



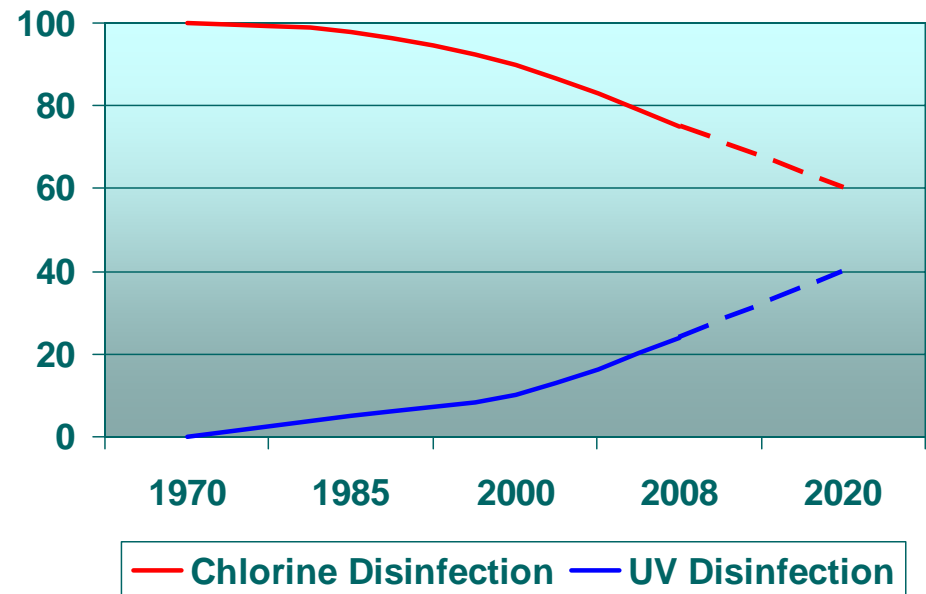
Closed Vessel UV for Reuse Applications in Hawaii

