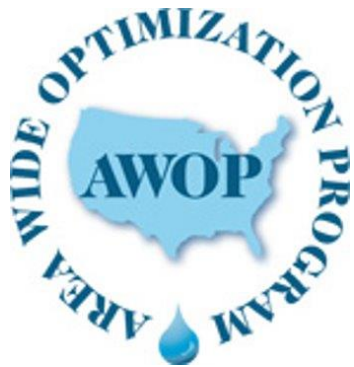**Washington State Department of HEALTH**

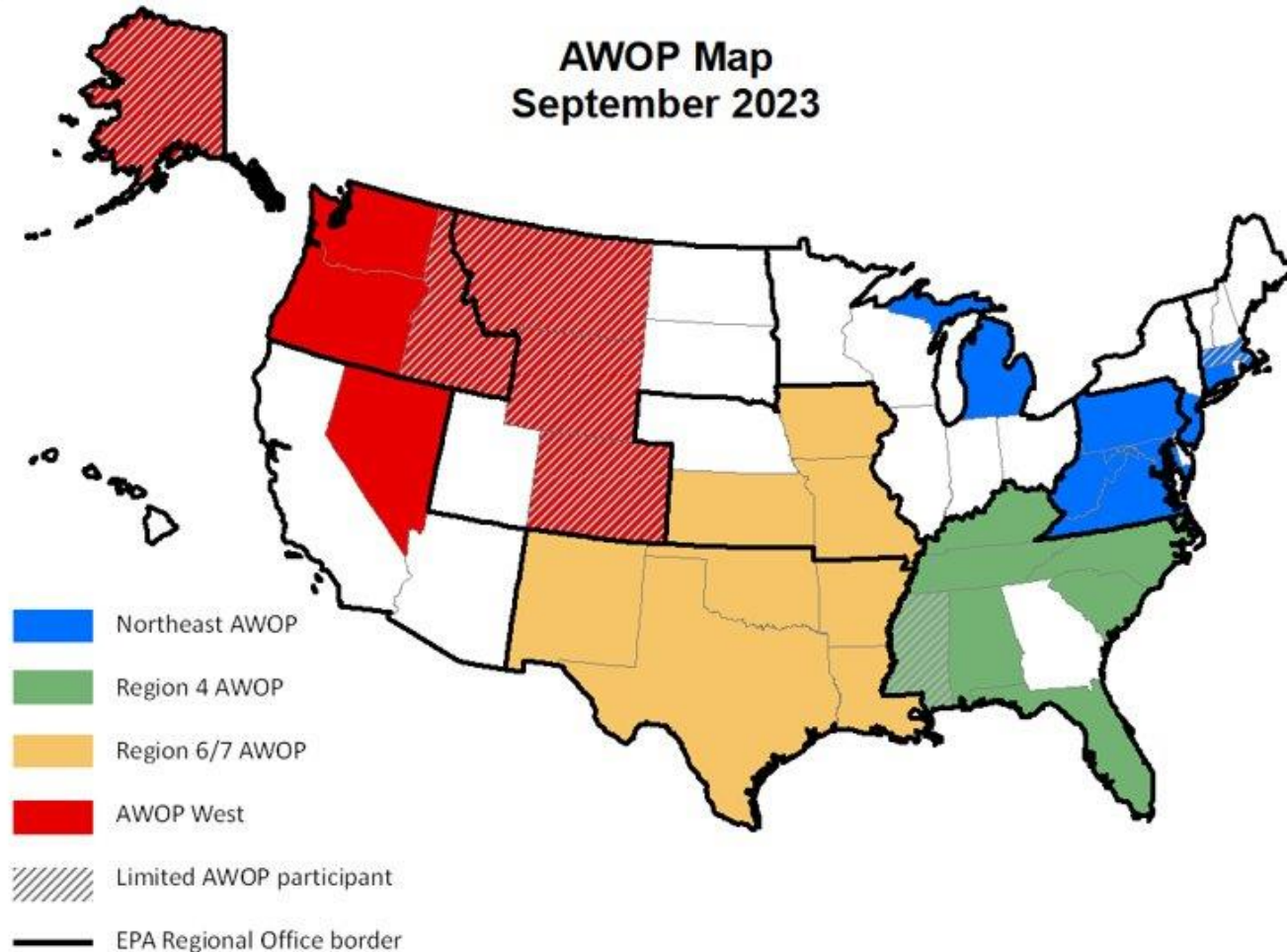# MEMBRANE DATA INTEGRITY PNWS-AWWA 2024 CONFERENCE

Jolyn Leslie, PE
Engineering & Technical Services
Office of Drinking Water

Enhance public health protection through optimizing the performance and operations of existing facilities

AWOP Map
September 2023

Northeast AWOP

Region 4 AWOP

Region 6/7 AWOP

AWOP West

Limited AWOP participant

EPA Regional Office border

What is Data Integrity?

