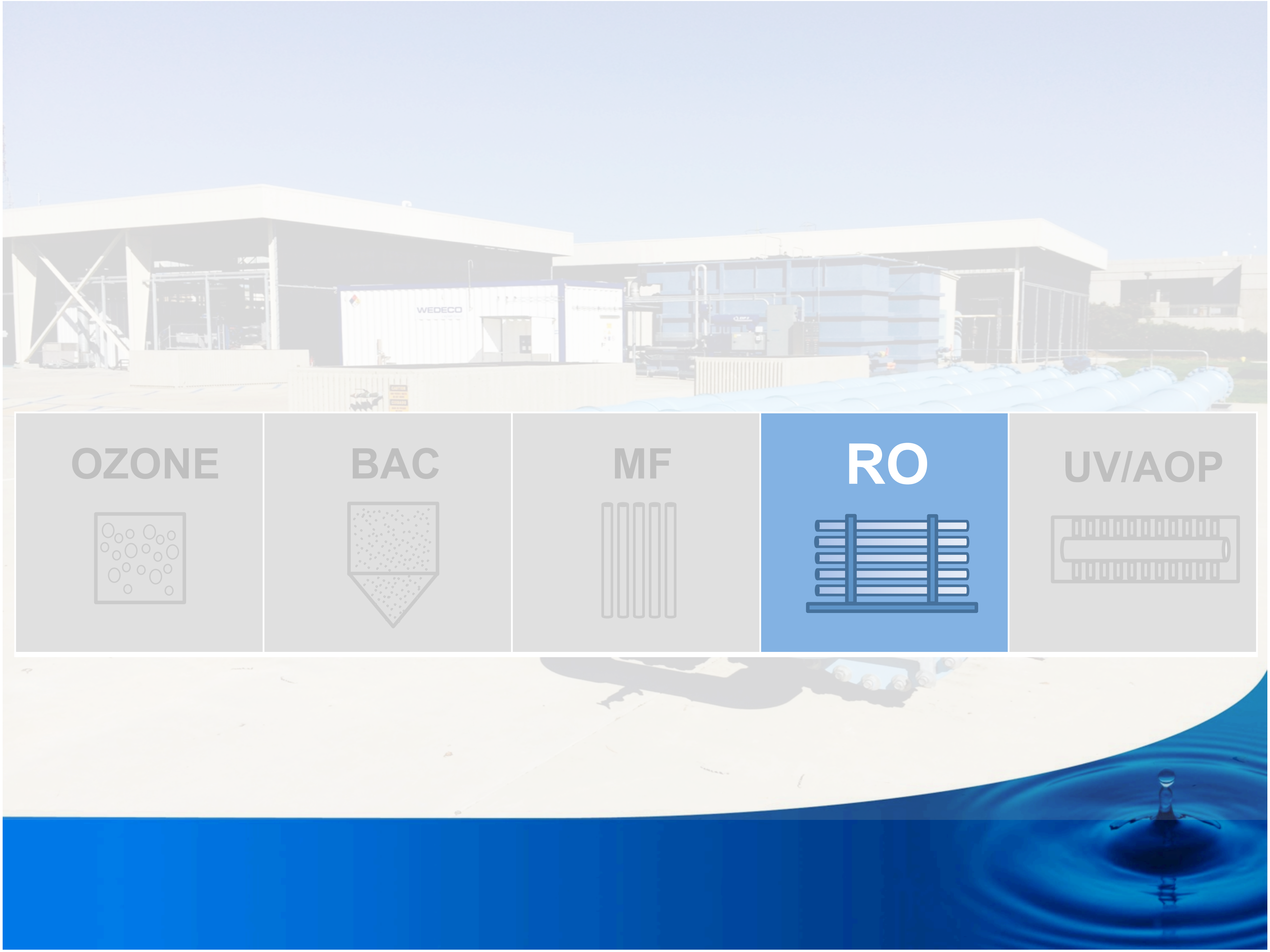


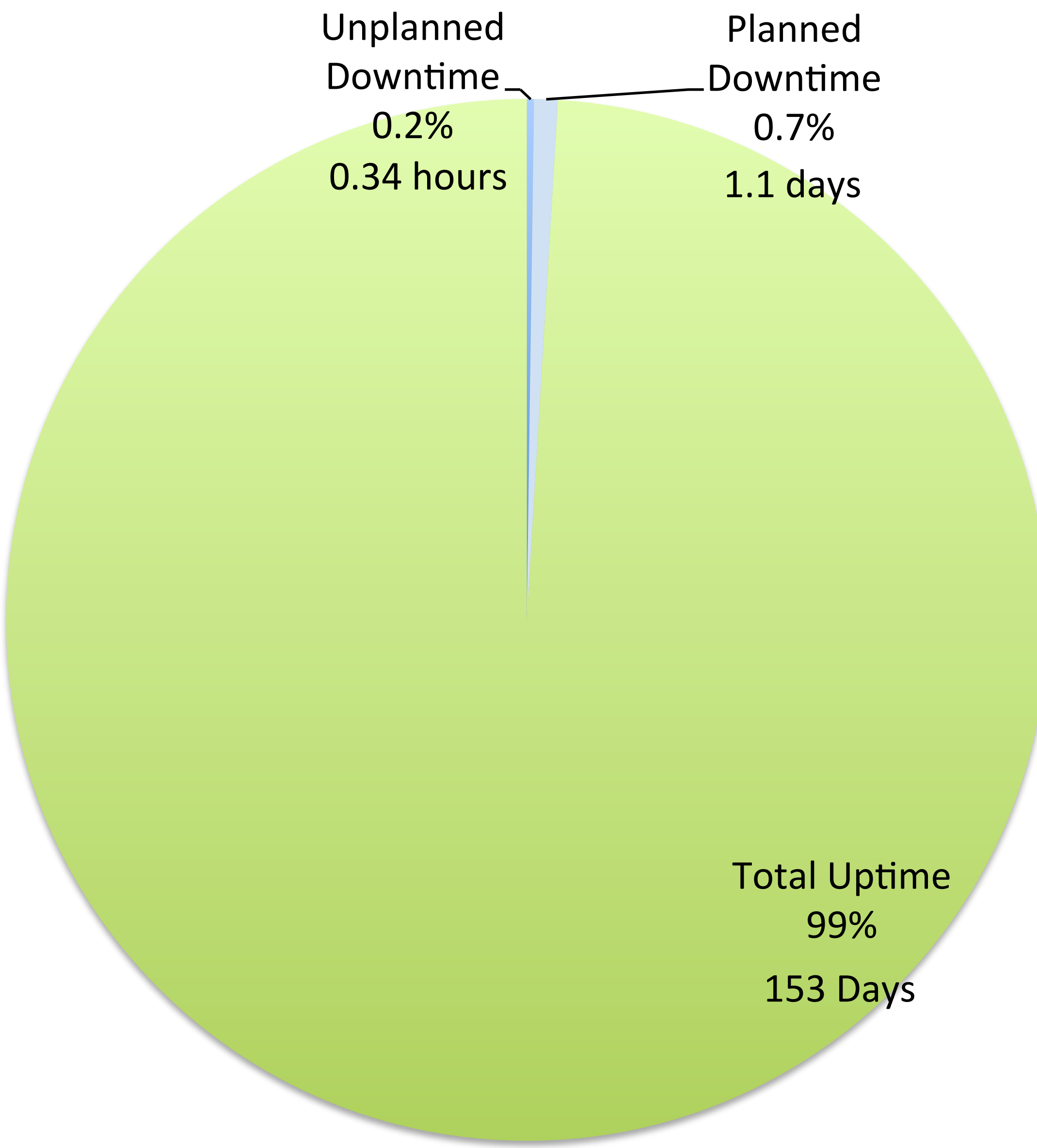
MF/UF Performance Curves






OZONE
BAC
MF
RO
UV/AOP

Mechanical Reliability



RO Performance Calculation

Performance Criteria

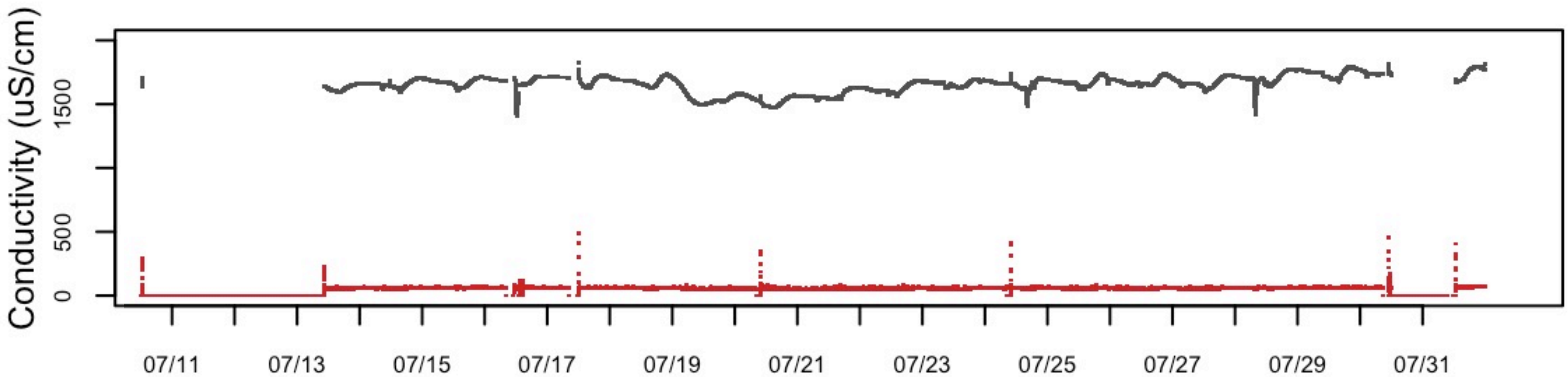
- RO Permeate TOC < 500 ppb
- Measure TOC reduction