March 16, 2010
Bree Trembly
Municipal Sales Engineer

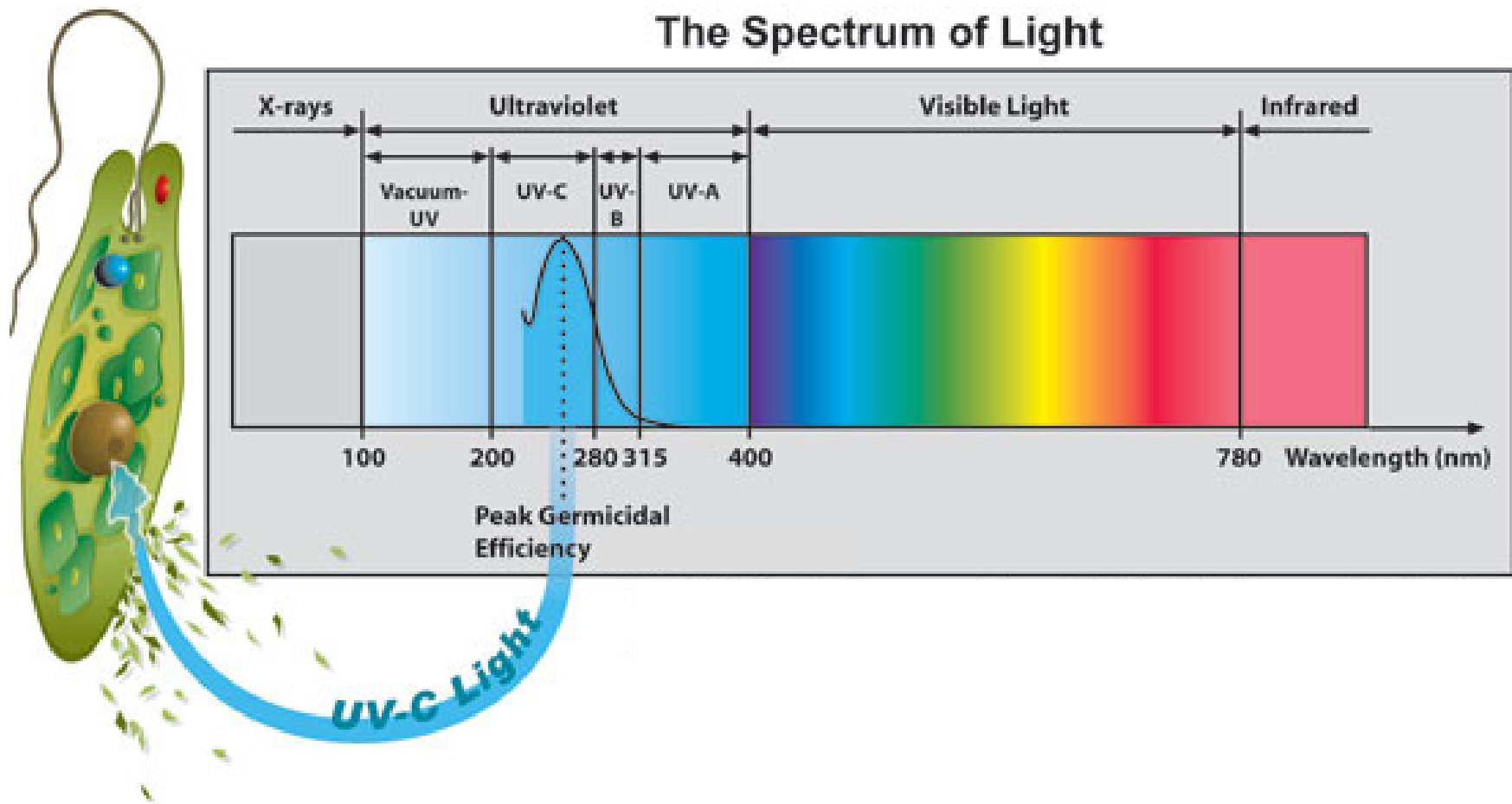
- Growth of UV in Wastewater
- UV Basics
- UV System Planning & Design
- Understanding NWRI - Reclaimed Water
- Closed Vessel
- References
- Lessons Learned

Growth of UV in Wastewater

- UV is a safe, environmentally friendly technology
- No disinfection by-products
- Chemical-free; no transportation, storage or safety concerns
- Effective against Chlorine resistant pathogens, e.g. Crypto. & Giardia
- Right disinfection choice; WW of upstream communities ultimately becomes DW of downstream communities



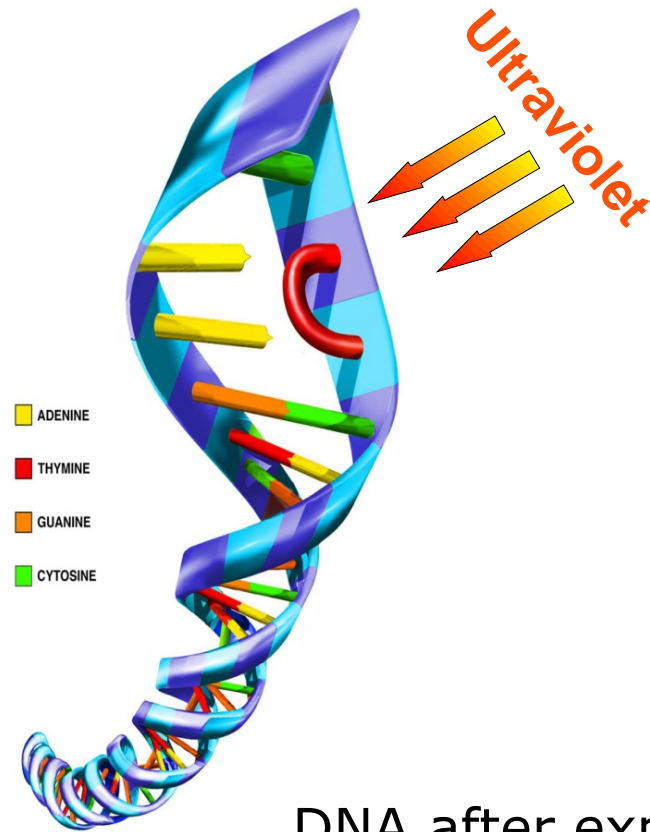
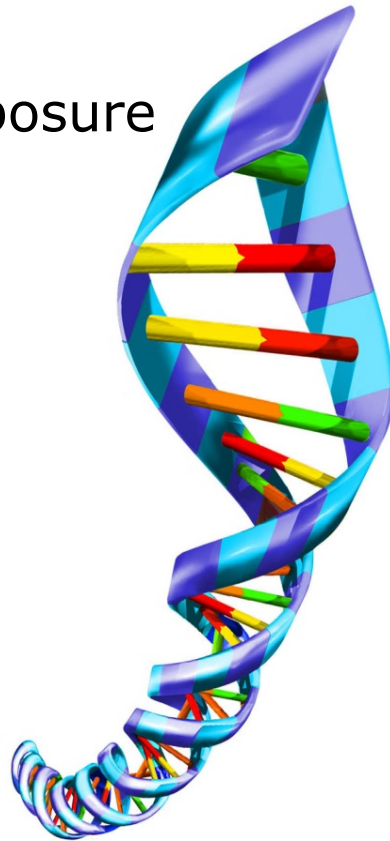
Spectral Output of UV Lamps



