Wastewater Reuse Treatment Technologies

June Leng, Ph.D., P.E.

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HDR

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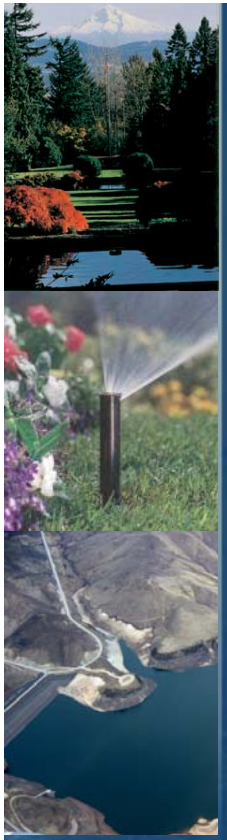

Presentation Outline

- Water Reuse Requirements
- Filtration Technologies
- Disinfection Technologies
- Technologies in Application

Water Reuse Requirements

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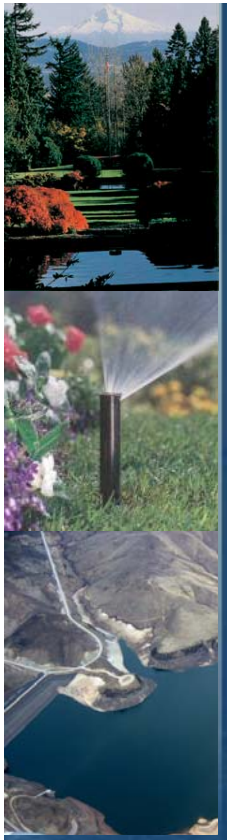
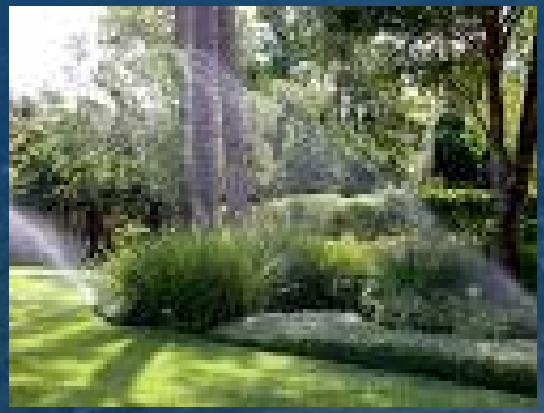
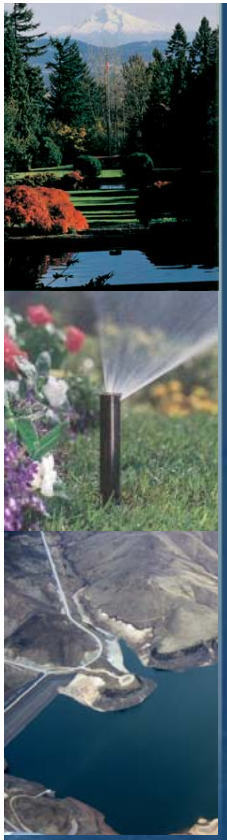


Recycled Water Quality Requirements

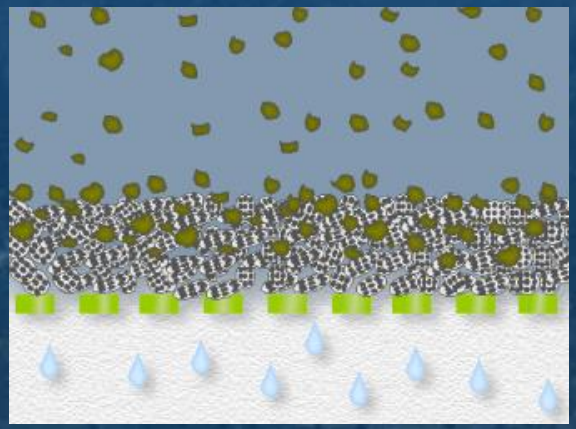
- Disinfected Tertiary Recycled Water for Non-Restricted Reuse
  - 7-day median total coliform ≤ 2.2/100mL; Never exceed 240 MPN/100mL
- Others for Restricted Reuse
  - Disinfected secondary – 2.2 recycled water
  - Disinfected secondary – 23 recycled water
  - Undisinfected Secondary

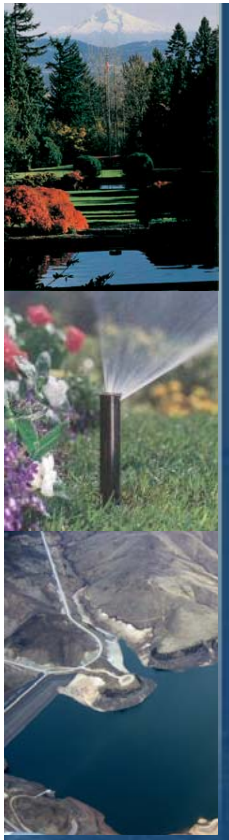




Filtered

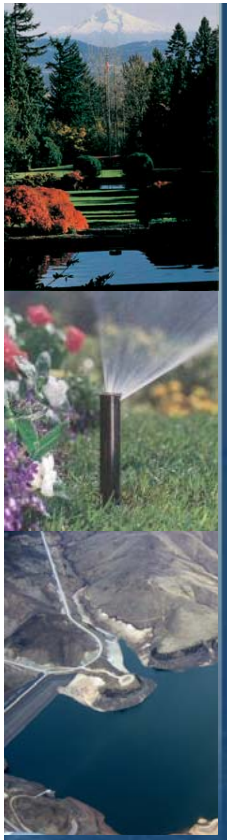
- Media Filters
  - filtrate turbidity not to exceed 2 NTU average daily
  - not to exceed 5 NTU more than 5% daily
  - never exceed 10 NTU
- Membrane
  - filtrate turbidity not to exceed 0.2 NTU more than 5% daily
  - never exceed 0.5 NTU





Disinfected

- Chlorination
  - CT ≥450 mg-minutes/L
  - Modal contact time ≥ 90 minutes based on peak dry weather design flow
- Other disinfection processes (i.e. UV)
  - inactivate or removal 99.999 percent bacteriophage or polio virus



Technology Validation Program

- Filtration and disinfection equipment validation
- Perform a pilot study
- Submit a report to the State Department of Health Services
- Conditional approval for water reuse application

California Department of Health Services

Idaho Department of Environmental Quality

Filtration Technologies

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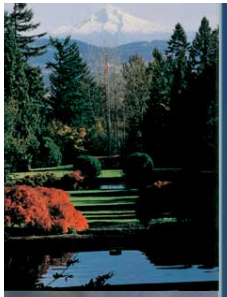
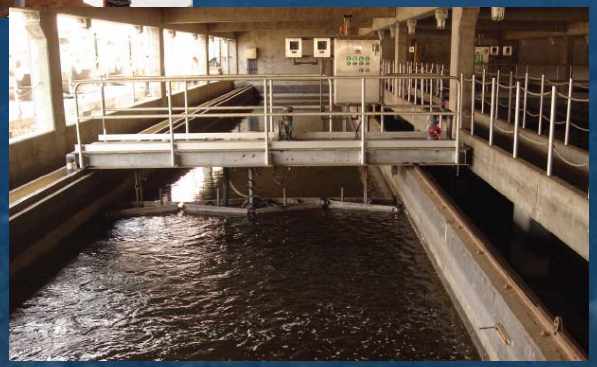
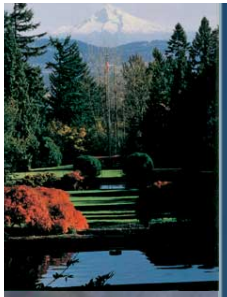


Filters in Water Reuse

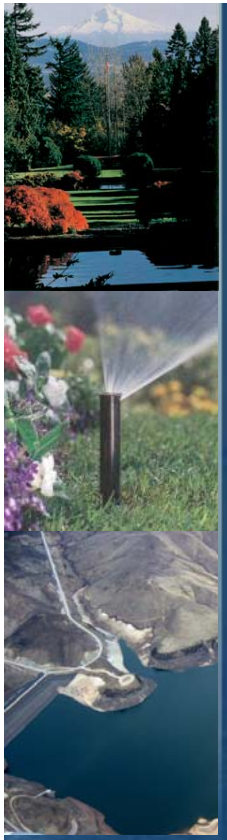
- Media Filters
  - Granular Media Type Filters
  - Fuzzy Filter
  - Cloth Media Filters
- Membrane
  - Pressure
  - Immersed





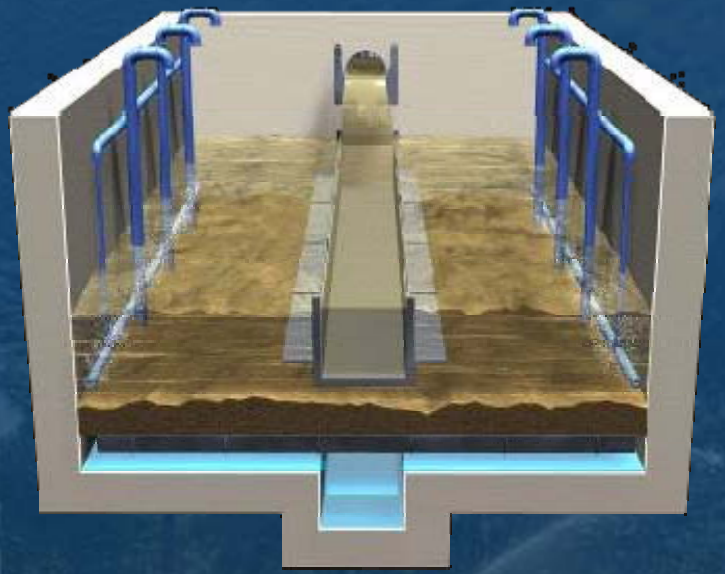
Granular Media Filters

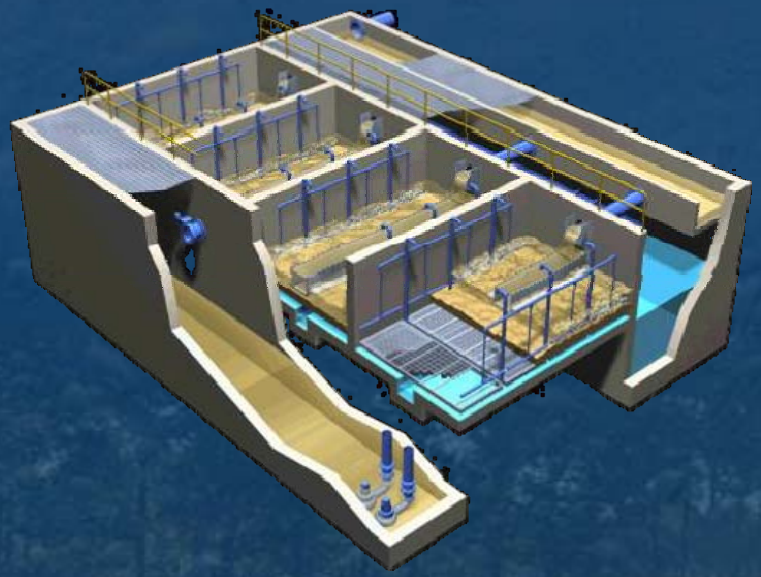
- Including deep bed, pulse bed, monomedia, dual media, multimedia, traveling bridge, continuous flow, etc.
- Most common technology - widely applied and proven effectiveness
- O&M staff familiarity
- High backwash volume and backwash requires shut down of entire filter unit