- Maintaining and ensuring accuracy and consistency of data from sample collection point until the data is used.
  - Instrument maintenance and calibration
  - Hardware/moving parts
  - Human factor

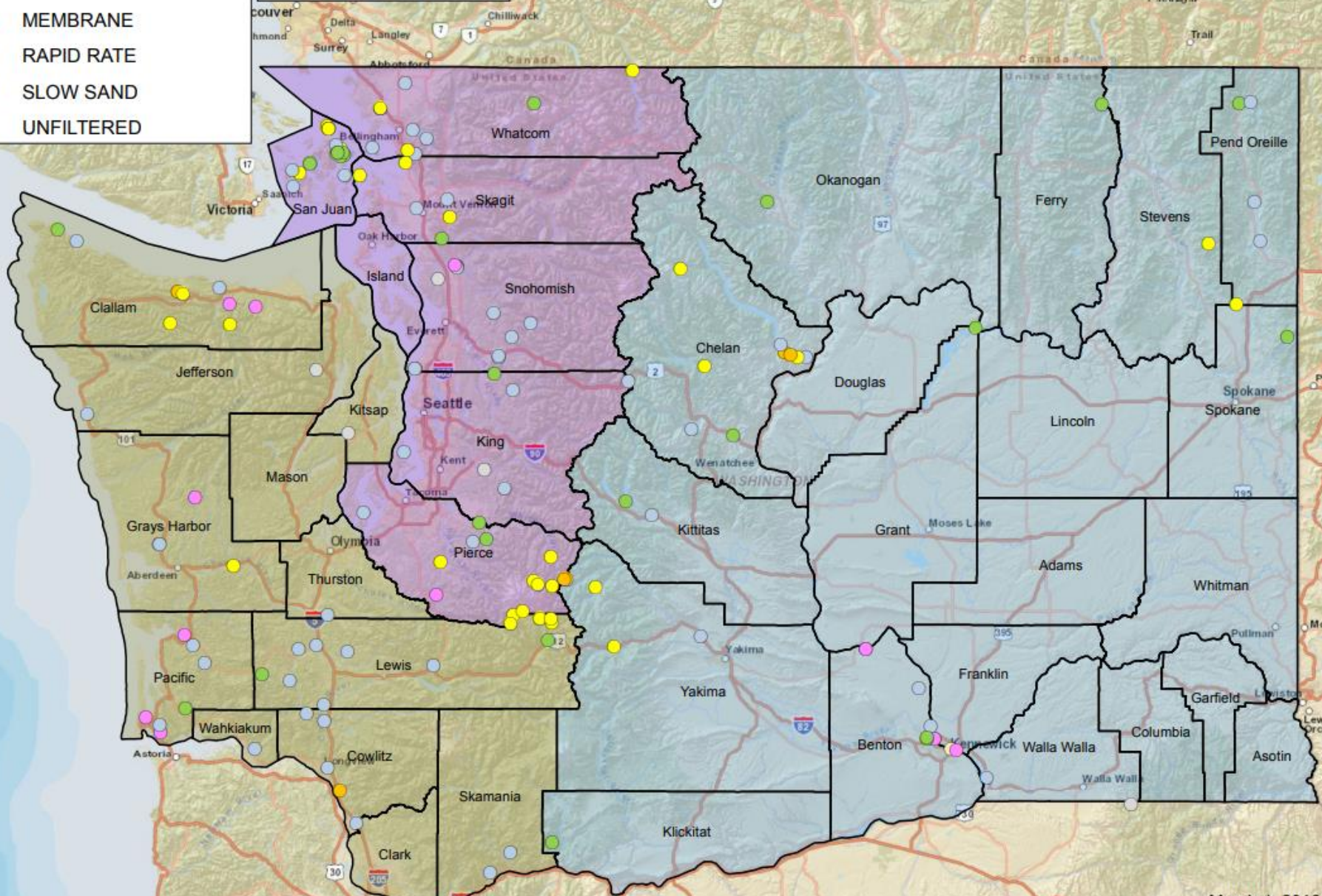# 134 Surface Water Treatment Plants

Bank Filtration, 2
Unfiltered, 4
DE, 5
Membrane, 15
Slow Sand, 18
Bag, 35
Rapid Rate, 55