- Measure conductivity reduction

Assign LRVs

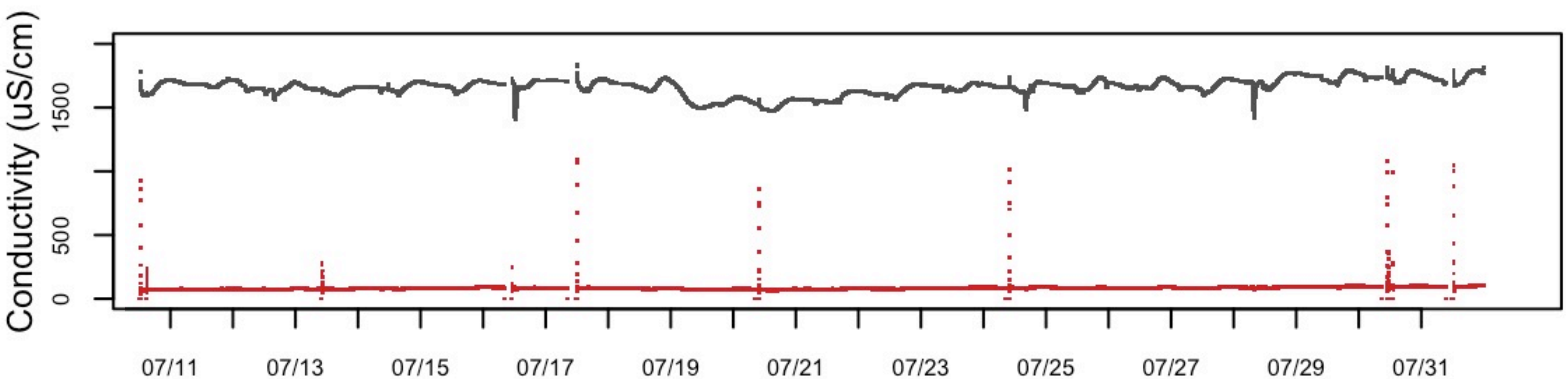
- All pathogens: LRV equals log removal of TOC or conductivity (greater)

RO Performance Data

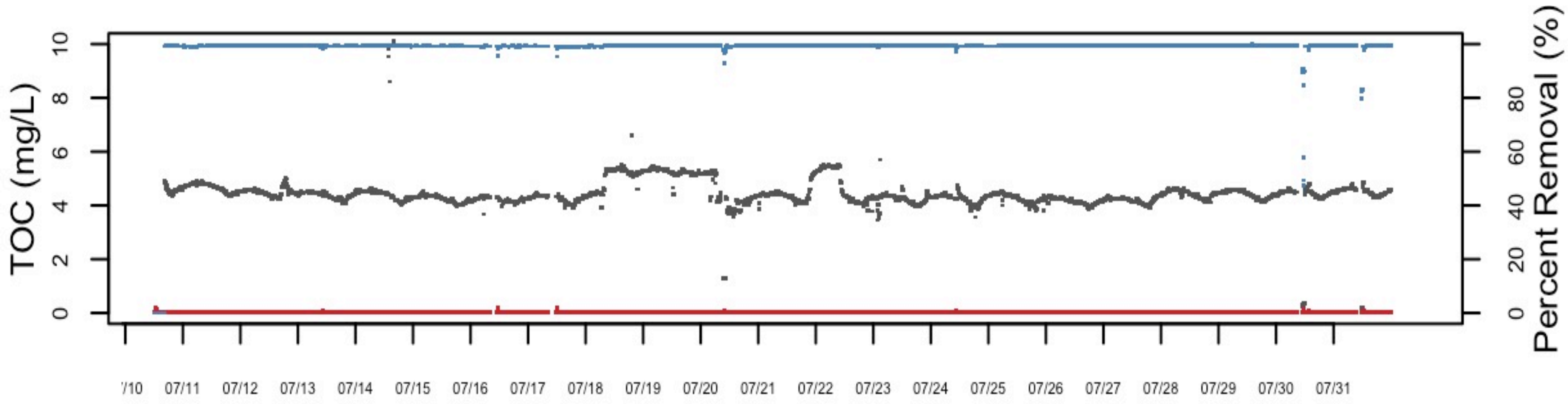
RO Train A Conductivity
Influent (Black) & Effluent (Red) Conductivity (uS/cm)



