How Old Are Your Lamps: Cost Effectively Upgrading Your UV System

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Presentation Overview

- UV Disinfection Overview
- Low Pressure, High Output UV Systems
- Case Study: Butler County UV Replacement

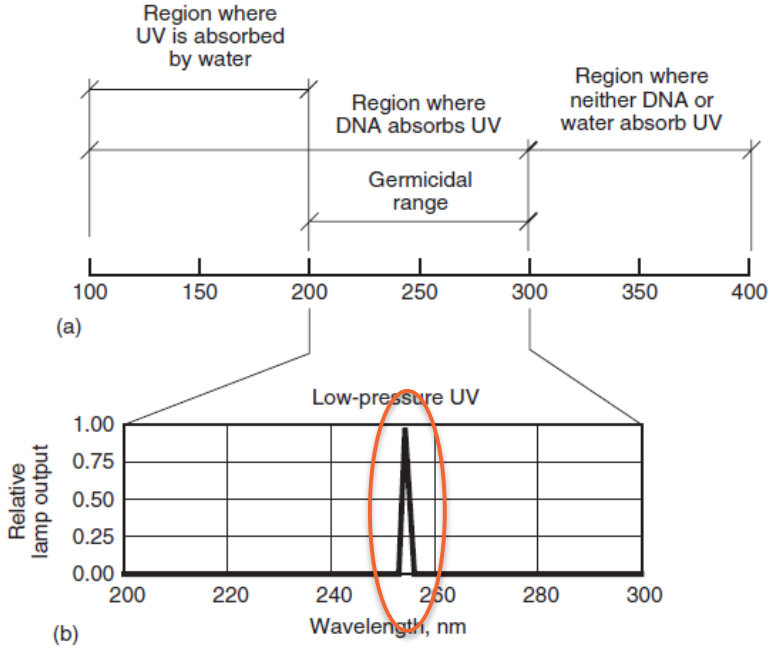
UV Disinfection Overview

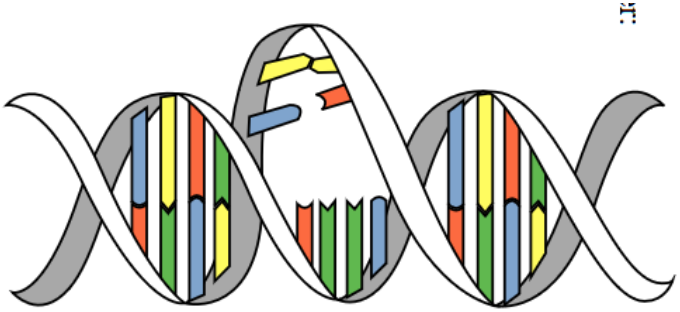
Why Consider UV Disinfection?

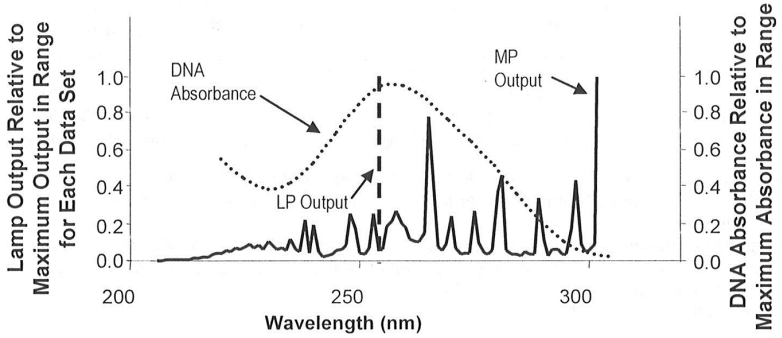
- May have lower cost
  - Capital costs
  - Annual costs
- Predictable annual costs
- Reduce use of chemicals
- Eliminate dechlorination
- Fast acting, small footprint
- May fit in existing chlorine contact tank

UV Fundamentals – UV Inactivation

- Ultraviolet light is electromagnetic radiation with a wavelength from 10 to 400 nm
  - Germicidal 200-300 nm
  - Low Pressure Lamps: 254 nm
- Direct damage to cellular nucleic acids
- Does not kill microorganisms
  - Prevents accurate DNA synthasis