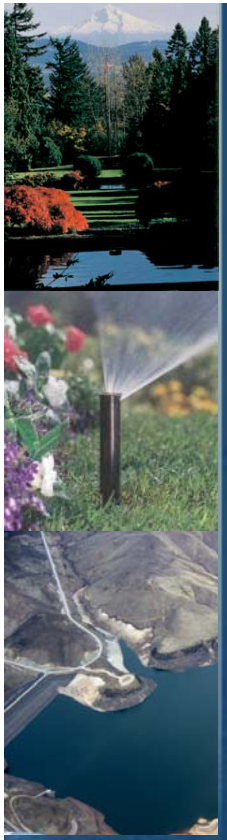


Granular Media Filter – Pulse Bed Filters

- HydroClear Filter
- Rapid sand filter
- Low profile, shallow bed, gravity filter
- Air is pulsed through the bed to regenerate media

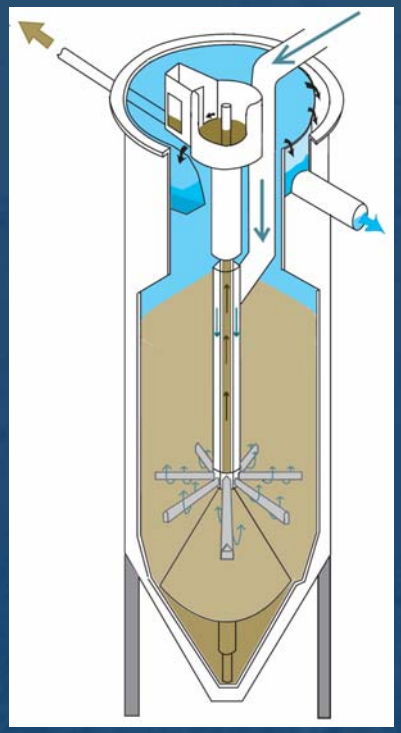


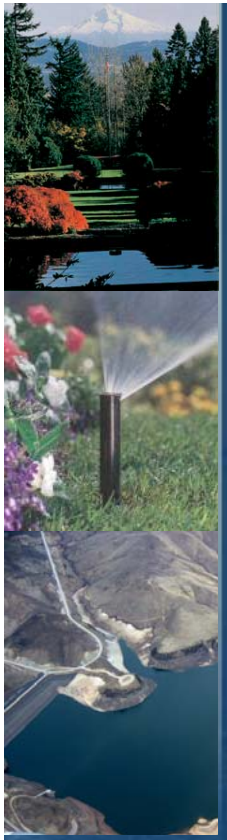




Granular Media Filter - Continuous Backwash Filters (CBF)

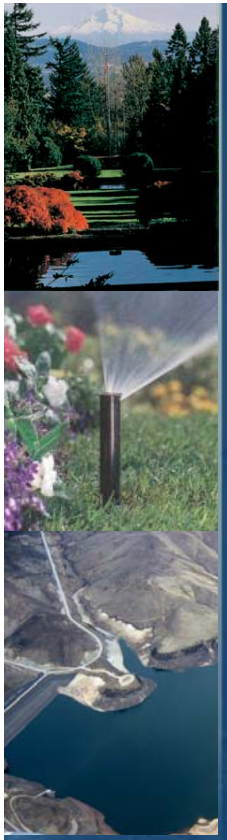
- DynaSand Filter
- Deep bed, self cleaning filter
- Water flows upward through the media
- Debris is trapped in the media and flows downward, lifted, cleaned, and deposited on top
- Highly tolerant to chemicals
- Post denitrification and phosphorous removal capabilities





Fuzzy Filter

- Water flows upward through the media
- Media bed: high porosity synthetic balls
- Compressible media Bed and adjustable porosity
- Small footprint with higher hydraulic capacity

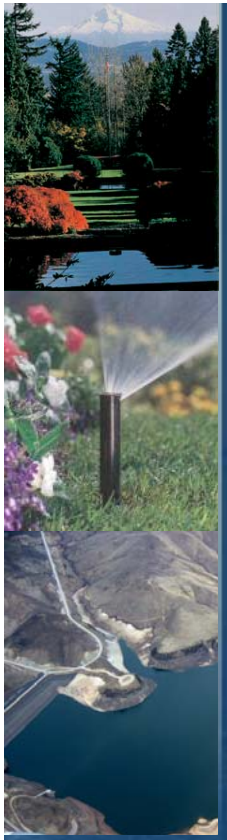


Cloth Media Filters

- Inexpensive and simple
- Low headloss
- Small footprint
- Low backwash volume
- Backwash while filter remains online
- No air requirement

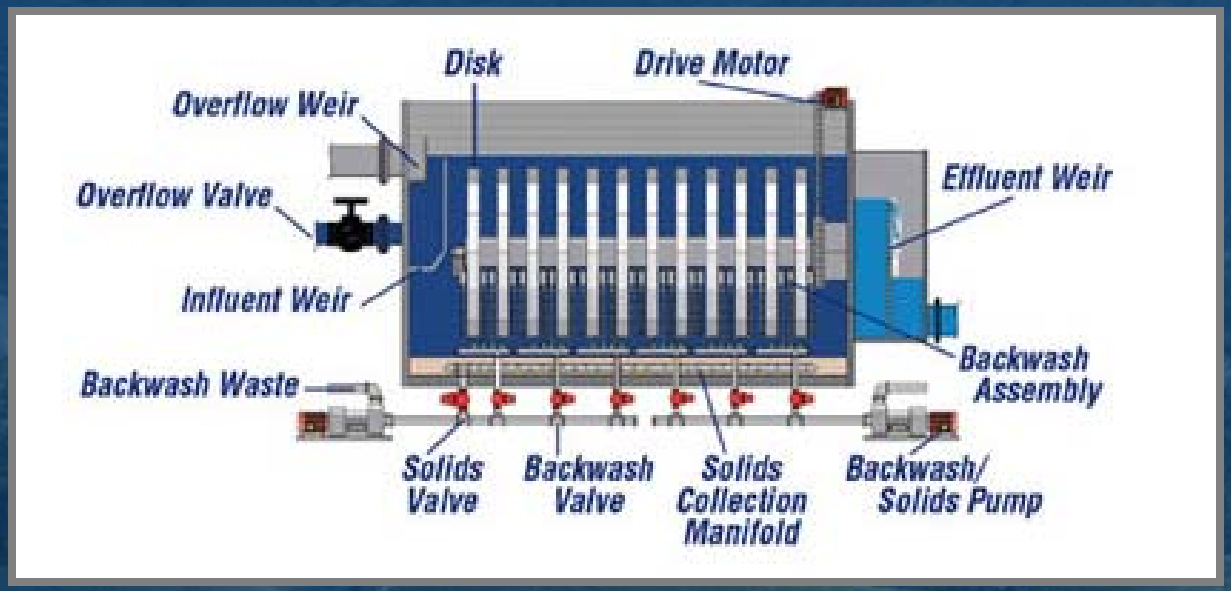
Cloth Media Filters (cont)

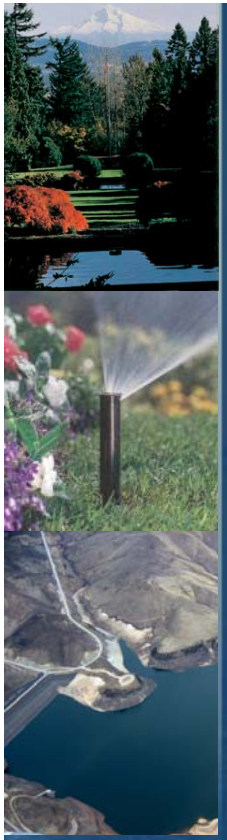
- Aqua-Aerobic Disc
- Kruger Hydrotech Disc
- Aqua-Aerobic Diamond