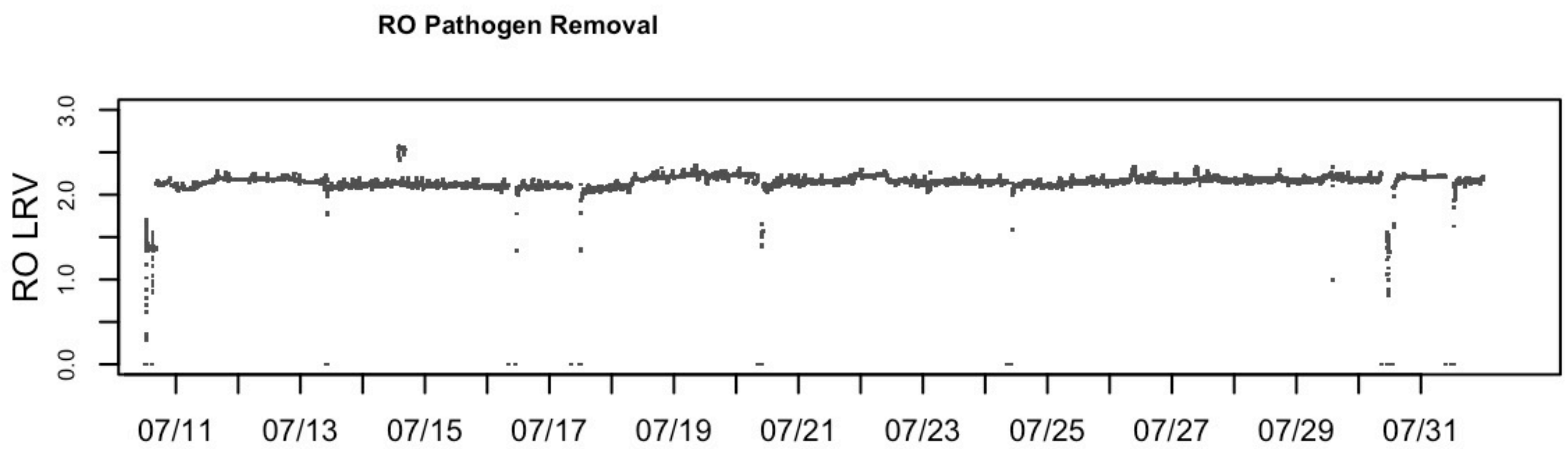
RO Train B Conductivity
Influent (Black) & Effluent (Red) Conductivity (uS/cm)