UV, The Mechanism

Effects of UV irradiation on DNA

DNA before exposure



DNA after exposure

What Makes Each Installation a Success?

- Proper Planning and Design
 - Consulting Engineer – understand plant and client
 - UV Manufacturer – understand science and UV design
- Proper Operation and Maintenance once installed
 - Owner and Operators
 - On-going support from Engineer and Manufacturer



Biological Validation for UV

Significant Protocols

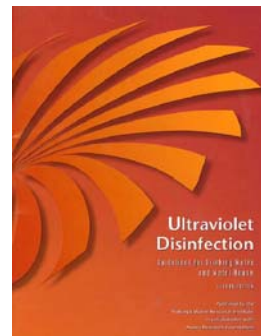
Drinking Water

- USEPA UV Disinfection Guidance Manual
- DVGW / ÖNorm



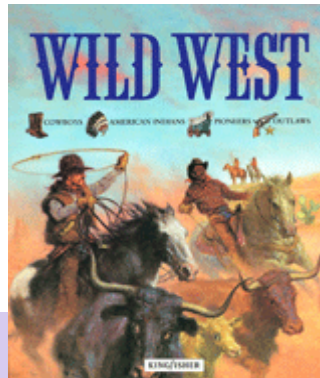
Reuse

- NWRI/AwwaRF



Wastewater

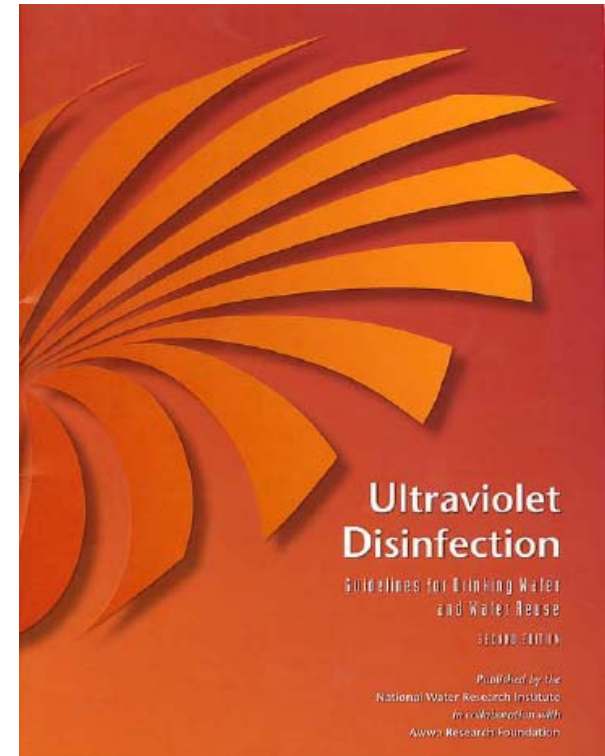
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Various State Regulations