Aqua Aerobic Disc Filters

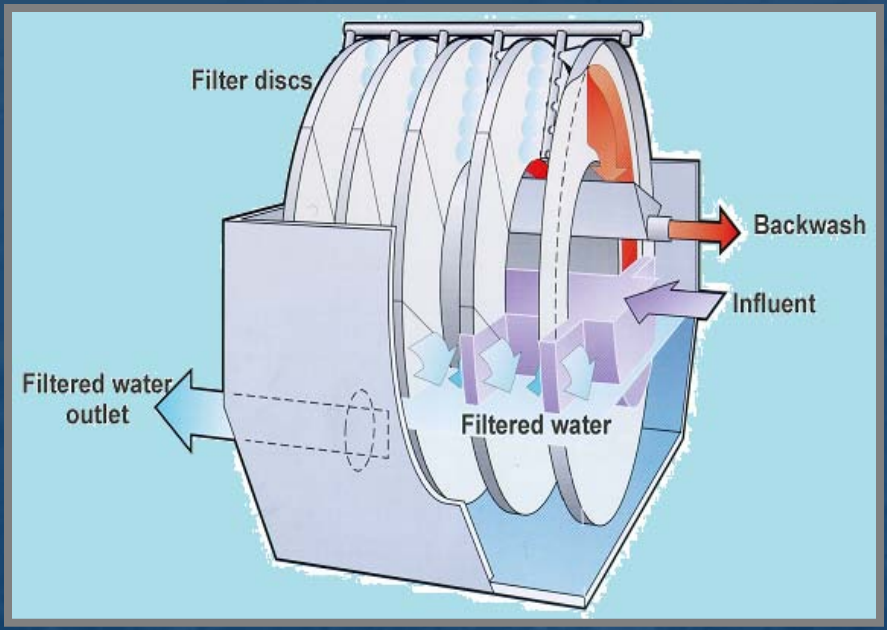
- Carpet like pile cloth (~1/4” thick) with nominal 10 micro pore size
- Round filter disks mounted on a rotating shaft
- Flow direction outside-in
- Disk fully submerged in filter feed water
- Maximum hydraulic loading of 6 gpm/sf

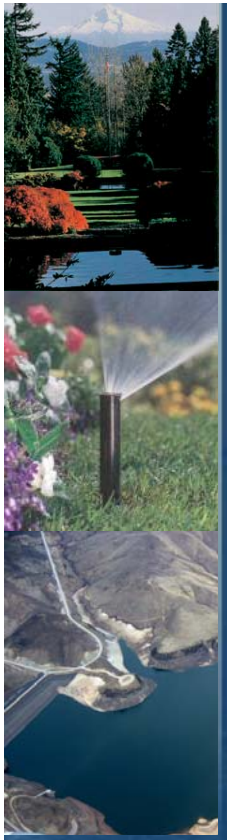




Kruger Hydrotech Disc Filters

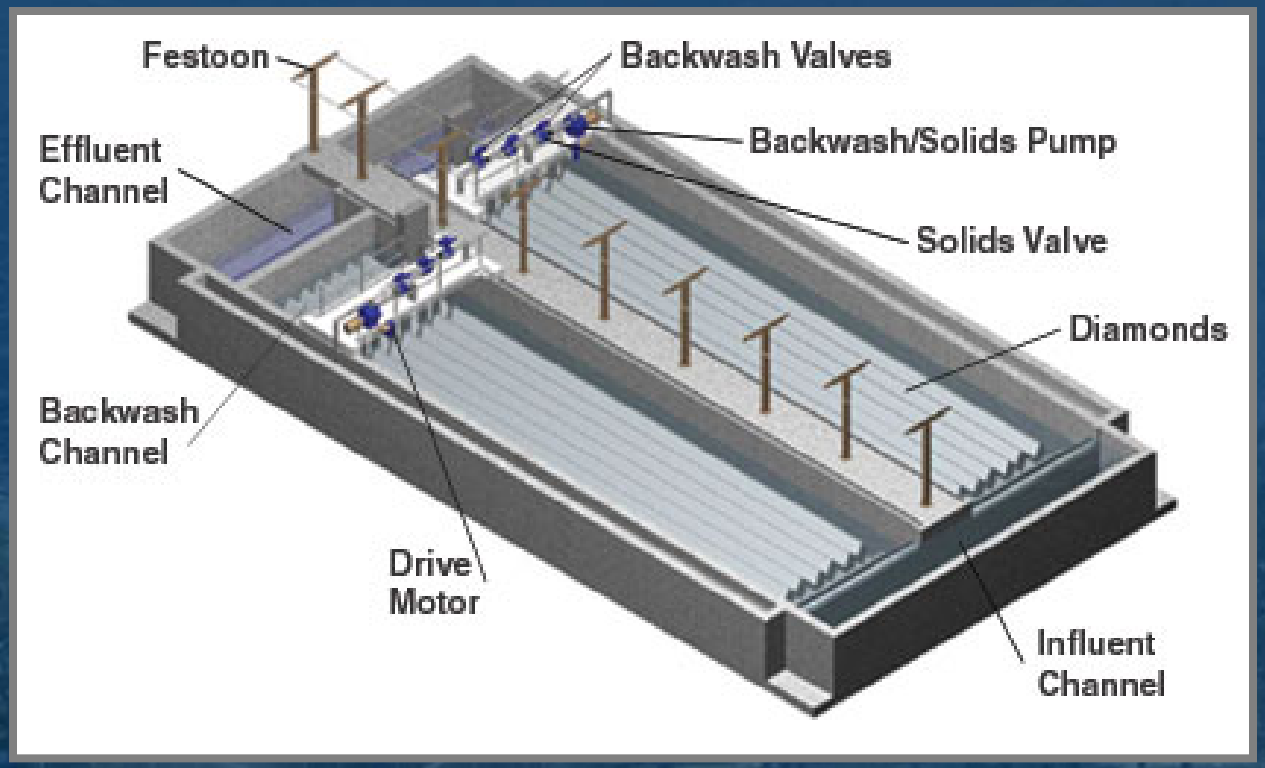
- Polyester fabric with 10 micron pore size
- Flow direction inside-out
- Disk 60 percent submerged in filtrate
- Maximum hydraulic loading of 6 gpm/sf

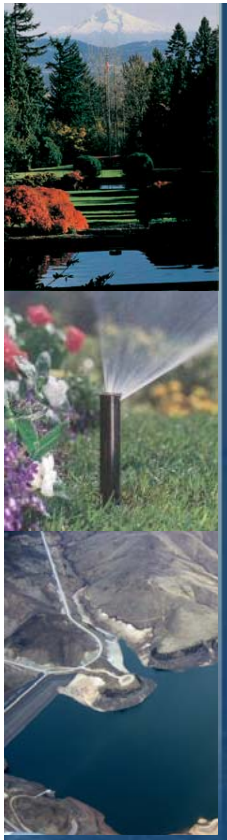




Aqua-Aerobic Diamond Filters

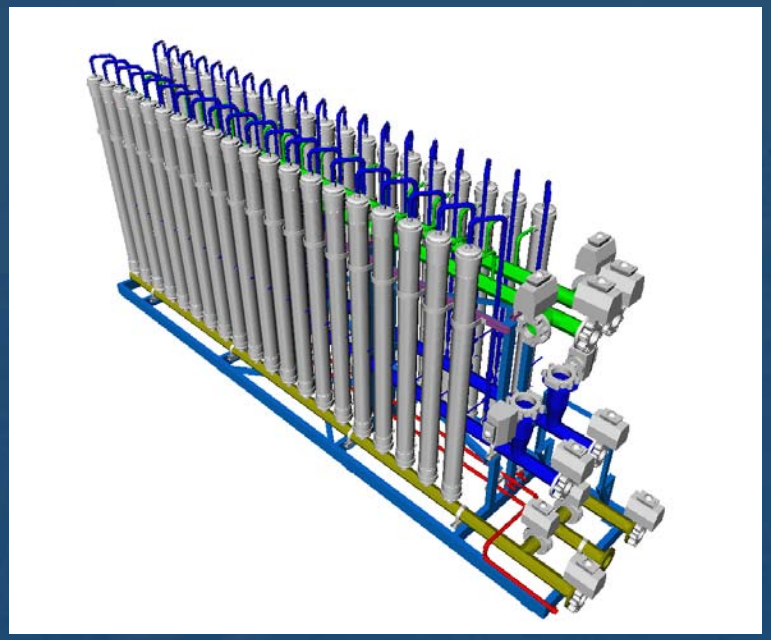
- Carpet like pile cloth (~1/4” thick) with nominal 10 micro pore size
- Designed for traveling bridge filter retrofit

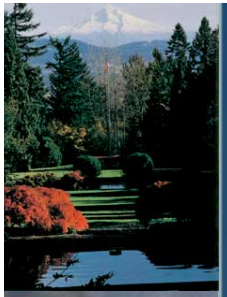




Membrane Filtration

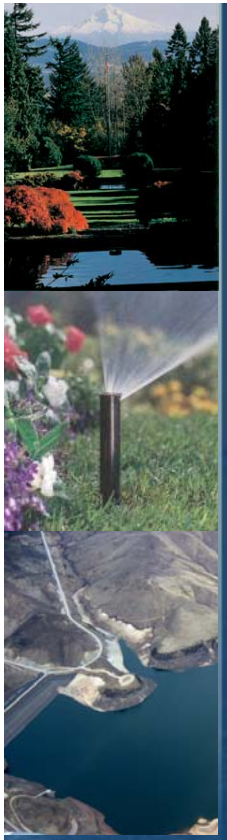
- Pressure
  - Siemens Memcor
  - Pall Aria Systems
- Immersed
  - Zenon ZeeWeed
  - Siemens Memjet
  - Kubota Flat Sheet





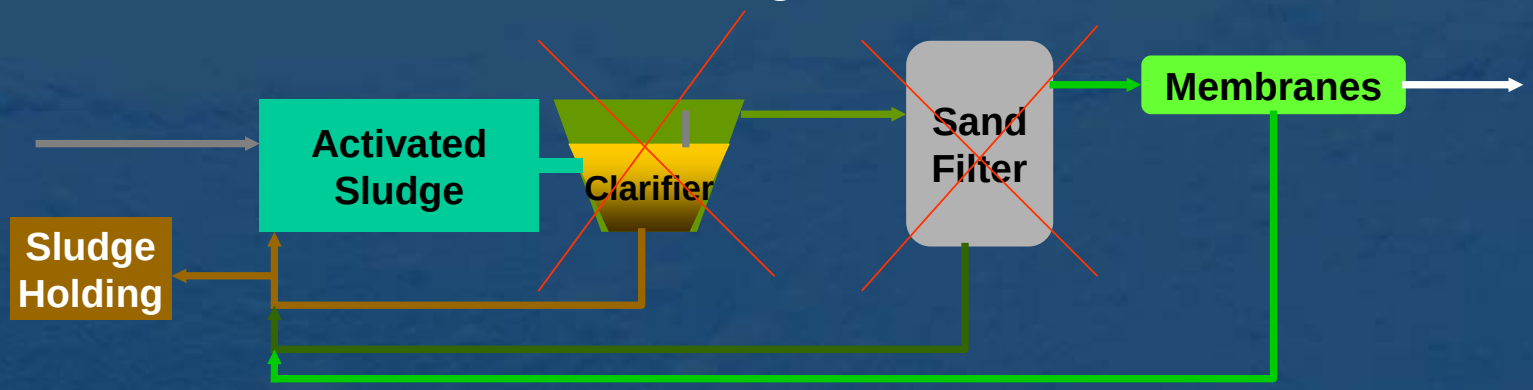
Membrane Bioreactor (MBR)