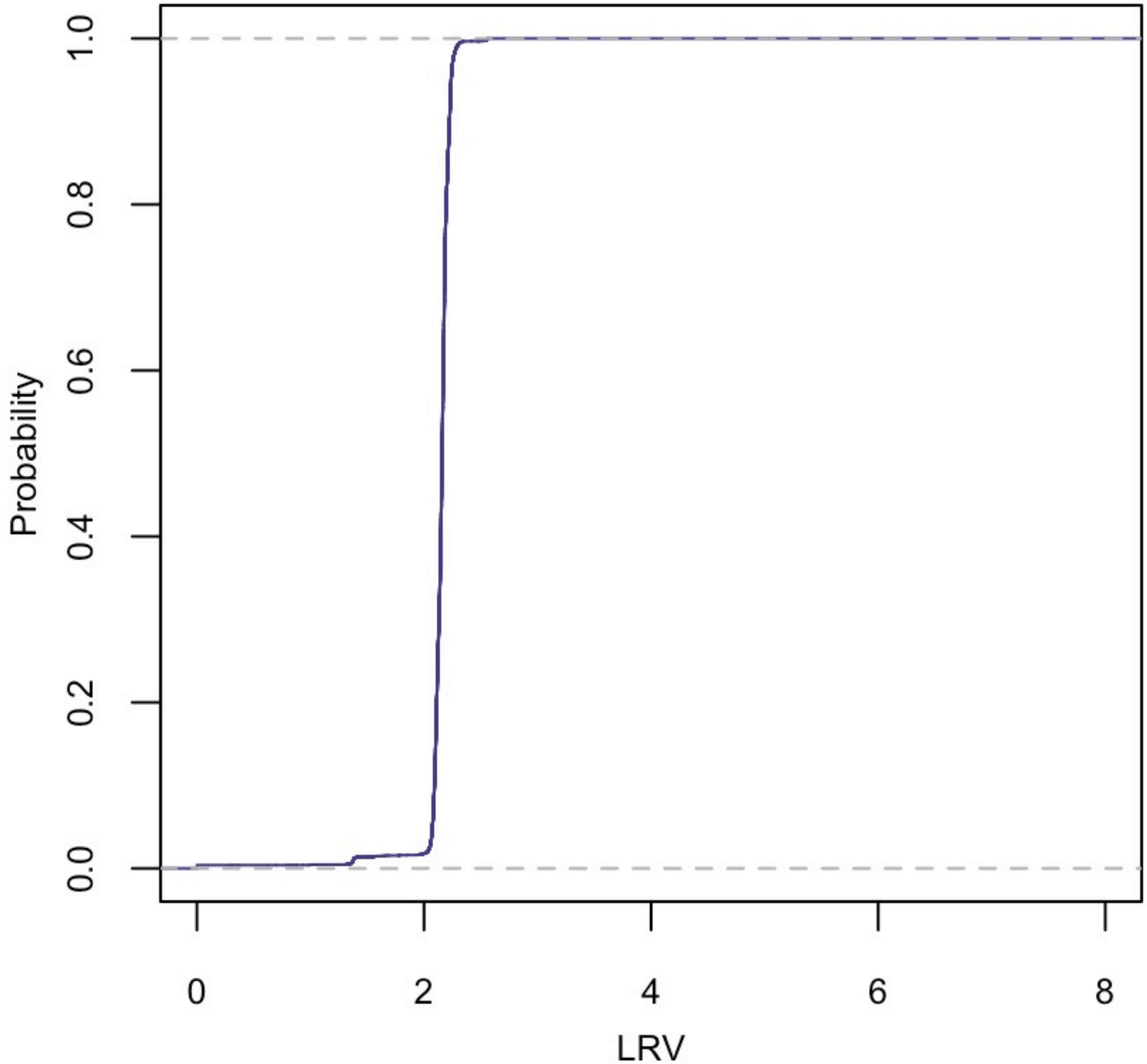
RO Performance Data



RO Performance Data



RO Performance Curve



OZONE

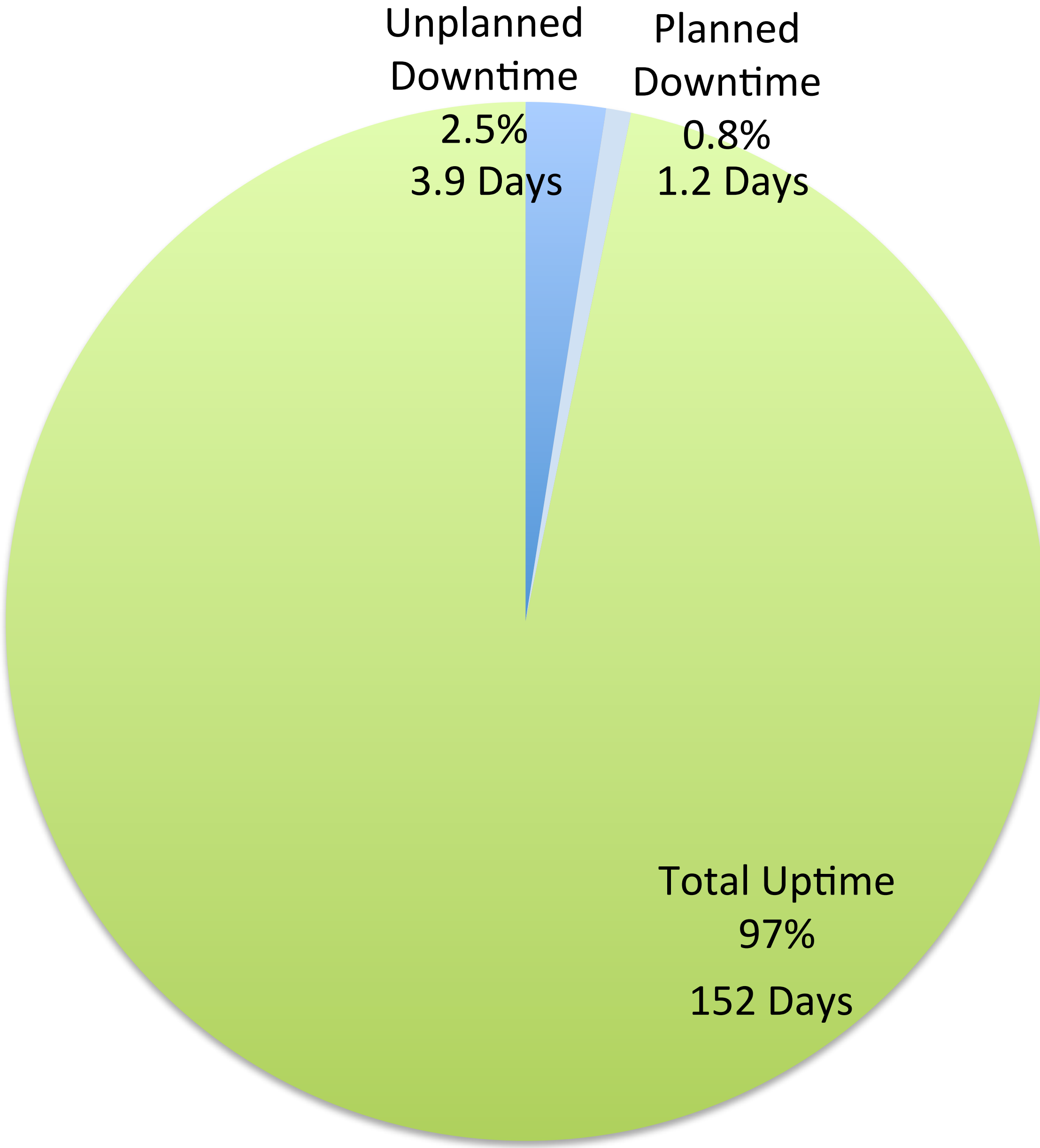
BAC

MF

RO

UV/AOP

Mechanical Reliability



UV Performance Calculation

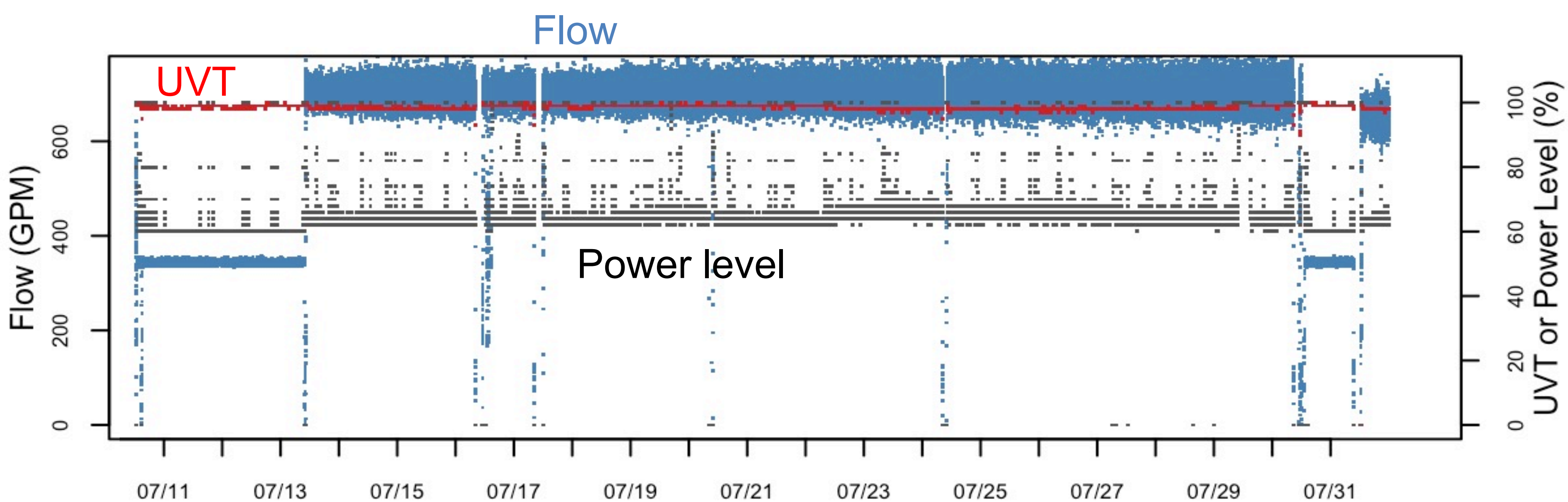
Performance monitoring

- Measure power level
- Measure UV intensity
- Measure UV transmittance

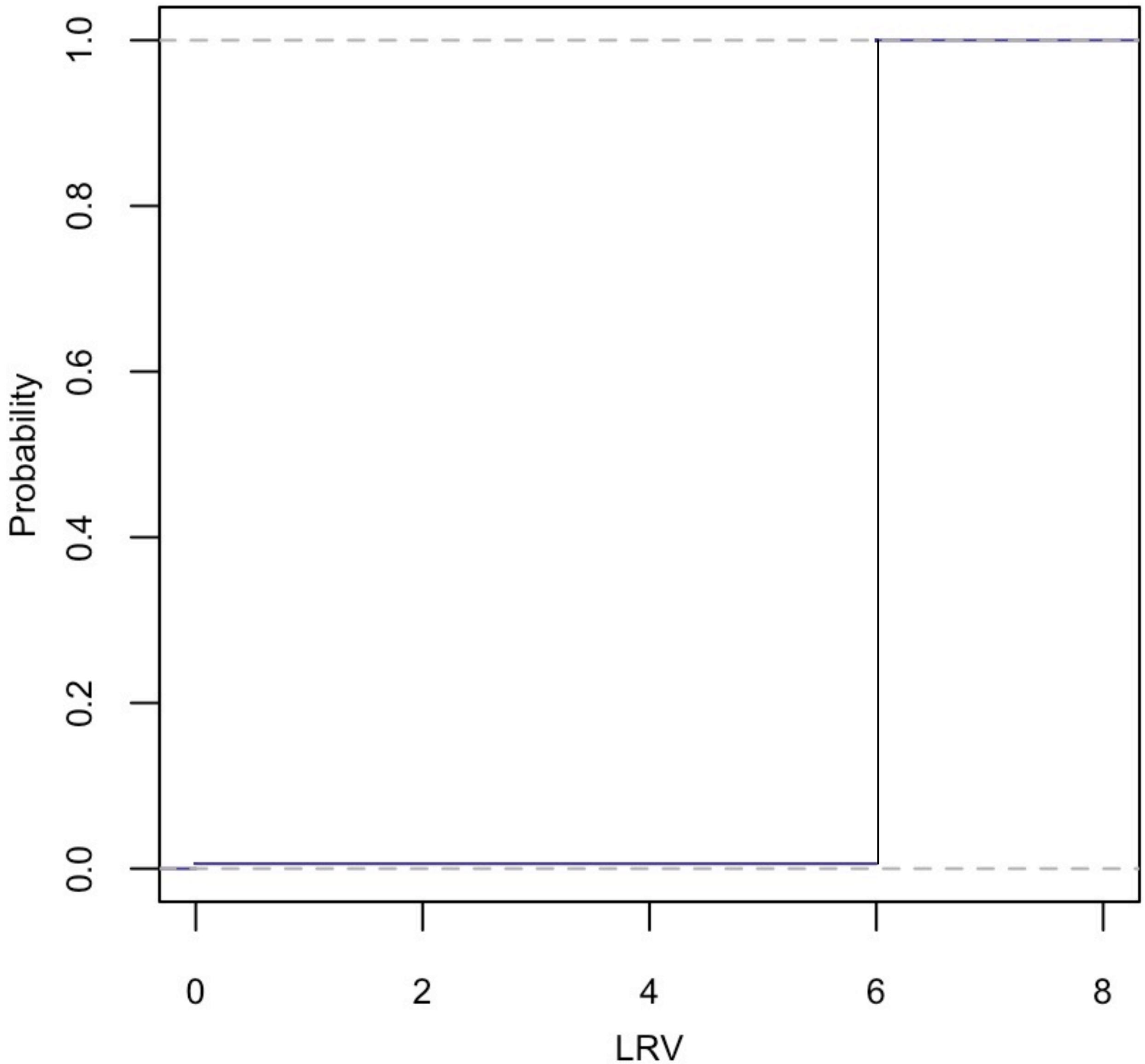
Calculate LRV

- **IF:**
  - Power ≧ 60%
  - UV intensity > 5 mW/cm^2
  - UVT > 95%
- **LRV = 6 for all pathogens**

UV/AOP Performance Data

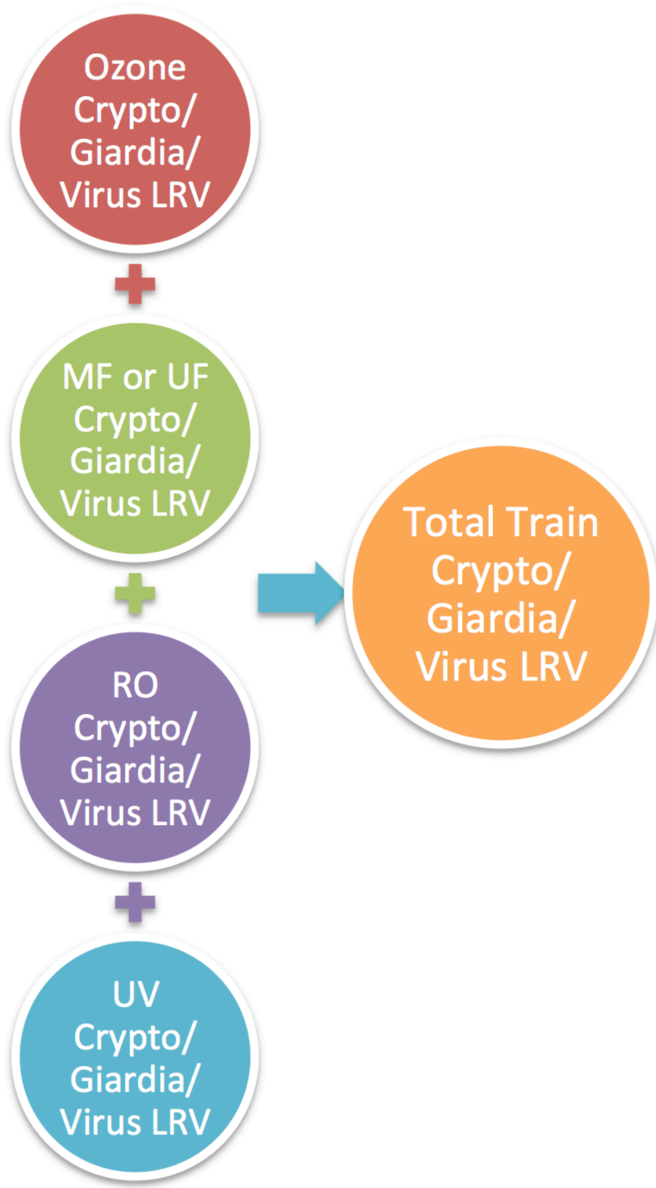


UV/AOP Performance Curve




Ozone
BAC