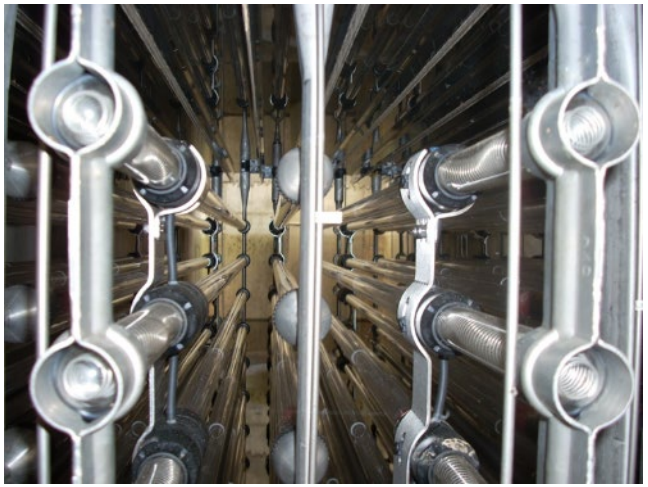






UV Disinfection – Common Terms

- UV Transmittance
- UV Intensity
- UV Dose
  - Theoretical
  - Point Source Summation
  - Reduction Equivalent Dose
  - Sensitivity Based Reduction Equivalent Dose
- Collimated Beam Test