- Commonly used in wastewater reuse application
- High quality effluent
- Small footprint
- Modular expansion capability
- Reduced sludge yield

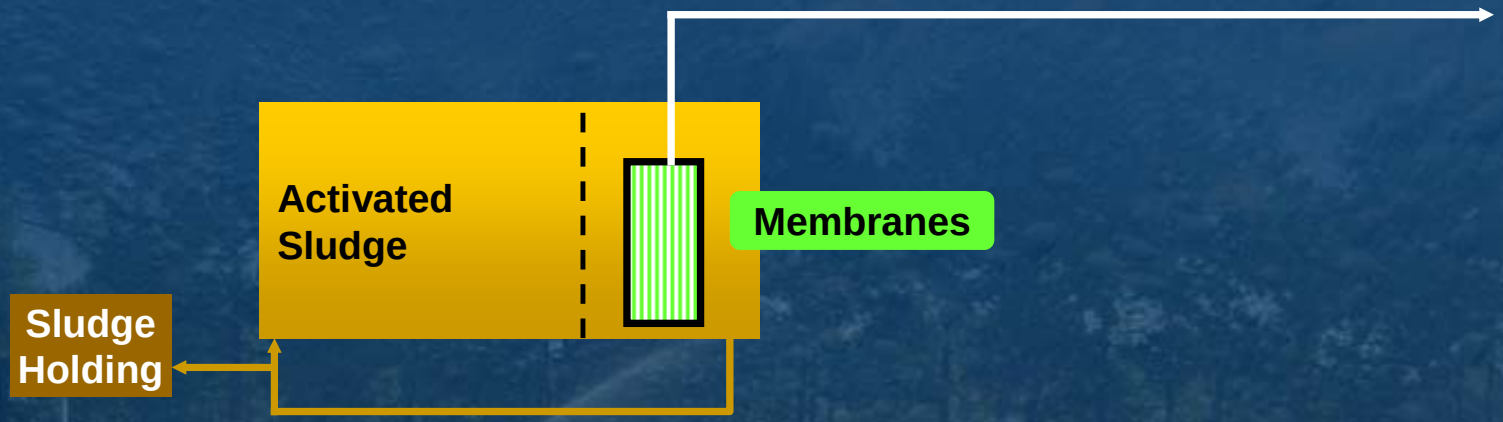


Membrane Bioreactor (cont)

Conventional Process Using Low Pressure Membranes



Integrated Membrane Bioreactor



Disinfection Technologies

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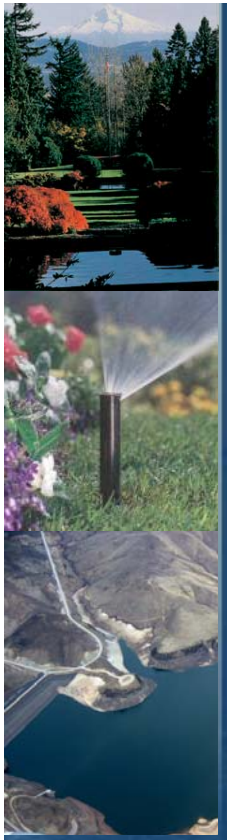
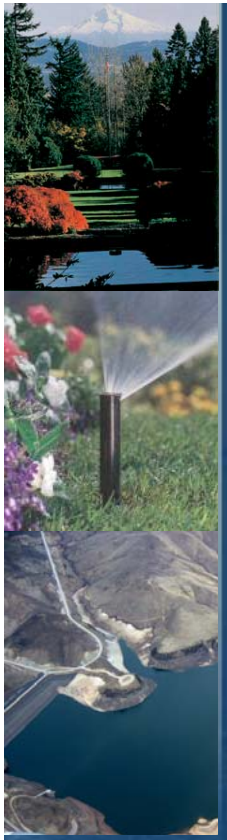


Disinfection in Water Reuse

- Chlorination
- Ultraviolet (UV) Disinfection
  - Low pressure high intensity
  - Medium pressure high intensity

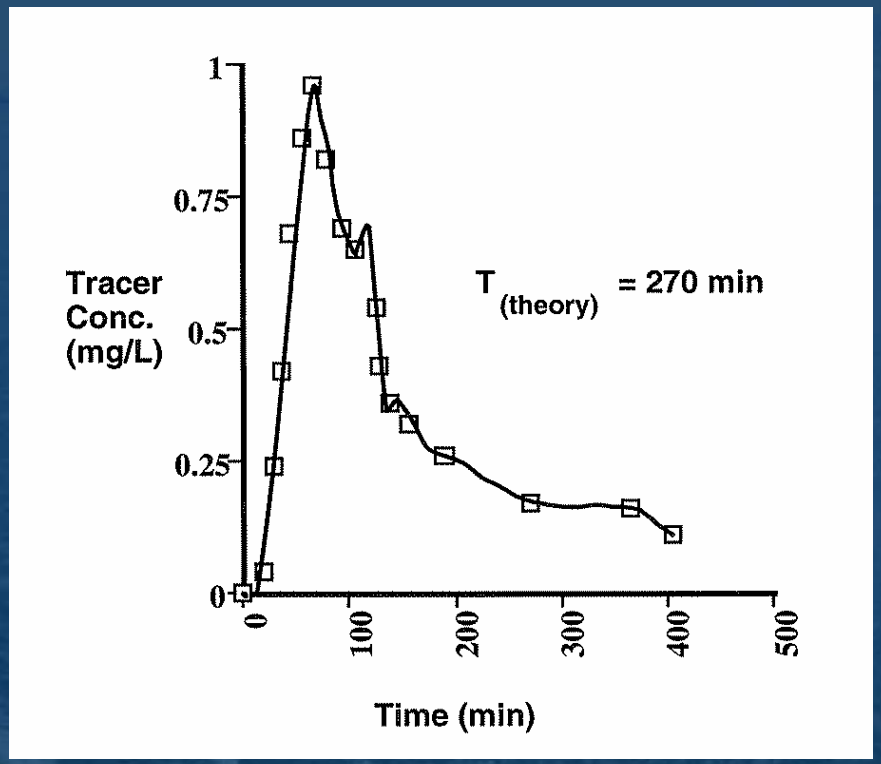


Chlorination

- Gaseous
- Liquid
- On-site Generation

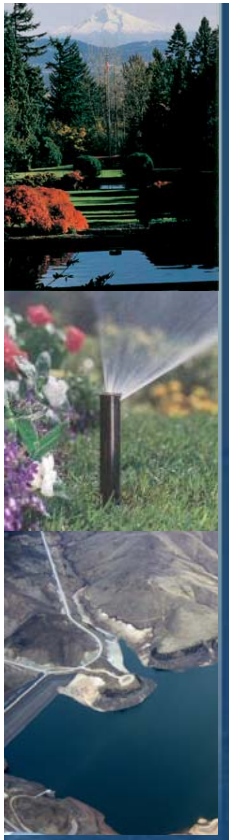
Chlorination (cont)

- Tracer Study



What is the modal contact time of your chlorine contact basin?

Try to fit a size 16 lady into a size 2 dress…

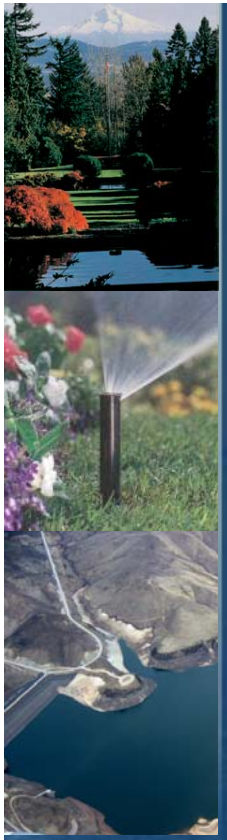


Chlorination (cont)

- Chlorination Byproducts – Trihalomethanes (THMs)

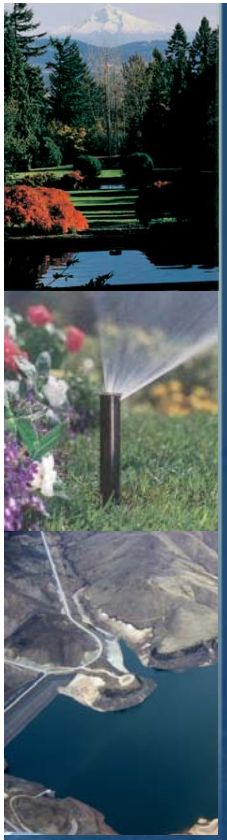
CTR THMs Criteria (µg/L) - Human Health-based Requirements		
THMs	Water & Organisms	Organisms Only
Bromodichloromethane	0.56	46
Dibromochloromethane	0.41	34
Bromoform	4.3	360