MF
RO
UV/AOP

System Performance Curve



System Performance Curve

Coming soon!

CHALLENGE TESTS

Expanding O_3 credit for Crypto

Exhibit 11.1 CT Values for *Cryptosporidium* Inactivation by Ozone (40 CFR 141.730)

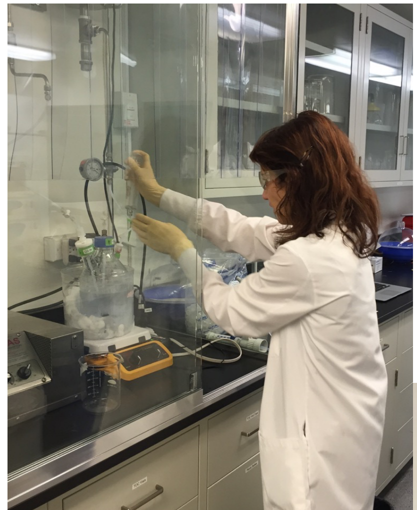
Log credit	Water Temperature, °C[1]										
	<=0.5	1	2	3	5	7	10	15	20	25	≥30
0.25	6.0	5.8	5.2	4.8	4.0	3.3	2.5	1.6	1.0	0.6	0.39
0.5	12	12	10	9.5	7.9	6.5	4.9	3.1	2.0	1.2	0.78
1.0	24	23	21	19	16	13	9.9	6.2	3.9	2.5	1.6
1.5	36	35	31	29	24	20	15	9.3	5.9	3.7	2.4
2.0	48	46	42	38	32	26	20	12	7.8	4.9	3.1
2.5	60	58	52	48	40	33	25	16	9.8	6.2	3.9
3.0	72	69	63	57	47	39	30	19	12	7.4	4.7