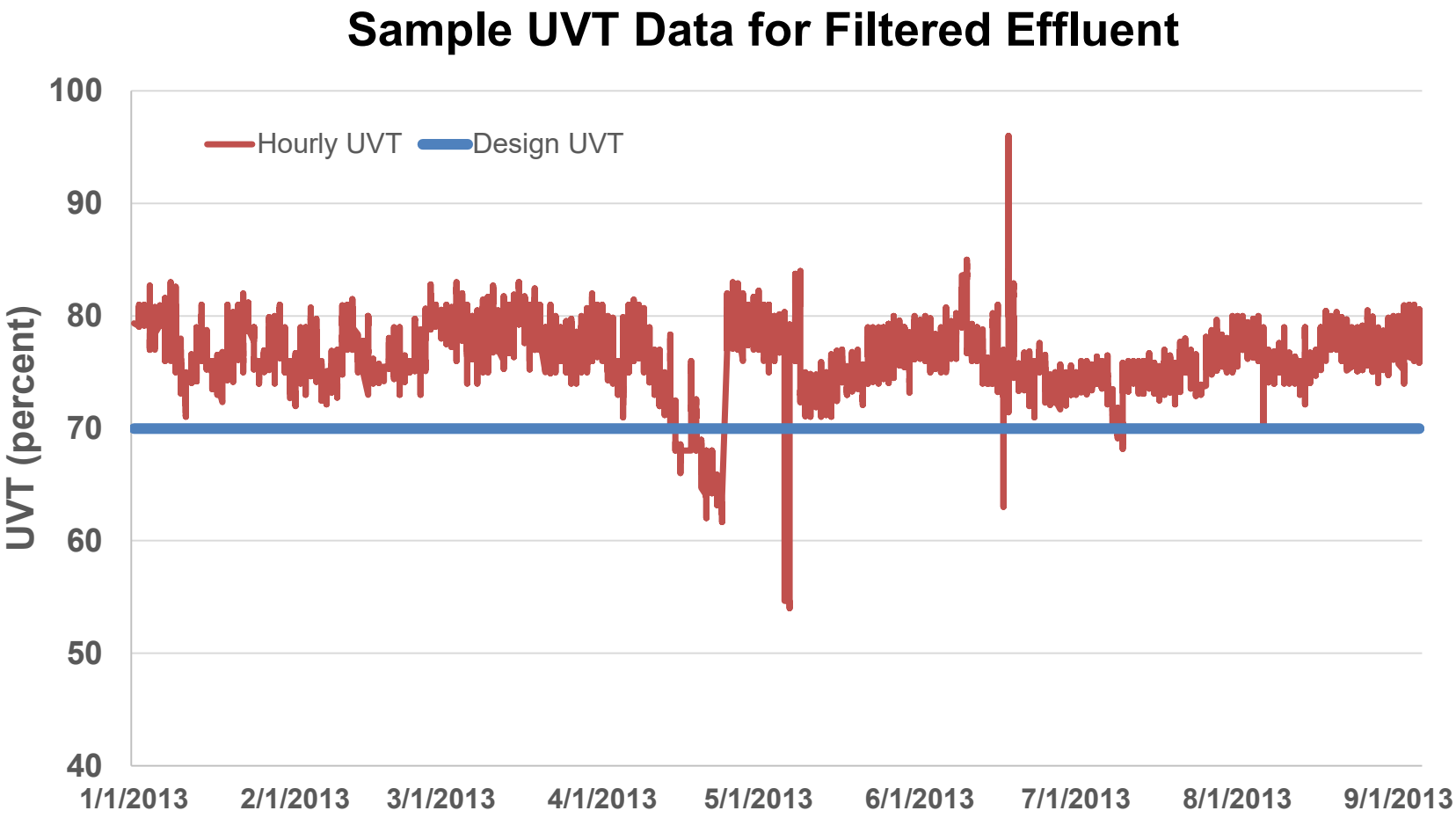


Common Terms – UV Transmittance (UVT)

- Percent of UV light at 254 nm that passes through 1 cm of water
- Deionized water = 100% UVT
- UVT has huge effect on size, kW of UV systems
- UVT 65% typical for wastewater, but not always
- Percent of UV light drops for every cm of pathlength – further from lamp, less UV exposure

1 cm	2 cm	3 cm	4 cm	5 cm
65%	42%	27%	18%	12%

UVT Varies: Domestic vs Industrial, Upstream Processes, Wet Weather, Seasons



Common Terms – UV Intensity (UVI)

- UV Intensity is UV energy in mW/cm^2 at a UV sensor at a point in a UV system
- UVT vs. UVI
  - UVT is a property of the water, independent of equipment
  - UVI is affected by lamp power, location, aging and fouling…and UVT
- UVI may be used for dose monitoring

Common Terms – Theoretical UV Dose

- Dose = Intensity x Time
- mJ/cm2 = (mWatt /cm2) x seconds

Common Terms – Reduction Equivalent Dose (RED)

- Bioassay
  - Infer UV dose using log inactivation of test organism in full scale system, compared to dose vs log inactivation data developed in lab
  - Dose = Intensity x Time = OK in lab setting
  - MS2 coliphage most common test organism
- Test organism must be stated with any RED
  - MS2 coliphage most common test organism
  - T1 coliphage REDs – lower number
- Ten State Standards – 30 mJ/cm^2 minimum dose
  - Need to account for lamp fouling and age
  - Lower dose possible for high quality BNR, tertiary processes

Collimated Beam Test

- Allows accurate measurement of UV Dose = UV Intensity x Time
- Private lab ($1000+)
- UV manufacturers (may do for free)
- Identify lowest effluent coliform achievable
- Apply safety factors to results
  - Single sample window in time
  - Peak flow, high solids events
  - Plants want to be under permit limits, not right at them

Economic Drivers

Favors UV:

- High UVT, low TSS
- Coagulant use
- Inexpensive power
- High cost of hypo
- High dose of hypo
- Fits in existing CCT
- TRC, DBP limits

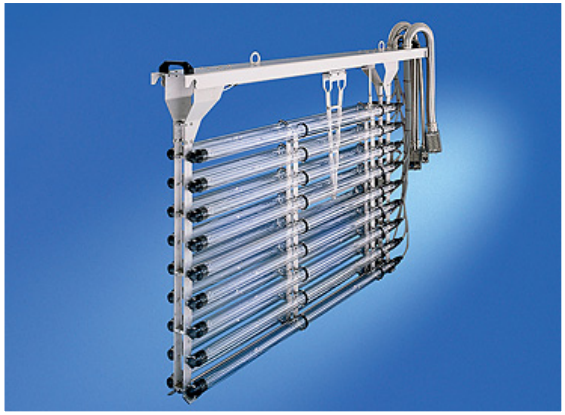
Does not favor UV:

- Low UVT, high TSS
- Dissolved iron
- High cost of power
- Low cost of hypo
- Low dose of hypo
- Low indicator limits
- High risk of floods

Low Pressure, High Output UV Systems

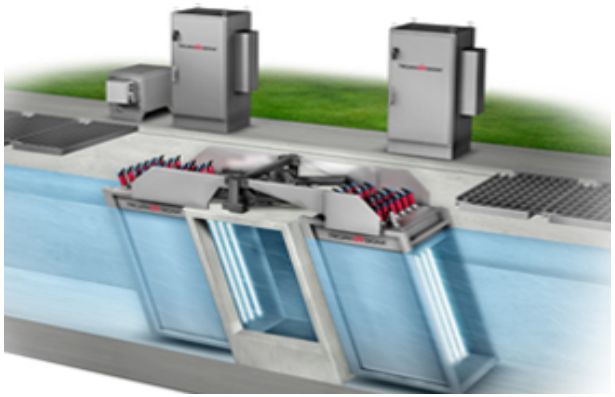
Established Products

- Low Pressure, High Output Lamps
- Horizontal lamps – Trojan UV3000plus, Wedeco TAK55
- Vertical lamps – Suez/Ozonia Aquaray 3X



Newer Products

- Inclined Low Pressure, High Output Lamp Systems
- Wedeco Duron, Trojan UVSigna
- TREND – Ballasts in panels, UV intensity in dose monitor
- TREND – Integrated lifting devices
- TREND – Fewer lamps per bank



Typical Maintenance Tasks

Primary maintenance activities:

- Lamp replacement
- UVT sensor cleaning and checks
- UVI sensor cleaning and checks
- Quartz sleeve cleaning
- Cleaning agents and wiper replacement

TREND:

Annual service agreements

UV Manufacturer/System Comparison

Item	Trojan Technologies UV3000Plus	Trojan Technologies UVSigna	Suez/ Ozonia Aquaray 3X	Xylem/ Wedeco TAK55HP	Xylem/ Wedeco Duron	Calgon Carbon C^{3}500D
Lamp Orientation	Horizontal	Inclined Vertical	Vertical	Horizontal	Inclined Vertical	Horizontal
Nominal Water Depth at UV Lamps	24''-34''	63'' (2-Row) 87'' (4-Row)	61''	24''-47''	42''	24''-48''
Power / Lamp (W)	250	1000	400	360	660	575
Ballast Location	Integral to Module	In Ballast Cabinets	In Ballast Cabinets	In Ballast Cabinets	In Ballast Cabinets	In Ballast Cabinets
Automated Cleaning	O-ring Wipers with Chemical Gel Between	O-ring Wipers with Chemical Gel Between	Teflon Ring Wiper	Teflon Ring Wiper	Teflon/Viton Ring Wiper	Stainless Steel Wire Ring Wiper
Variable Power	60–100%	30–100%	60–100%	50–100%	50–100%	60–100%
Wiper Driver	Hydraulic	Hydraulic	Electric	Pneumatic	Electric or Pneumatic	Electric
Removal from Channel	Overhead Hoist	Automatic Lift	Overhead Hoist	Overhead Hoist	Integral Lift	Overhead Hoist
Guaranteed Lamp Life (hrs)	12,000 (prorated after 9,000 hrs)	15,000	14,000	14,000 (prorated after 9,000 hrs)	14,000 (prorated after 9,000 hrs)	16,000 (prorated after 10,000 hrs)
Guaranteed Ballast Life (yrs)	5 (prorated after 1yr)	10 (prorated after 2yrs)	5 (prorated after 1yr)	5 (prorated after 1yr)	5 (prorated after 1yr)	10 (prorated after 2yrs)

Case Study: Butler County

Project Background

- Upper Mill Creek WRF (UMC)
  - 16 MGD rated capacity
  - 9.1 MGD average, 40 MGD peak
- LeSourdsville WRF (LES)
  - 15 MGD rated capacity
  - 8.5 MGD average, 35 MGD peak
- UV3000 systems by Trojan Technologies Inc.
  - Low pressure, high output lamps
  - UMC – 1992 & 1999
  - LES – 1994