"Good to drink, but not to discharge"
Got to find disinfection alternatives



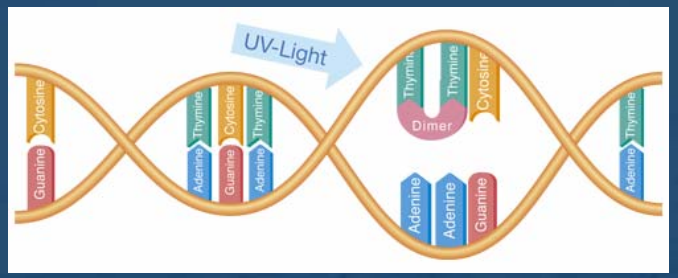
Disinfection Alternatives

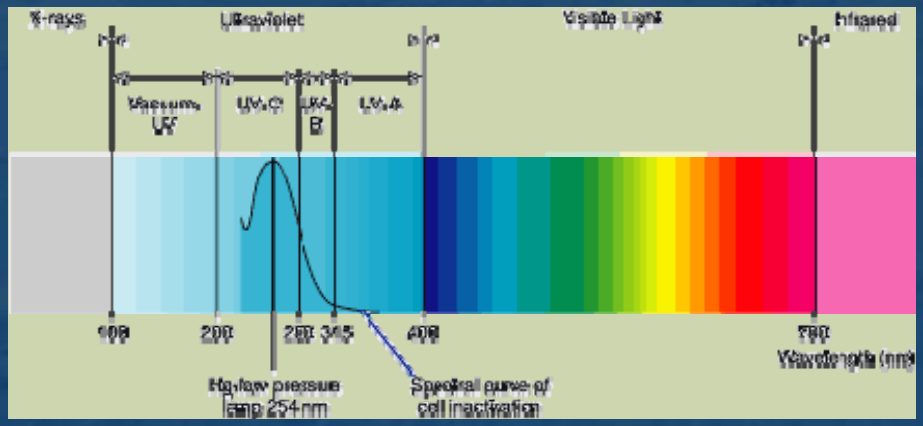
- Chloramination
  - Lowest cost for both small and large systems
  - Doesn’t make sense when you are required to do nitrogen removal
- Ozone
  - Highly corrosive and toxic
  - Energy intensive
  - Forming DBPs
  - Relatively expensive
  - Relatively complex system

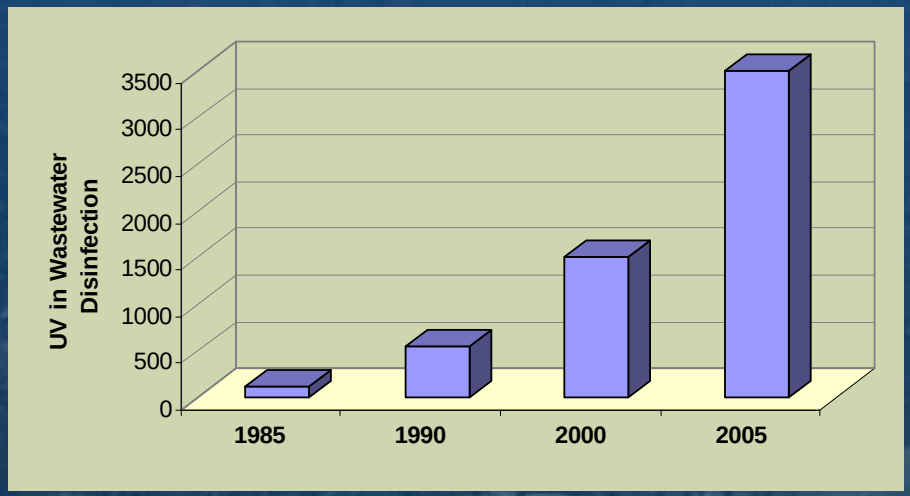


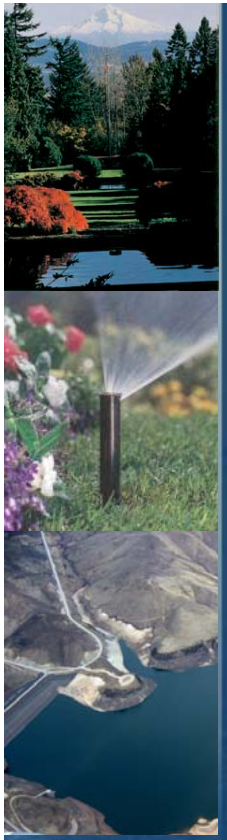
UV

- Environmental Friendly Disinfection Methods
- Increased Disinfection Effectiveness
- Space Saving
- No Post-Treatment
- Easy to retrofit into existing plants
- Thousands of installations in the past two decades
- Lower life-cycle cost compared to other disinfection technologies
- Modular system for adaptability and easy expansion



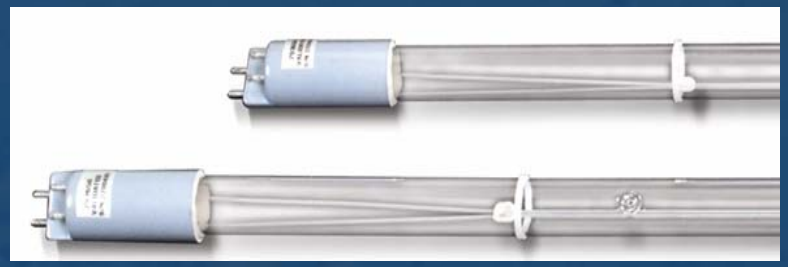


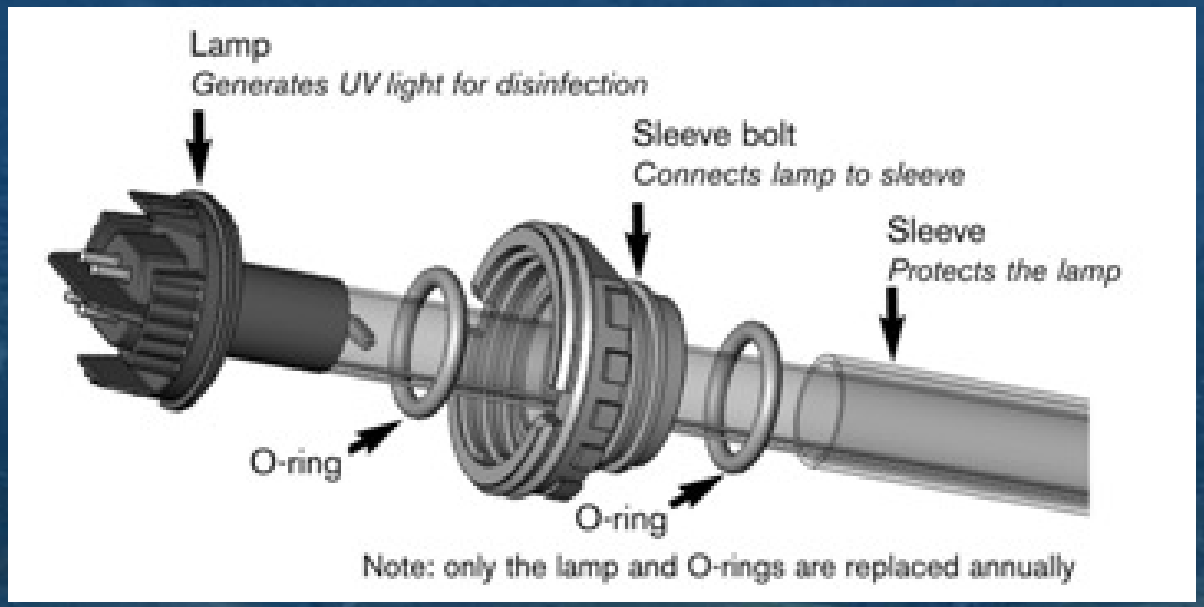


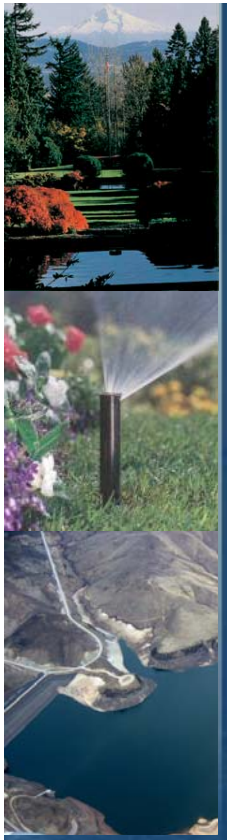


UV (cont)

- UV System categorized based on types of UV Lamps
- Three UV systems in wastewater disinfection
  - LP/LO UV Lamps
  - LP/HO UV Lamps
  - MP/HO UV Lamps