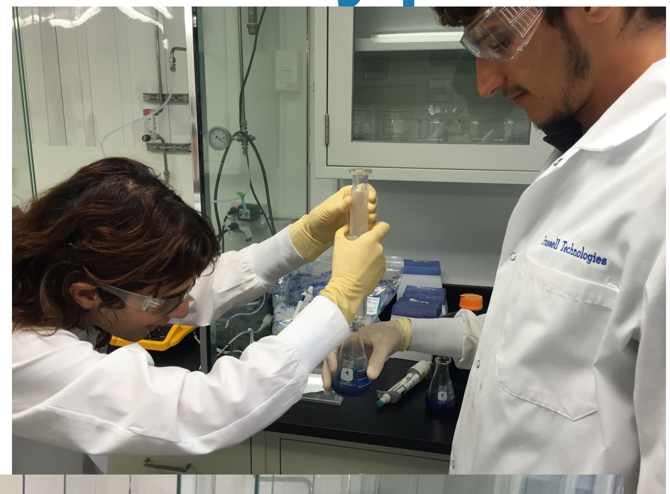
[1]CT values between the indicated temperatures may be determined by linear interpolation.

Ozone credit maxes out at 3-logs for drinking water

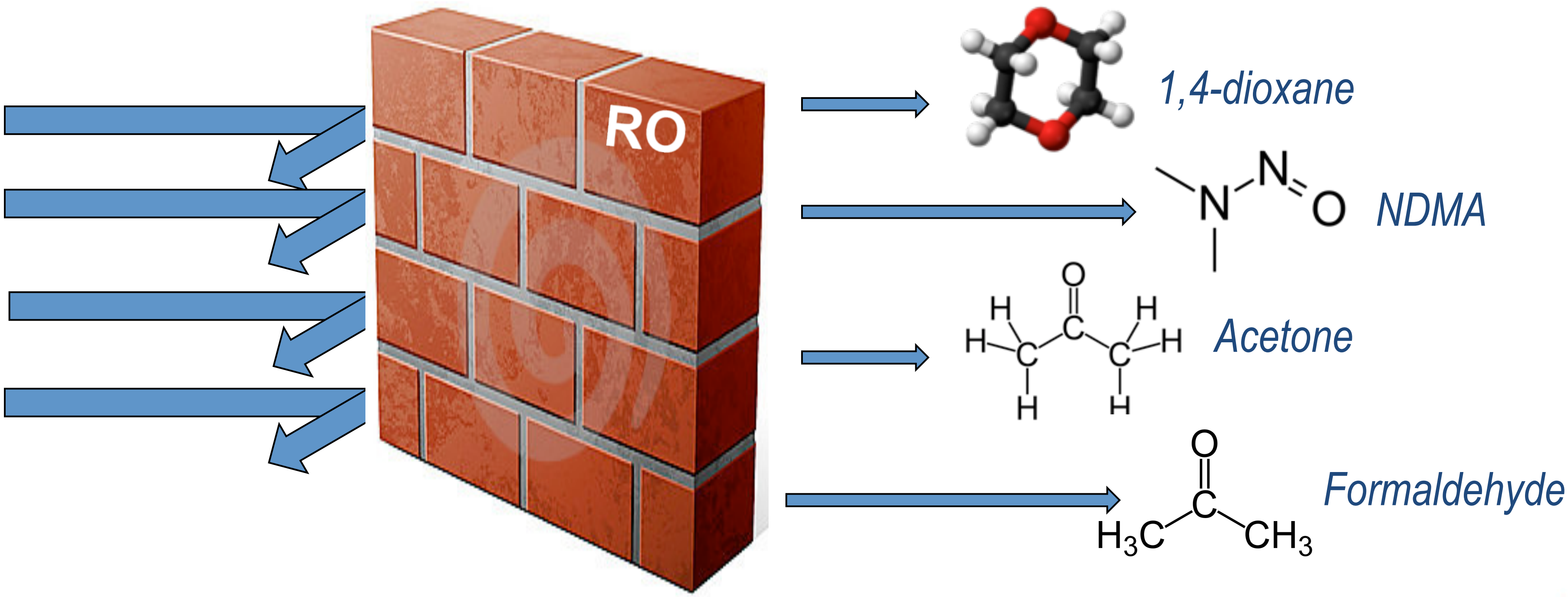
Expanding O_3 credit for Crypto

- Experimental plan reviewed by IAP/PAC
- Comparing ozone inactivation of Crypto in surface water and 3ry effluent
- Assessing up to 5-log inactivation in 3ry water
- Two rounds of testing began in Sept 2015
- Biovir Labs providing safety oversight