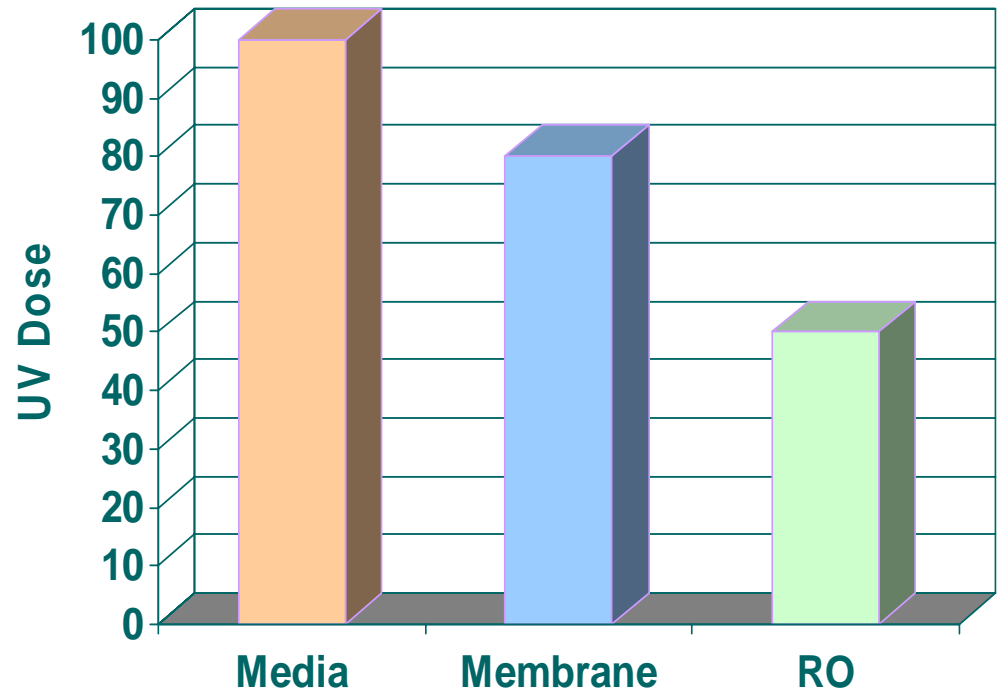
- California "Title 22"
- Arizona "Class A+"
- Hawaii "R1"
- Florida "High Level"

→ NWRI/AWWARF
Guidelines for Water Reuse



Design Conditions

- Disinfected Filtered Reclaimed Water
 - Pathogen Free
 - 5-log poliovirus inactivation
 - 2.2 MPN/100 ml total coliform
- Uses for reclaimed water
 - Irrigation of food crops
 - Parks
 - Playgrounds
 - Residential landscaping
 - Golf courses
 - Cooling towers
 - Decorative Fountains
 - Carwashes