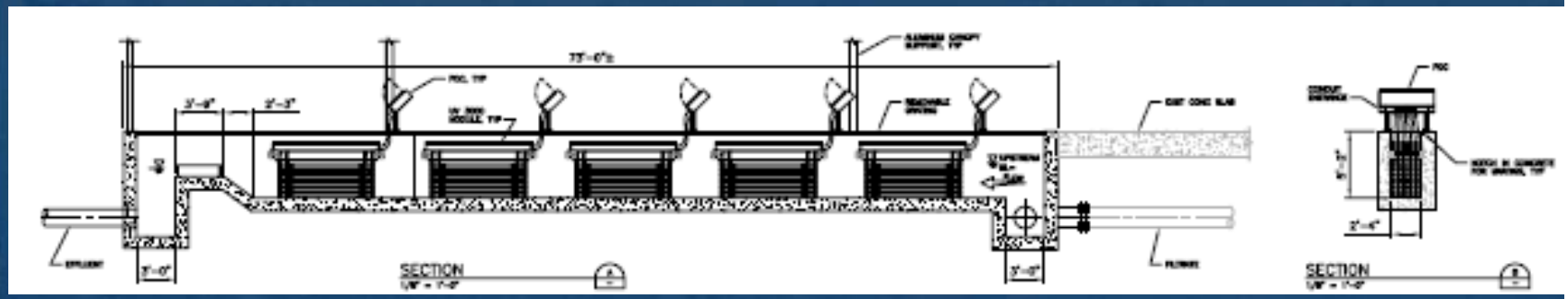




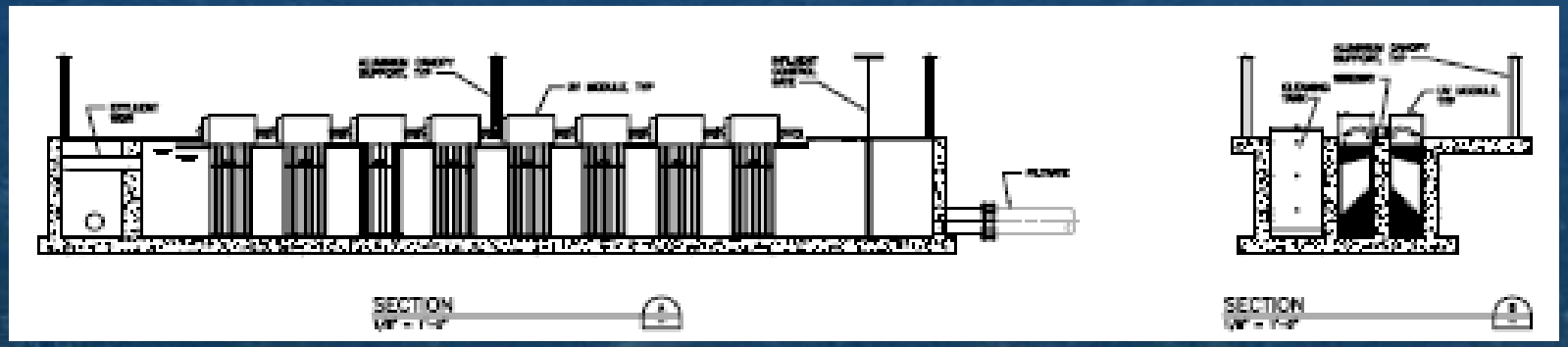


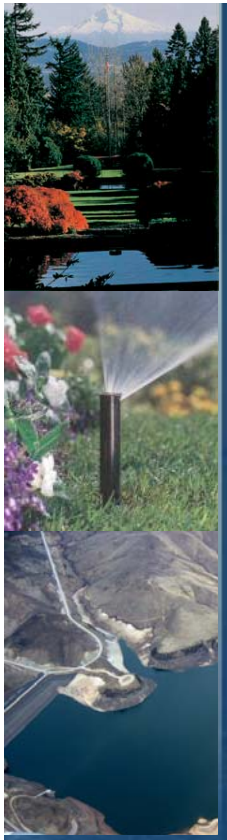
UV (cont)

- In open channel
  - Horizontal and parallel to flow



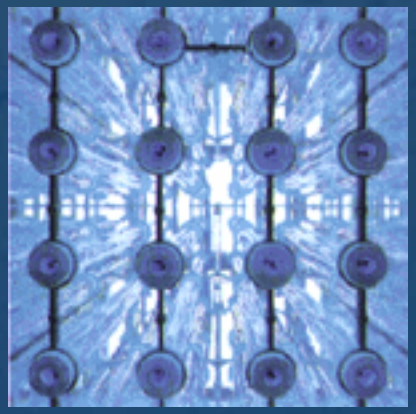
  - Vertical and perpendicular to flow

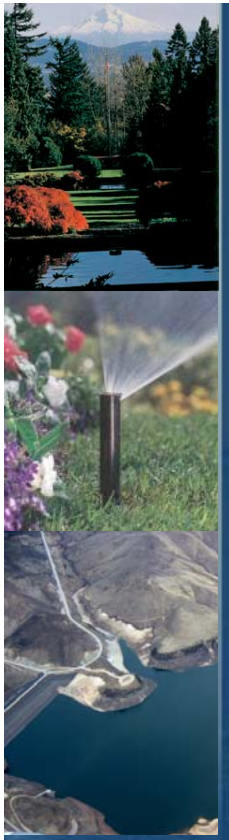




UV (cont)

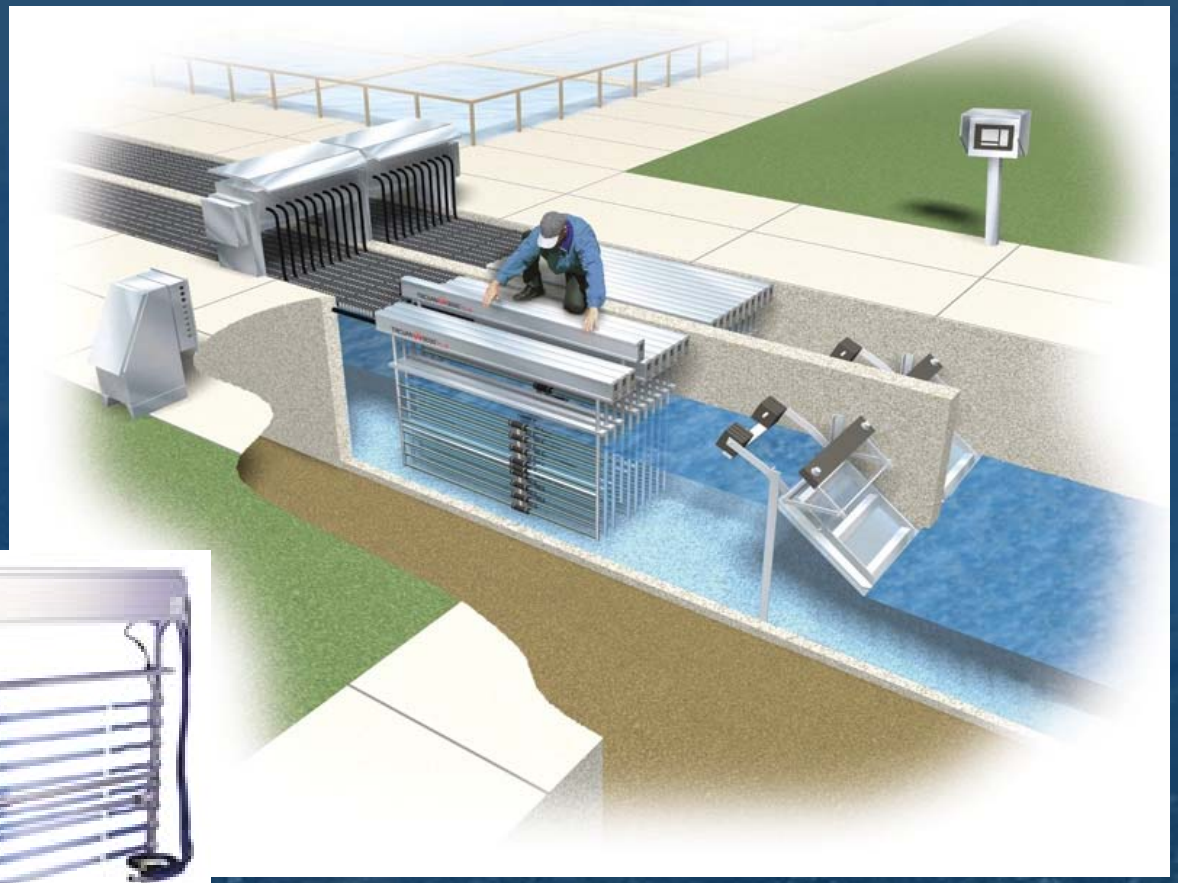
- Major UV technologies in wastewater reuse
  - Trojan 3000plus
  - Wedeco TAK55
  - Ozonia Aquaray 40HO
  - Trojan 4000
  - Aquionics In-Line