Past Issues / Concerns

- Automatic cleaning of lamps
- Removal of lamps, modules, and banks
- Ballast location (flooding)
- Turndown capabilities
- Reliable control system

Item	LES WRF	UMC WRF
Number of Channels	3	4
Number of Banks per Channel	2	2
Total Number of Lamps	1056	1408
Channel Width	72”	66”
Nominal Water Depth	24”	24”

Design Considerations

Ease of operations and maintenance

Flexibility and energy efficiency

Current and future NPDES permit compliance

Updated controls and automation

Design Considerations (cont'd)

- Horizontal vs. Vertical vs. Inclined
- Lift mechanism
- Ballast location
- Cleaning mechanism
- PLC and SCADA connection
- Plant hydraulics/modifications to channels
- Future capacity
- Manufacturer experience / service
- Installation lists
- Site visits

System Alternatives

TrojanUV3000Plus – Horizontal

Wedeco TAK55 – Horizontal

Calgon Carbon C3500D – Horizontal

Wedeco Duron – Inclined

TrojanUVSigna – Vertical

Suez/Ozonia Aquaray 3X – Vertical




System Alternatives Eliminated (Channel Depth)

TrojanUV3000Plus – Horizontal

Wedeco TAK55 – Horizontal

Calgon Carbon C3500D – Horizontal

Wedeco Duron – Inclined

~~TrojanUVSigna – Vertical~~

~~Suez/Ozonia Aquaray 3X – Vertical~~




System Alternatives Eliminated (Site Visits)

TrojanUV3000Plus – Horizontal

~~Wedeco TAK55 – Horizontal~~

~~Calgon Carbon C3500D – Horizontal~~

Wedeco Duron – Inclined

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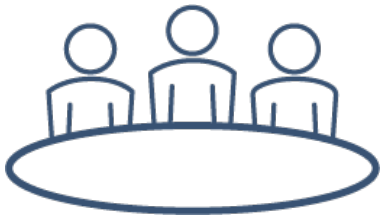


Design Approach

LeSourdsville and Upper Mill Creek WRFs

- Analyze hydraulics at each plant
- Collect UVT and E. coli data at each plant
- Site visits
- Develop design criteria and sent to manufacturers
  - "Apples to apples" proposal comparison
- Pre-select UV Equipment
  - Cost proposal
  - Number of channels, lamps and ballasts required
  - Power consumed at average and peak flow
  - Guaranteed life of replacement parts
  - Replacement part cost

} Used to determine life cycle cost

Pre-Selection Benefits

- Pre-selection is not pre-purchase
- Open competitive bid for UV equipment package
- Life cycle cost evaluated – guaranteed power use
- Guaranteed prices for replacement lamps, parts
- Non-cost factors can be considered:
  - Vendor experience and customer satisfaction
  - Service team location and availability
  - Equipment unique features
  - Head loss differences
- Expandability

Data Needed for Vendor Quote

- Key Parameters
  - Peak flow
  - Minimum UV Transmittance
  - Design UV Dose (MS2 bioassay based)
  - Indicator organism permit limits
- Additional Data
  - Redundant banks or channel required
  - Minimum number of banks in series
  - Upstream processes (SBR, BNR, Filters) and chemicals
- Project-specific specification as early as possible

Design Criteria

LeSourdsville and Upper Mill Creek WRFs

- 10 State Standards
- National Water Research Institute (NWRI)
- Peak Flow Rate
- Effluent TSS – 30 mg/L
- 2 banks per channel
- Reduction Equivalent Dose – 30 mJ/cm2 based on MS2 bioassay validation
- UV Transmittance (UVT) – 65%

Trojan UV 3000Plus

- Horizontal
- Fit is existing water depth
- Ballasts on top of module in channel (but can be extended)
- Extensive installation list; serviced well by HPT
- Chemical cleaning system concerns
- Need separate lifting system
- Extra cost for rack to lift entire bank
- Requires 2 channels at both plants