Required UV Dose dependant on Pre-Treatment Type

Design Factors – UV Dose

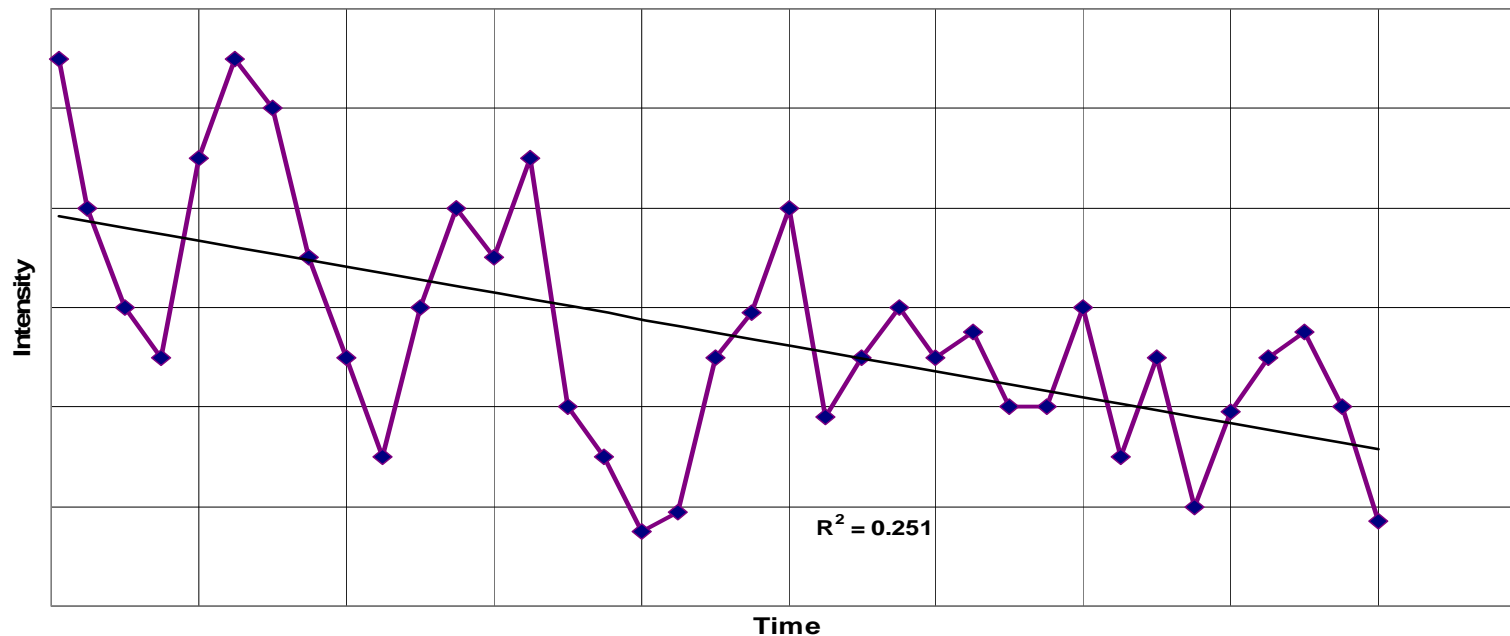
Guidelines describe UV Dose as:

$$Dose = EOLL * FF * f \text{ (UVT, Power, Flow)}$$

- **EOLL** → Lamp Aging Factor
 - 50% of new lamp output
- **FF** → Quartz Sleeve Fouling Factor
 - 80% for automatic mechanical cleaning systems
- Historical UVT Data
 - Three samples per day for 6 months

Sensor Based Control

Reality is that fouling and lamp aging do not always follow predicate patterns



Therefore change lamps and clean sleeves as indicated by predetermined low sensor values

Sensor Based Control

Use of Certified Sensor (NIST/DVGW) allows real-time, closed-loop control



Dose now described as:

$$Dose = f (Sensor Intensity, Flow)$$

Only utilizes energy that is required. No more, No Less

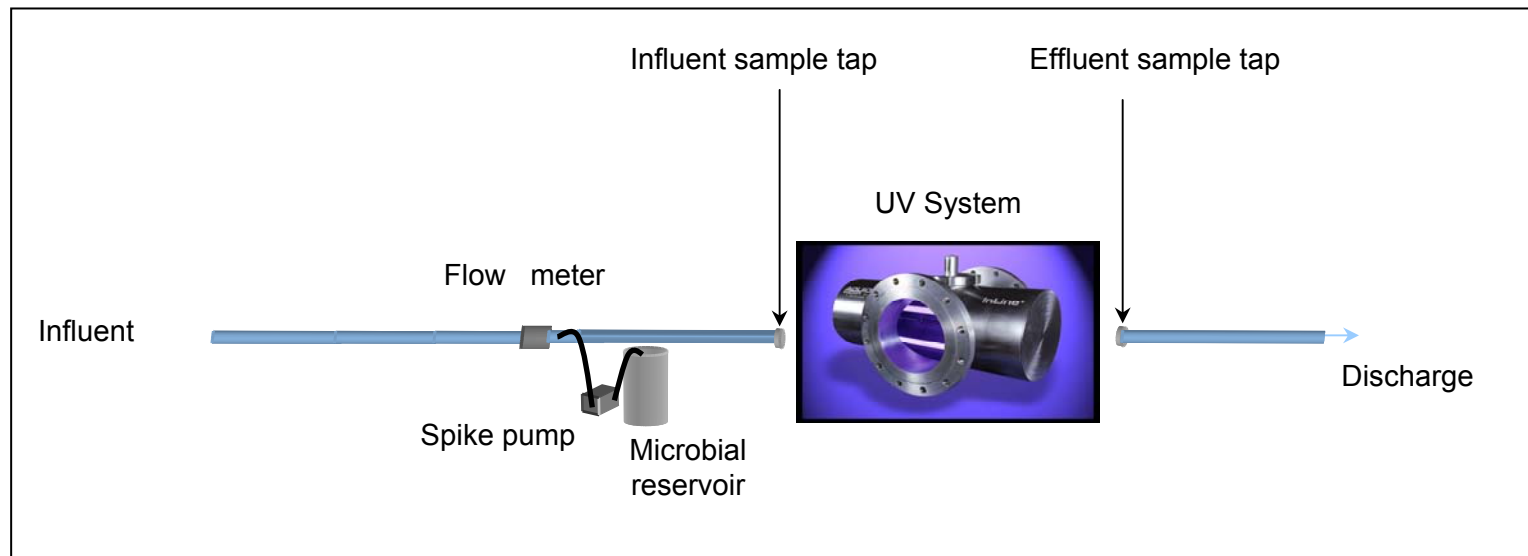
Conditional Acceptance

- What does conditional acceptance mean?
 - The state has approved use of the technology for reclaimed water based on the third party validation report submitted
 - Set of conditions relating to testing must be followed
 - **Checkpoint bioassay or velocity profile to verify performance**



Checkpoint Bioassay

- Verify that the UV system meets the specified performance requirements up to maximum flow conditions with a water quality \geq than design
- 8 – “checkpoints” or test conditions
- MS2 Phage is most typical surrogate organism



Conditional Acceptance

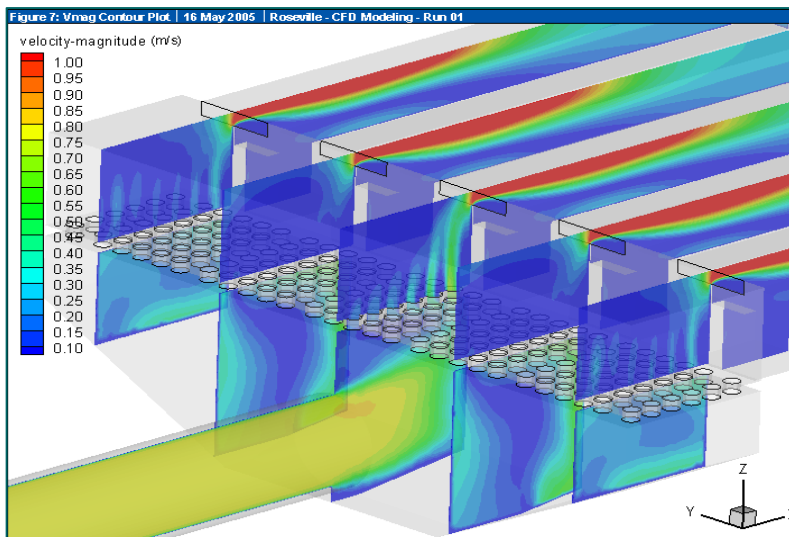
- Velocity Profile vs Checkpoint Bioassay

	Pros	Cons
Velocity Profile	<ul style="list-style-type: none">• Cheaper• Verifies appropriate mixing to ensure dose distribution	<ul style="list-style-type: none">• Doesn't verify:<ul style="list-style-type: none">➢ UVT➢ UV Dose delivered to micro-organism
Checkpoint Bioassay	<ul style="list-style-type: none">• Ensure validation was performed properly• Allows for actual site conditions to be tested	<ul style="list-style-type: none">• Expensive• Thought to be redundant after validation testing performed