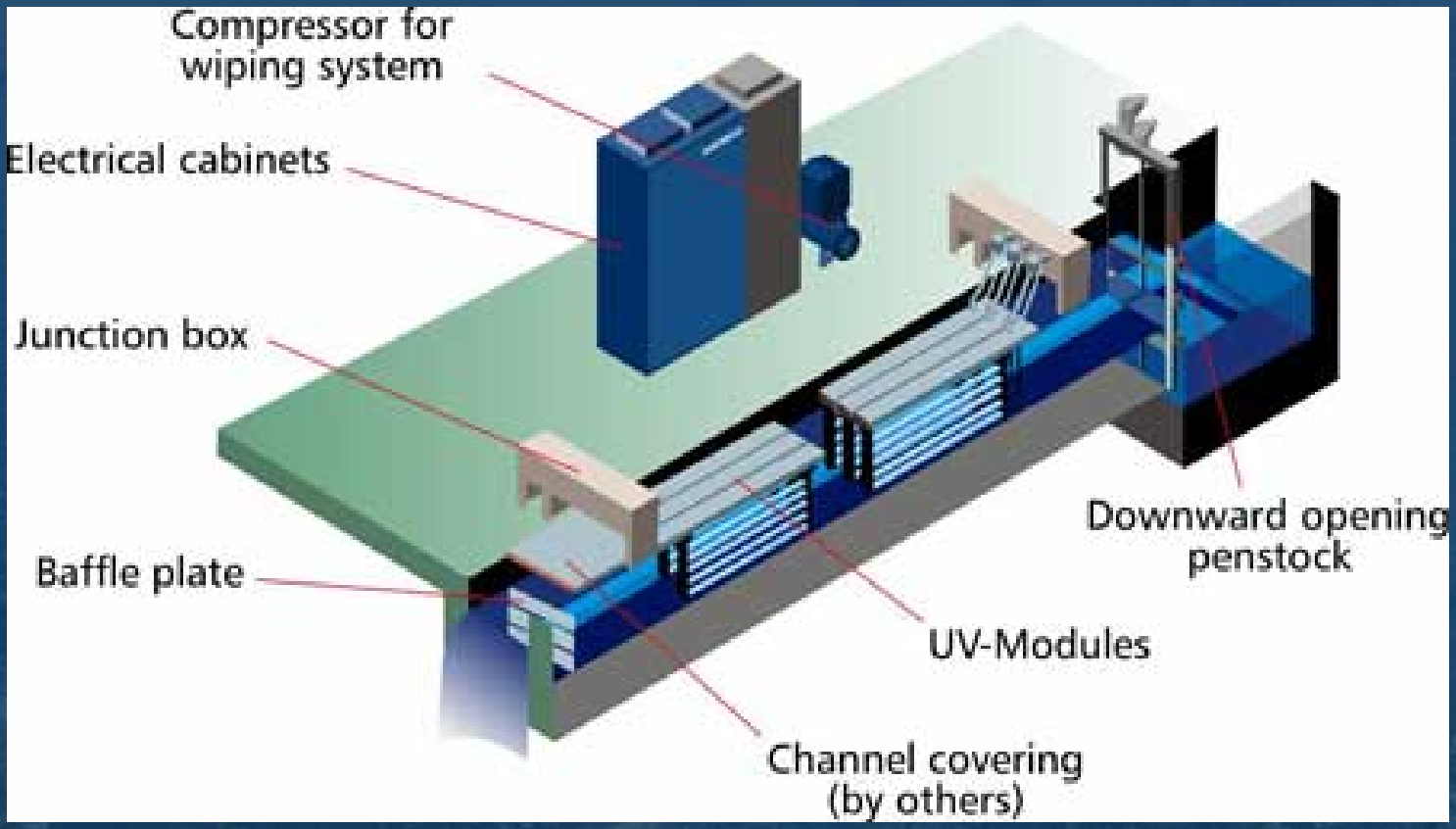
Trojan 3000Plus System

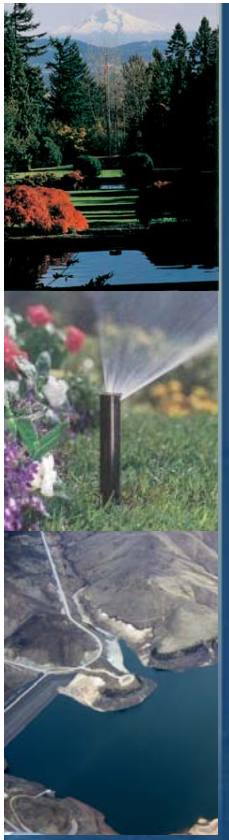
- Low Pressure High Intensity Lamps



ITT Wedeco TAK 55

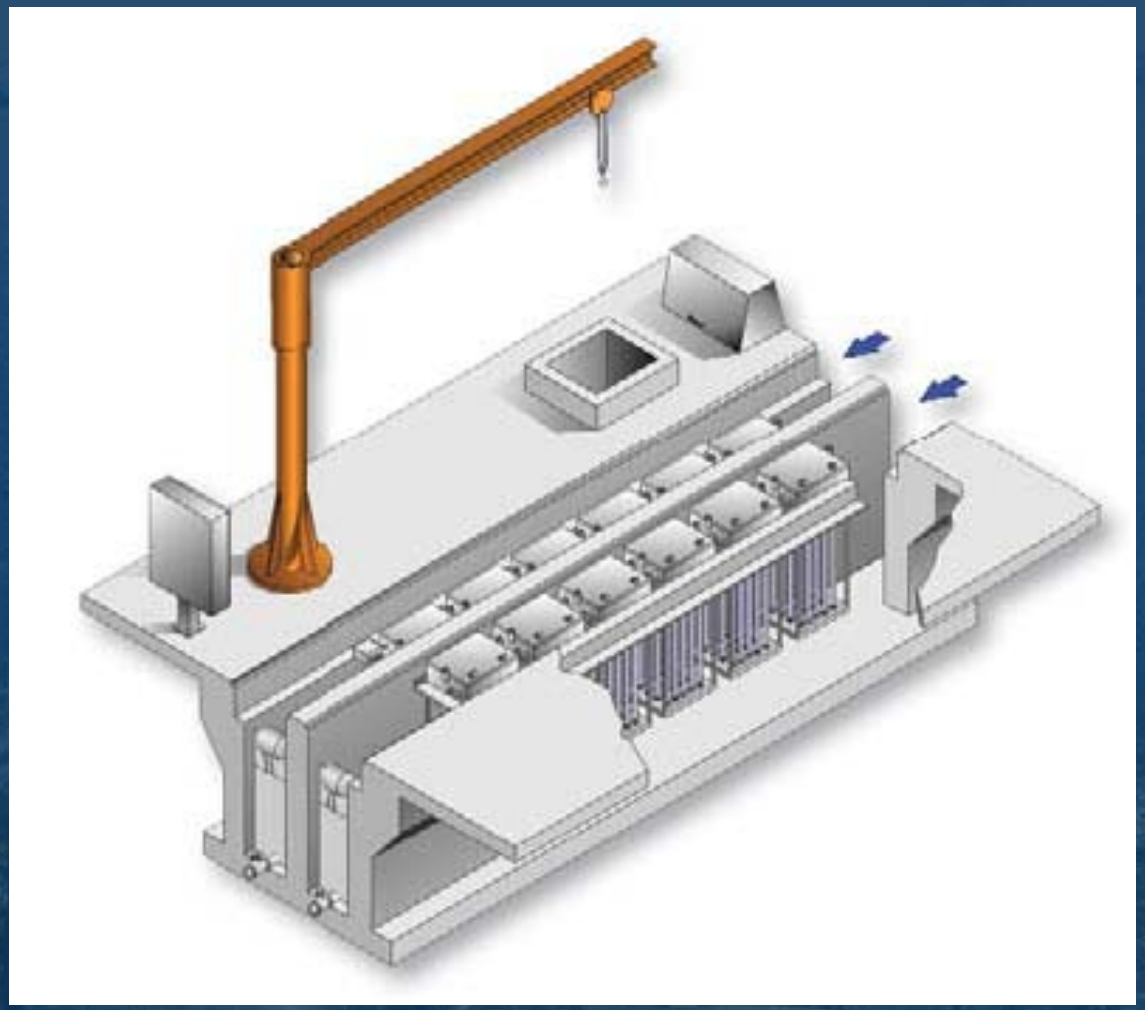
- Low Pressure High Intensity Lamps

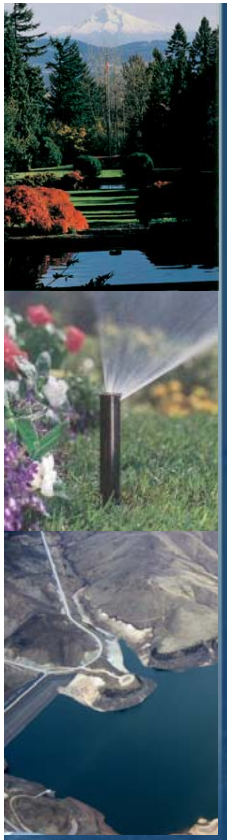




Ozonia Aquaray 40 HO System

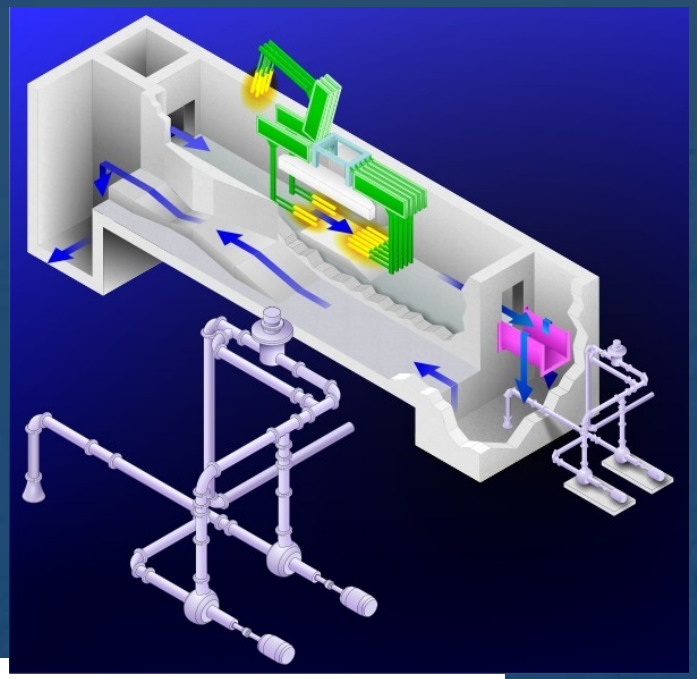
- Low Pressure High Intensity Lamps

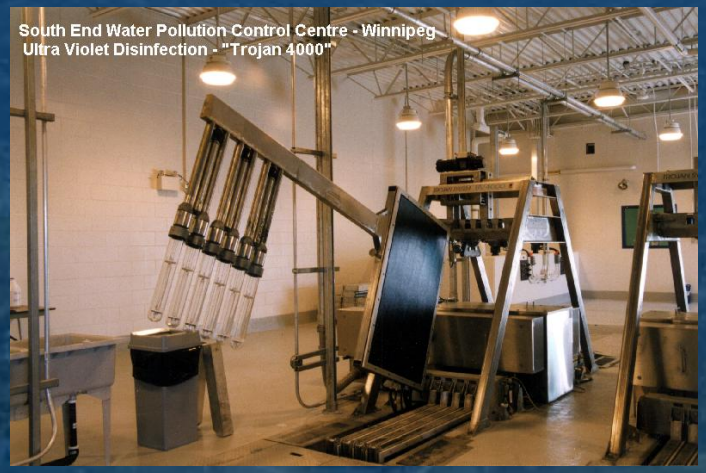


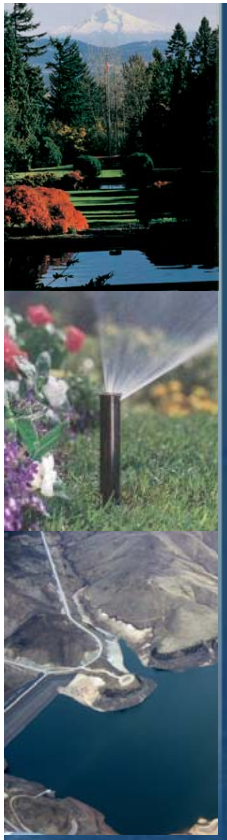


Trojan 4000Plus System

- Medium Pressure Lamps







Aquionics In-Line System

- Medium Pressure Lamps

Technologies in Application

HDR

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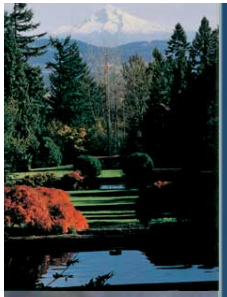


Select a Technology Right for You

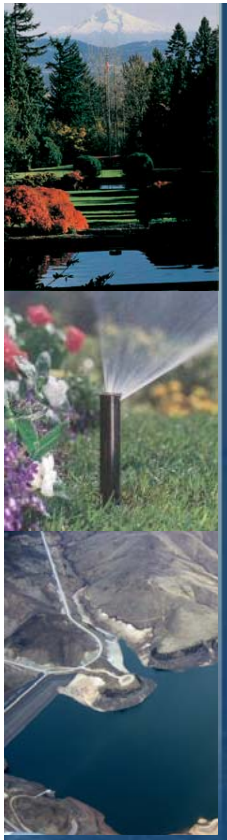
VS.

VS.

VS.