Wedeco Duron

- Vertical/Inclined
- Modifications required to deepen and narrow channels
- Ballasts in panels away from channel
- Gaining experience/installation list; good references; serviced by Wedeco from North Carolina
- Mechanical only cleaning
- Unit lifts lamps out of channel (equipment in channel for lift)
- Requires 3 channels at both plants

Non-Economic Factors

- Ease of operation and maintenance
  - Location of ballast
  - Automatic cleaning of lamps
  - Removal and cleaning of lamps
  - Seasonal storage of lamps
- Staff familiarity
- Constructability
- Reliability

Economic Considerations

- Construction costs (up-front)
  - Equipment cost
  - Modifications to accommodate new equipment
    - Structural and Electrical for Wedeco
- Operations and maintenance costs (annual)
  - Electrical
  - Lamp and ballast replacement
  - Maintenance and operations
  - Lamp cleaning chemical

Construction Cost Comparison

Item	Trojan UV3000Plus	Wedeco Duron
UV equipment cost		+$184,000
Outdoor ballast panel cost		+$132,000
Structural channel mods		+$150,000
Electrical cost		+$100,000
Instrumentation cost		-
UV channel roof covering and monorail improvements		-
Cost difference		**+$566,000**

Note: Trojan UV3000Plus deduct for cleaning system $194,200, but more lamps required to account for lower fouling factor

Annual O&M Cost Comparison

Item	Trojan UV3000Plus	Wedeco Duron
Electrical demand	$0	$6,500
Maintenance materials cost	$6,200	$0
Labor costs		
Chemical costs	$200	$0

Notes:
1.Electrical demand saving estimated at $15,000 per year over existing systems.
2. Wedeco must save nearly $50,000 a year to cover up-front cost difference.

Non-Economic Comparison

Item	Trojan UV3000Plus	Wedeco Duron
Ease of operation and maintenance		+
Manufacturer support	+	
Staff familiarity	+	
Constructability	+	
Reliability	+	+