Scale-up and Inlet Considerations

Open channel

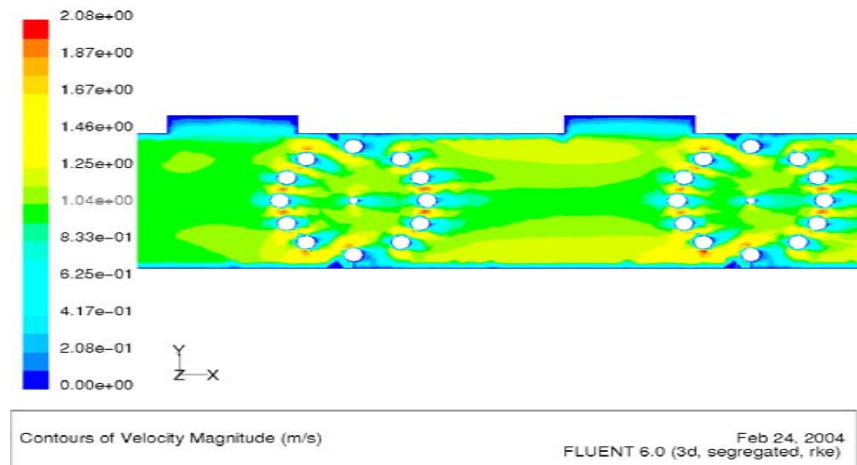
Can be scaled up to 10x the number of lamps



- Short circuiting concern
- Often see poor entrance conditions

Closed vessel

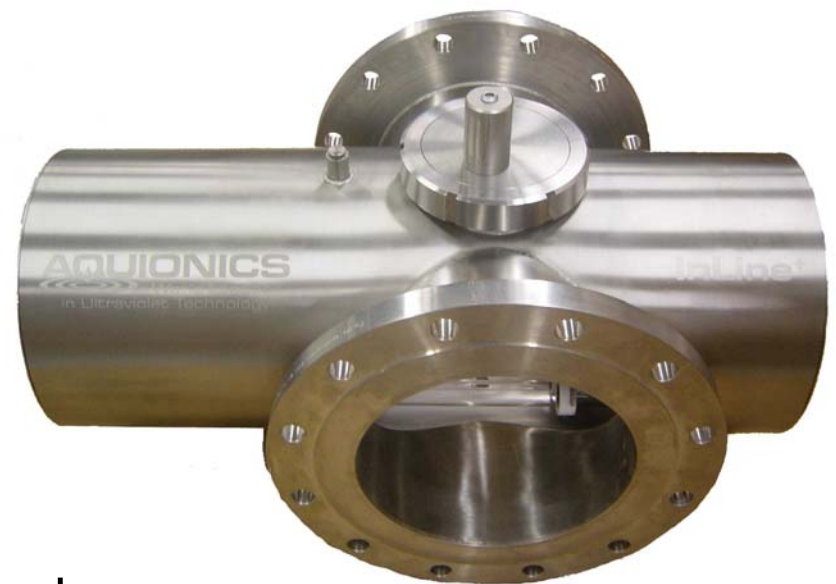
No guidelines exists for scaling up



- CFD has been shown to confirm design scale-up
- Smaller footprint allows straight inlet
- Cross-flow: no short-circuiting

Closed Vessel Technologies

- Smaller footprint/compact design
- Medium lamps
- Inline to pipe; no concrete channel
- Automatic electric cleaning
- Vertical or horizontal flow design
- Sensor set-point monitoring approach
- More installation location options



Reference: NWRI Reclaimed Water



Crescent City, CA

UV-T 65%

Dose: 80 mJ/cm² RED

InLine 7500+

Flow: 1.2 MGD



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Reference: 2000 NWRI Reclaimed Water



Laguna Sanitation District, CA InLine 7500+

UV-T 65%

Flow: 3.6 MGD

Dose: 80 mJ/cm² RED



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Reference: NWRI Reclaimed Water