Water Quality and Goals → **Technology Evaluation and Screening** → **Pilot Testing** → **Detailed Analysis** → **Optimum Selection**

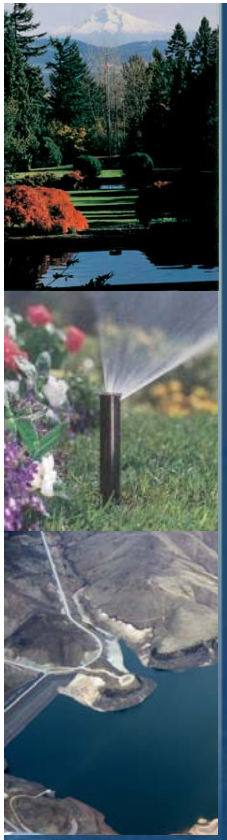
Typical Consideration: Impact to O&M Staff, Performance, Life-Cycle Cost, and Integration with Existing Facilities



Technology Evaluation and Screening

- Filter Technology Evaluation (example)

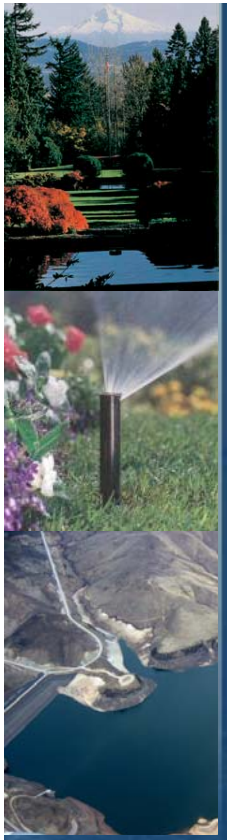
💻 Good ❍ OK – Potential Issue	Continuous Backwash	Pulsed Bed	Cloth Media	Gravity Filters	Membrane
Cost	❍	💻	💻	💻	–
O&M	–	💻	💻	❍	–
Retrofit	–	❍	💻	💻	❍
Proven Applicability	💻	❍	❍	💻	–
Constructability	–	❍	💻	💻	❍
Hydraulic Profile	–	💻	💻	💻	–
Chemical	❍	–	–	❍	💻
Backwash Volume	–	💻	💻	❍	❍



Technology Evaluation and Screening (cont)

- UV Disinfection Evaluation (example)

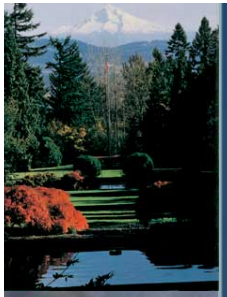
ADVANTAGES	DISADVANTAGES
• No toxic by-products of disinfection	• Higher power consumption than chlorination
• Higher virus inactivation than with chlorine system	• Requires O&M training
• No in-stream chemicals required for disinfection or dechlorination	• May still need chlorine system for Nocardia, RAS, and reuse water chlorination
• Many existing full-scale facilities in operation	• Requires upstream filtration
• Less space required	



Technology Evaluation and Screening (cont)

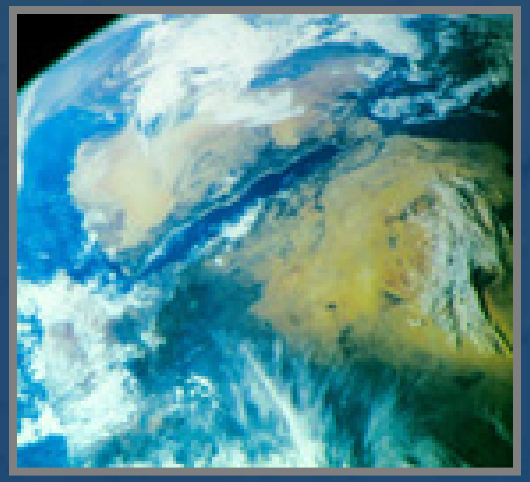
- Economic Comparisons (example)

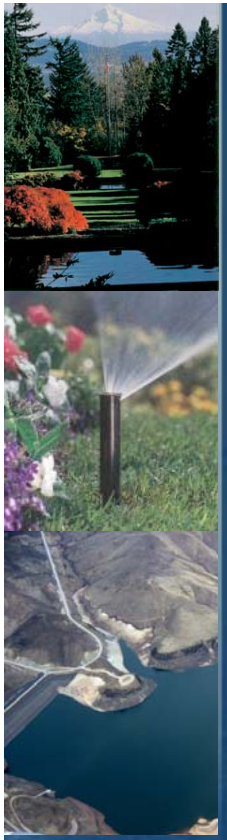
DISINFECTION ALTERNATIVES (Cost in million $)	Annualized Capital	Annual O&M	Total Annual	Rank
1. (Existing) Gas with safety and security improvements	0.5	1.2	1.7	3
2. (Existing) Gas with only security improvements	0.1	1.2	1.3	1
3. Liquid Conversion with Outside supplier	0.2	1.3	1.5	2
4. Liquid Conversion with On-site Generation	1.2	4.8	6.0	6
5. UV with Low Pressure High Output Lamps	1.2	3.1	4.3	4
6. UV with Medium Pressure High Output Lamps	1.1	3.9	5.0	5



Technology Evaluation and Screening (cont)

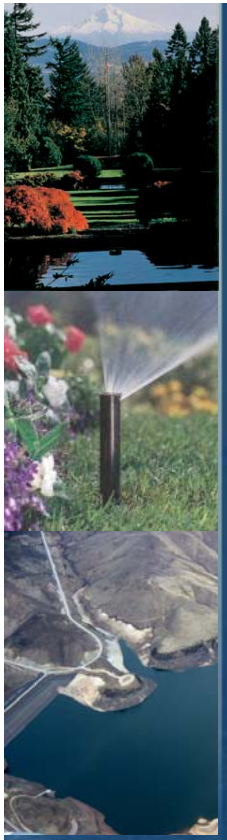
- Non-economic Comparison (example)
  - Very low risk to public
  - Public acceptance
  - Staff safety
  - Potential regulatory changes
  - Risk Management Plan
  - Operational friendly
  - System complexity
  - Constructability
  - Training requirements
  - Staffing requirements
  - Impact on existing operation





Pilot Study

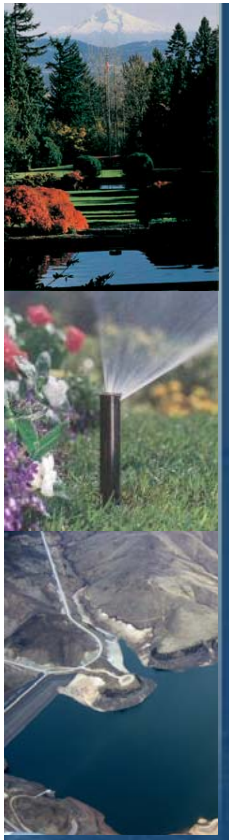
- Application is Site-Specific
  - Regulatory requirements
  - Existing treatment processes
    - Activated sludge
    - Trickling filters
    - Pond system (i.e. BioLac)
  - Secondary effluent quality
- Look at the conditions in the “Conditional approval”
- Select candidates



Detailed Analysis (example)

- Do you need pre-filter coagulation/flocculation?

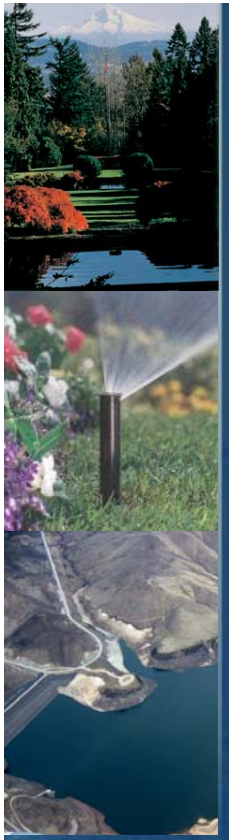
"Influent turbidity to filter not to exceed 10 NTU more than 5-percent of the time within a 24-hr. period and never exceed 15 NTU…"
- Class A Filter Acceptance



Detailed Analysis (example)

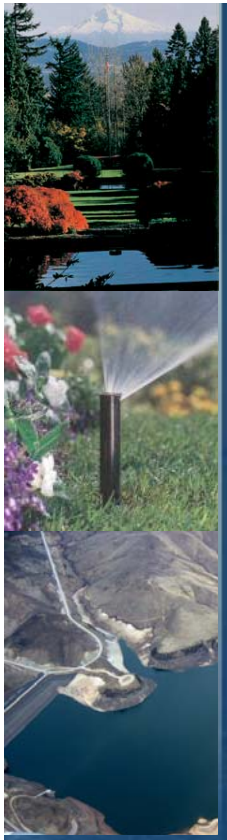
- UV Comparison

LOW PRESSURE	MEDIUM PRESSURE
More lamps	Less lamps
No continuous flow required	Continuous flow required
Low power demand (300W)	High power demand (4,000W)
No dangerous byproducts formation	Possible byproducts formation (nitrite)
Longer lamp life (12,000 hours)	Shorter lamp life (5,000 hours)
Low operating temperature (180°C)	High operating temperature (800 °C)
Low fouling potential	High fouling potential
Higher efficiency (40%)	Lower efficiency (15%)
Low annual power consumption (30%)	High annual power consumption (100%)
Lower cost lamps and sleeves	Higher cost lamps and sleeves
Easy lamp replacement	Complex lamp replacement
No cool down before restart	Fifteen minutes cool down required before restart



Procurement or Competitively Bid

- No two technologies are “equal”
- Pre-purchase
  - Develop RFP
  - In-depth evaluation of proposals
  - Select the technology you want
- Competitively Bid
  - Develop multiple designs
  - Develop performance based specification
  - Develop alternative specifications



For Your Leisure Reading

- Class A Filtration Technology Acceptance
  - by Idaho Department of Environmental Quality
  - http://www.deq.idaho.gov/water/permits_forms/permitting/ww_filtration_technology_acceptance.cfm
- Treatment Technology Report for Recycled Water
  - by California Department of Health Services
  - "Living" document http://www.dhs.ca.gov/ps/ddwem/
- UV Disinfection Guidelines for Drinking Water and Water Reuse
  - by National Water Research Institute (NWRI)

Wastewater Reuse Treatment Technologies

June Leng
916-817-4953
jleng@hdrinc.com

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