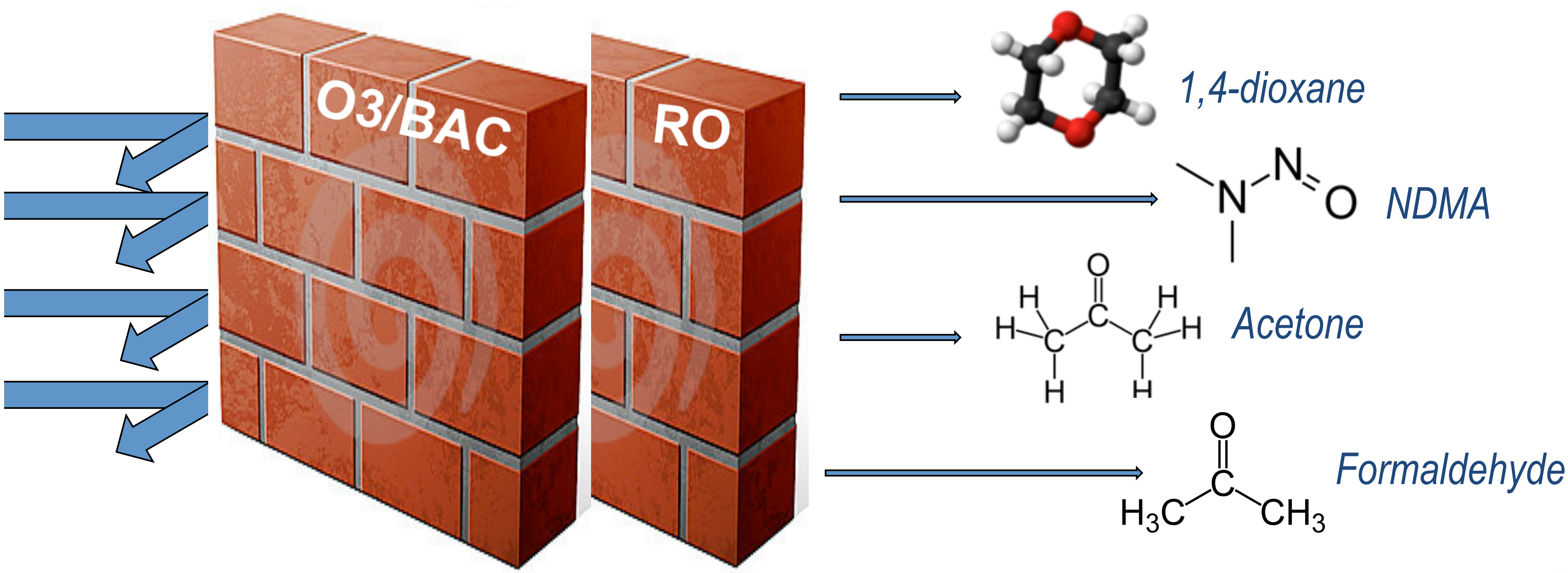




Chemical Challenge Test



Chemical Challenge Test



Chemical Challenge Test

Testing at Demonstration Facility on September 18, 2015

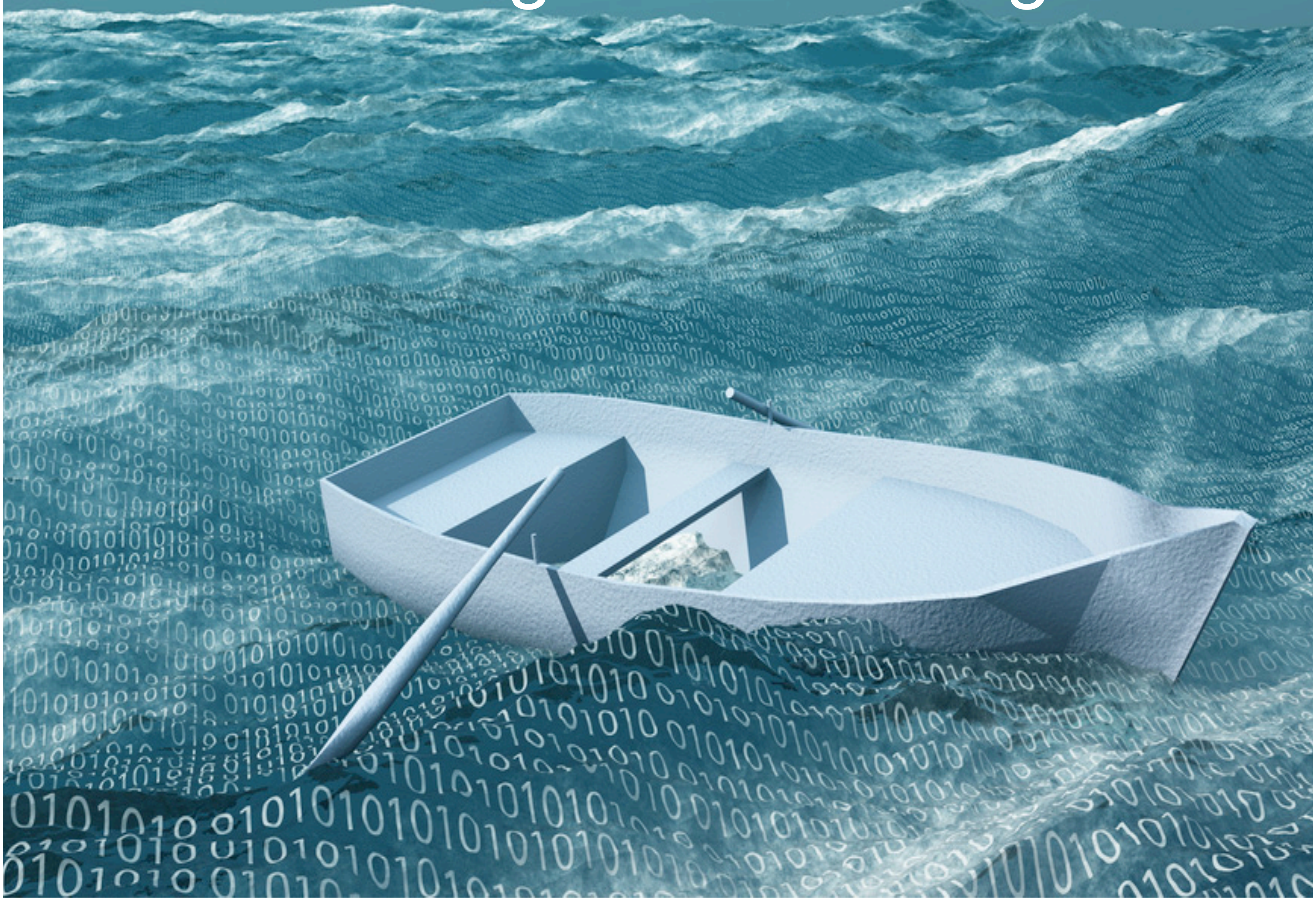
REGULATORY INTERACTIONS

Moving Crediting Schemes into Potable Reuse

- Ozone crediting from Surface Water Treatment Rules
- MF/UF crediting from EPA Guidance
- Expanding ozone credit for Crypto