Carnation, WA

UV-T 65%

Dose: 80 mJ/cm² RED

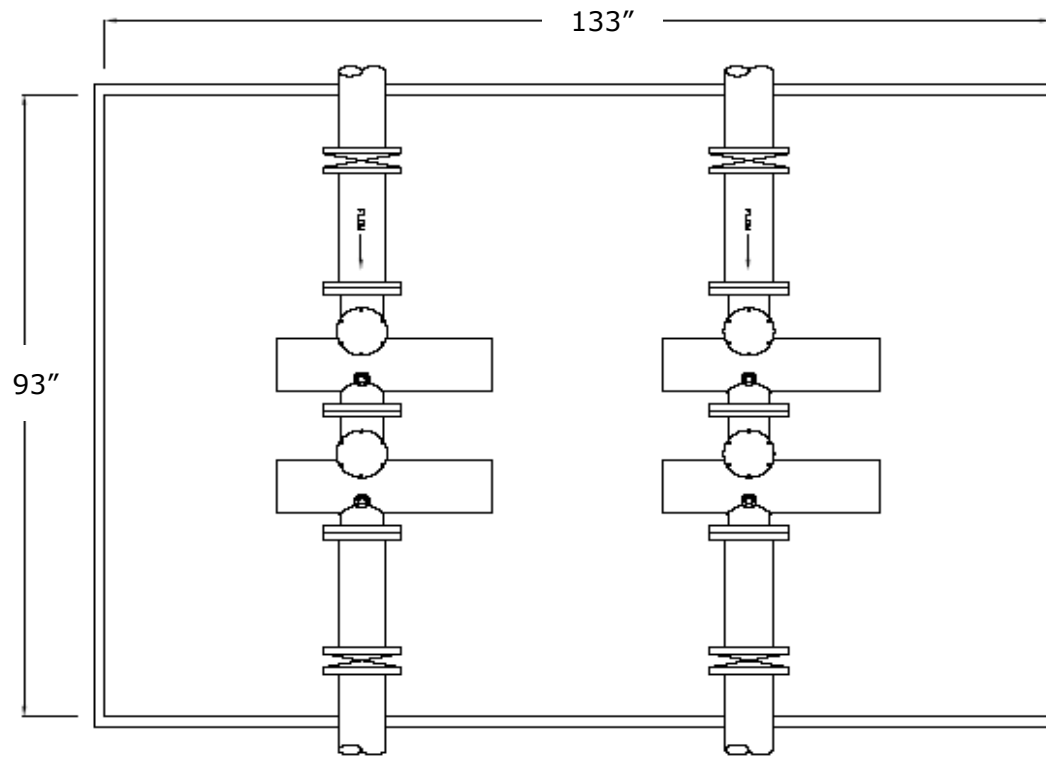
InLine 7500+

Flow: 1.3 MGD



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Reference: Reclaimed Water



Pukalani, HI

InLine 400+

UV-T 65%

Flow: 0.9 MGD

Dose: 80 mJ/cm² RED



Lessons Learned

Being in the business over 20 years provides experience and expertise on design issues to avoid

- Design Layout & Interfacing
 - Air Entrapment
 - Creates air pockets causing overheating and impair disinfection
 - Hydraulics
 - Insufficient upstream straight pipe run; splitting flow evenly through parallel systems
 - Matching our process to yours
 - Sequencing Batch Reactor (SBR) process with multiple daily start/stops



Lessons Learned

- Water Quality Design Issues
 - Sampling Location
 - Effluent samples should be taken directly after UV unit
 - Industrial Water Quality Disruptions
 - Contribute to UVT, TSS and influent fecal spikes
 - Algae
 - Clarifier and channel covers help with algae growth while mechanical wipers remove from sleeves
 - Iron
 - Precipitates onto sleeves & requires chemical cleaning for Fe >0.1 mg/l



Where UV is used it is not only important to...

- Design with certified equipment
- Apply appropriate UV Dose

but also to...

- Understand influent hydraulic design
- Consider appropriateness of Open Channel or Closed Vessel
- Be aware of UV system control methodologies
- Consider operational issues

Discussion

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