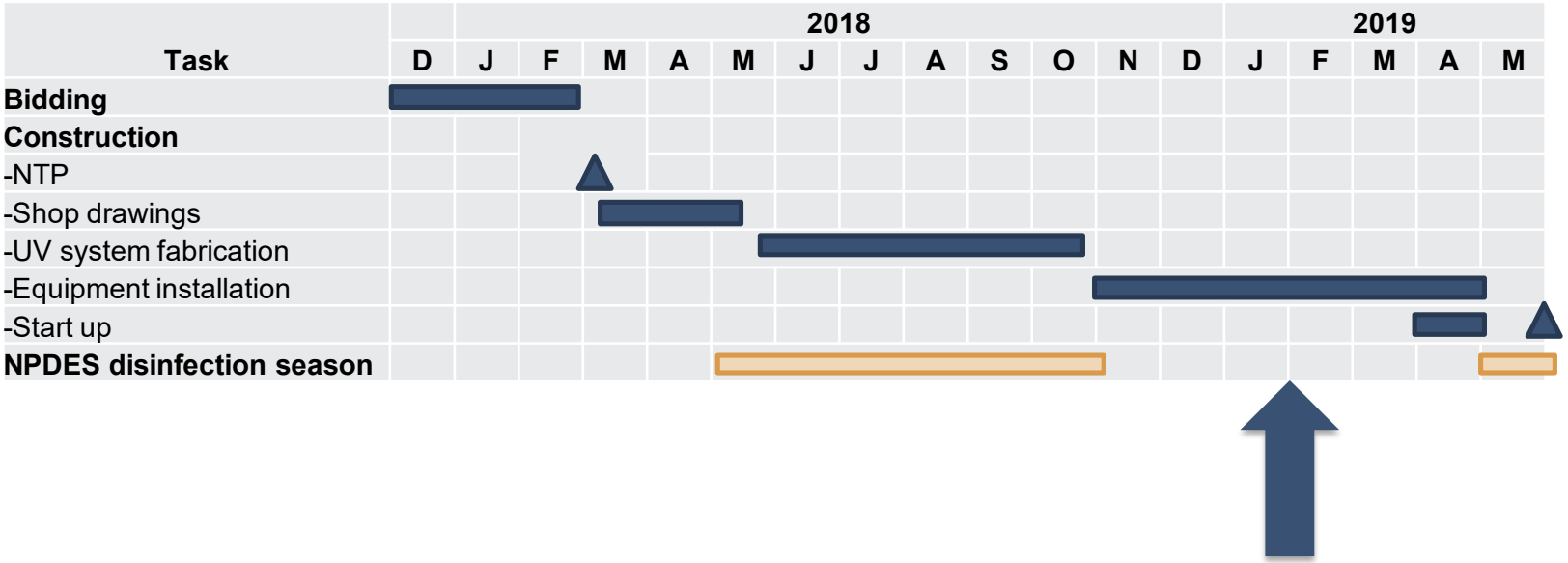
Pre-Selection

- Trojan UV3000Plus selected
  - Economic Factors
  - Non-economic Factors
- New system has many upgrades over existing system – many past issues addressed
  - Less lamps
  - Automatic cleaning
  - Variable power
  - Improved controls

Pre-Negotiation

- Prices from competitively bid projects of similar size
- Guaranteed power usage
- Guaranteed lamp and ballast life
- Guaranteed spare parts cost for 20 years
- Compare prices to past design projects
- Spare parts / cost adders

Construction Considerations



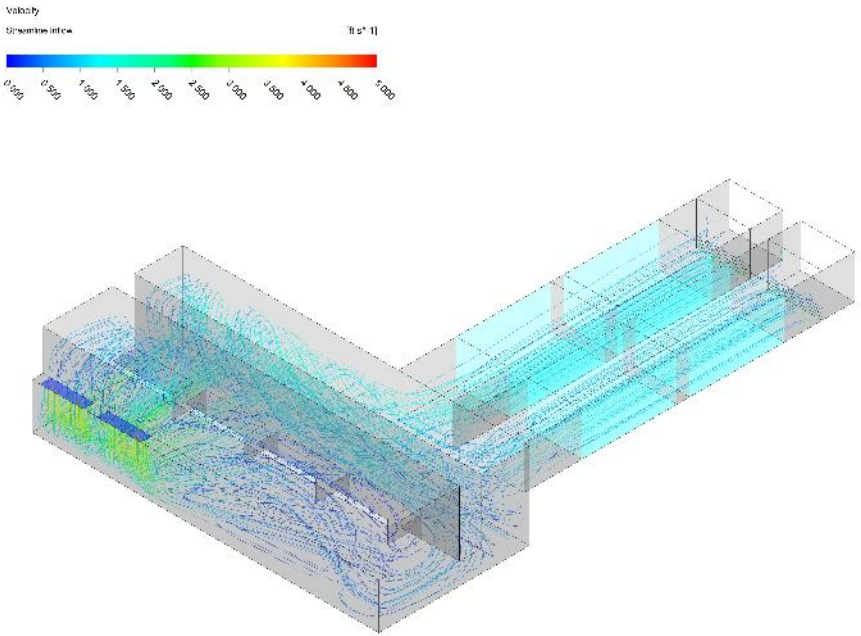
Construction during non-disinfection season

Construction Discoveries

- UMC Flow Splitting
  - Baffle wall openings across from effluent pumps to dampen velocity

Construction Discoveries

- UMC Flow Splitting
  - Pumps further from channels operating – flow did not split evenly between channels
  - Blocked far baffle wall opening for better flow distribution



Construction Discoveries

- Higher channel velocity, higher turbulence
  - UV bank rack caused turbulence at high flow
  - UV system turning off
  - Relocated low water level rods
- Automatic Level Controller Gates
  - Client preferred over modulating weir gate
  - Weights used to adjust gate to regulate flow
  - Higher range of flow with new systems
  - During high flows, don’t regulate flow as well

Conclusion

- Many factors to consider with UV system
  - Plant-specific considerations for cost effectiveness
- No two UV systems are the same
  - Operator input needed for configuration and feature preferences
  - New construction vs. retrofit may favor one system over the other
- Work with manufacturers early
  - Uniform design criteria
  - Project-specific specification

Questions

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