LESSONS LEARNED

Data management is a big deal



Data management is a big deal

1 meter

x

One reading

=

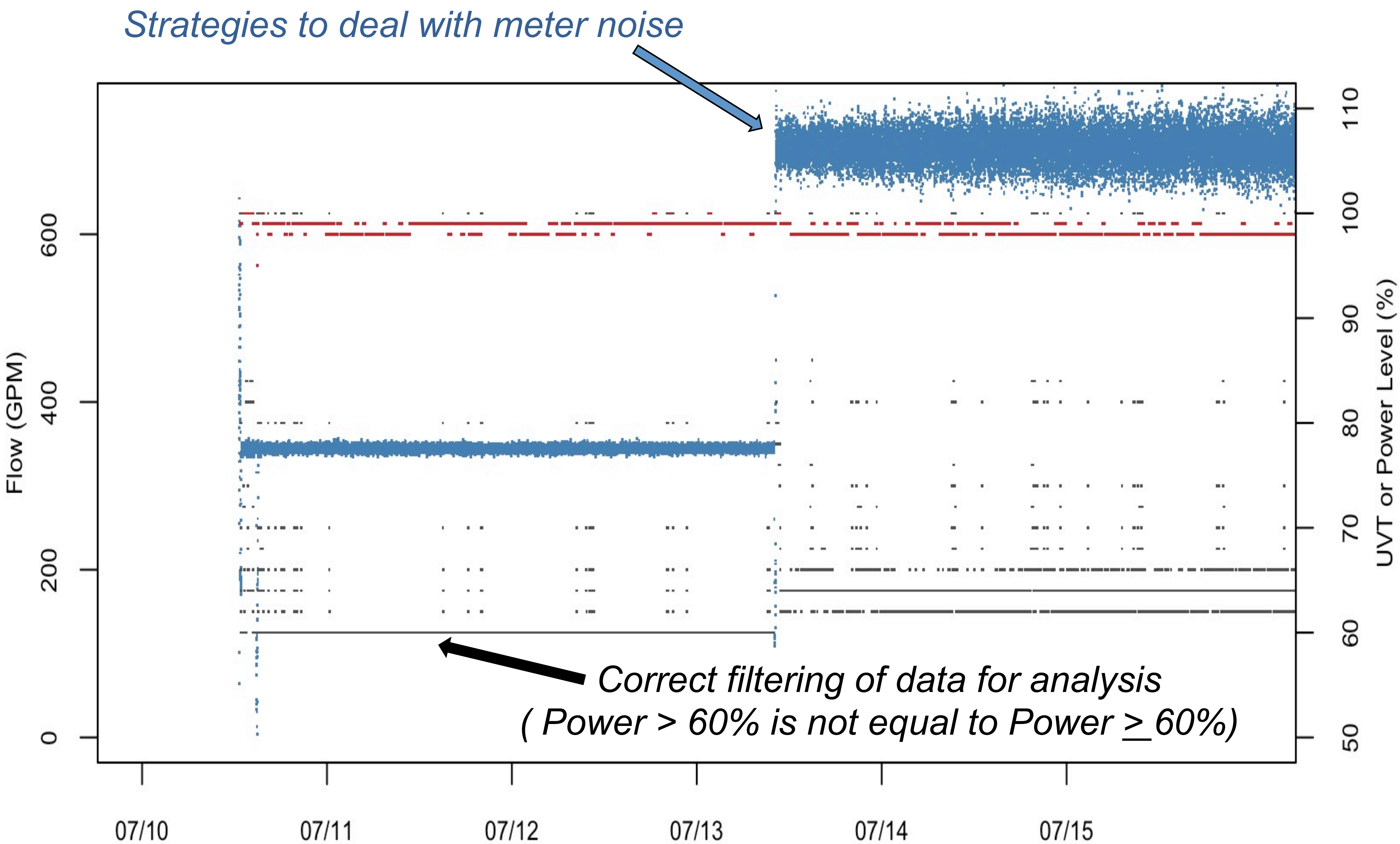
> 250,000
data points

=

> 3,000,000
data points

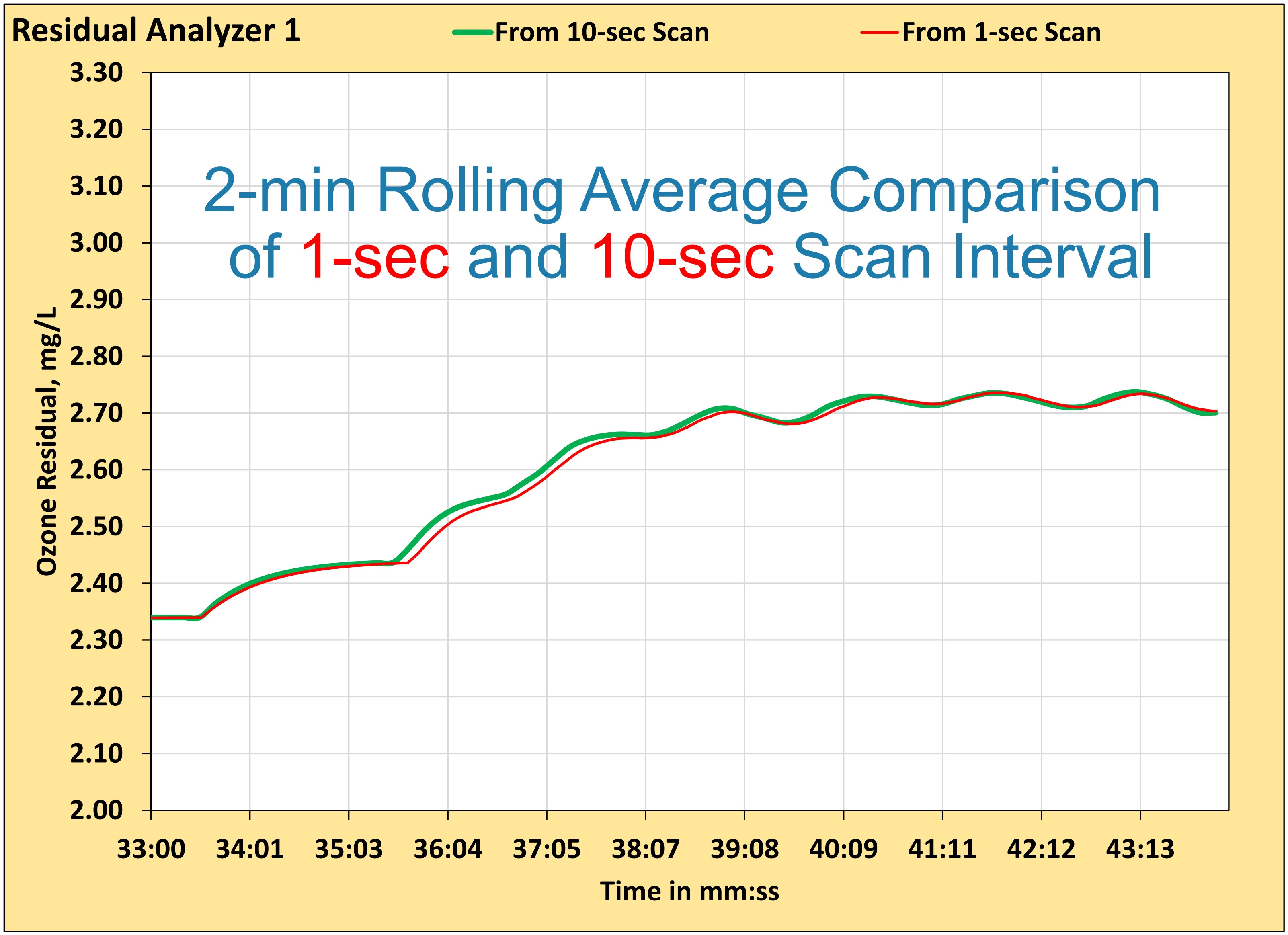
Uncommon to mine this much data…

Data filtering takes time



Learning some logged data are unnecessary – while some unlogged data are!

More is not necessarily better….



Strategies for Future Implementation

- Connect all monitors to a single data storage system
- Ensure data is easily accessible for analysis
- Develop data processing logic prior to start-up can save time
- Provide adequate time for meter commissioning

Next Steps

- Continue data collection and data mining (April 2015 – April 2016)
- Adapt monitoring strategies based on findings
- Build performance curves to assess reliability
- Report on challenge test results

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- **WateReuse Research Foundation**'s financial, technical, and administrative assistance in funding and managing the project through which this information was discovered, developed, and presented
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Supporting Utilities

City of San Diego
PUBLIC UTILITIES
Water & Wastewater

PADRE DAM
Municipal Water District

Helix Water District


Questions?
WEDECO
Direct Potable Reuse in California: Specialty Seminar
September 23rd, 2015