Drinking Water Treatment Plants
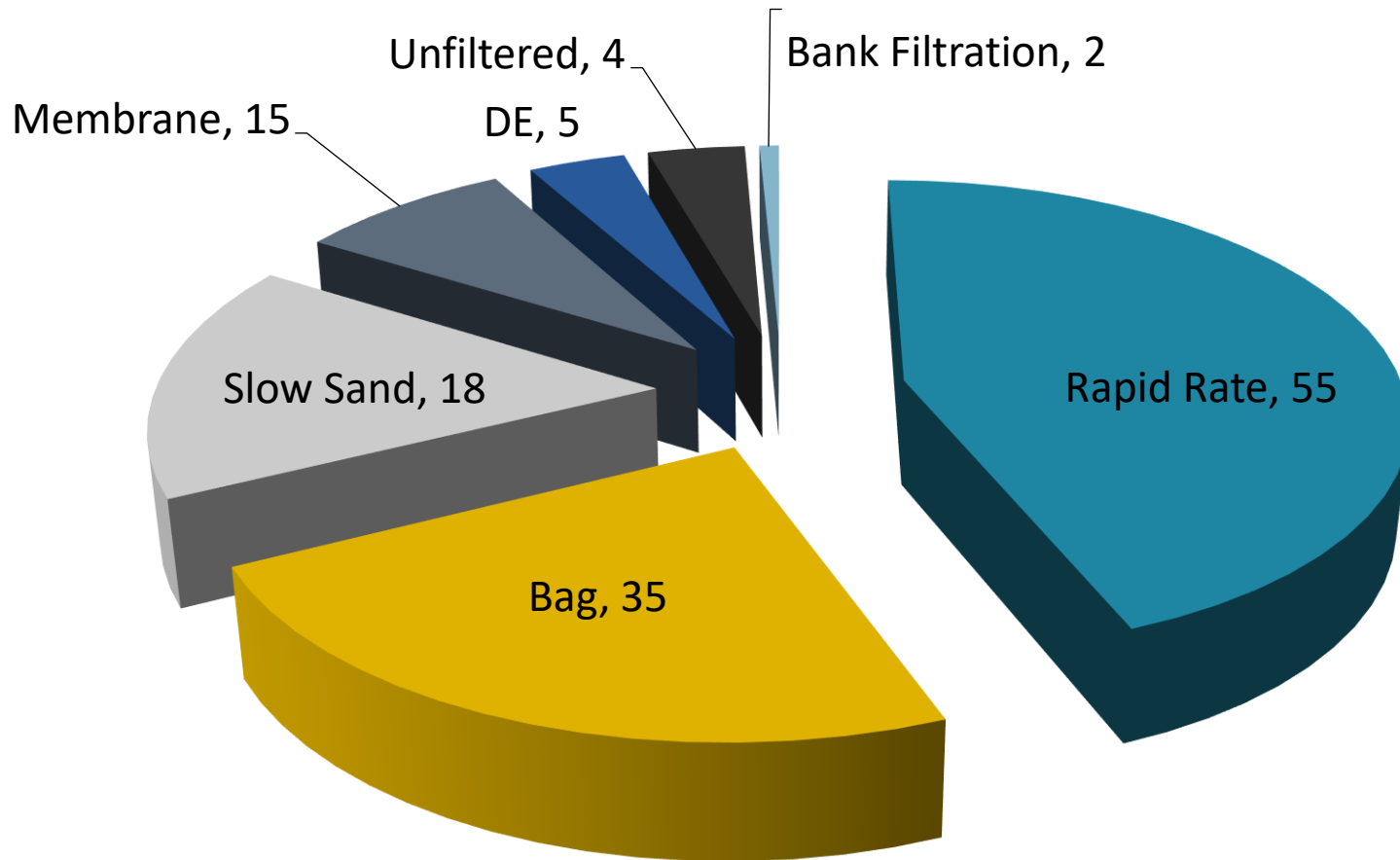
Filtration Technology
- ● BAG/CARTRIDGE
- ● BANK FILTRATION
- ● DIATOMACEOUS EARTH
- ● MEMBRANE
- ● RAPID RATE
- ● SLOW SAND
- ● UNFILTERED

Drinking Water Region
- EA
- NW
- SW

March 4, 2016

Data Integrity in Washington State

1 **2012-2013**
- Turbidity
- 25 rapid rate filtration plants

2 **2014-1015**
- Disinfection
- 33 surface water treatment plants

3 **2019-2024**
- Membrane
- 8 of 15 membrane plants (so far)

Membrane LRV – Data Integrity Project Goals

- Verify plant operating within approved design parameters
- Confirm reporting representative of actual operation
- Confirm MOR current and reflects design approval limits
- Learn about/gain comfort with LRV
  - Attempt to verify number reported in SCADA (if applicable)
- Identify needed improvements in our program/internal staff training opportunities

Alternative Filtration Technology Approval

- Established for each make/model
  - Pathogen removal credit
  - Operating Parameters
  - See alternative technology approval memo

Parameter	Value
Maximum Transmembrane Pressure	45 psi
Maximum Flux Rate	100 gal/ft^2·day
Quality Control Release Value	0.070 psi/min
Turbidity performance requirement[1] WAC 246-290-660 (1)(a)(i) and (iv)	≤ 0.10 NTU 95% of the time[2] Never Exceed 1.0 NTU in any measurement
Direct Integrity Testing Requirement	Daily[3]
Minimum Initial Test Pressure	13.6 psi
Indirect Integrity Monitoring Threshold	Applied to each membrane unit Particle Counts[4] – 30 counts/mL; or Turbidity[5] – 50 mNTU
Automatic Shutdown of Membrane Unit[6]	Calculated Log Removal Value (LRV)[7] <3.0 or Pressure Decay Test >UCL

Current raw water turbidity = ___ NTU. Current raw water temperature= ___ °C

Operating data (from SCADA) date/time:

Filter Train:	Flowrate (gpm)	Flux (gfd)*	TMP (psi)	LRV-displayed	LRV-calculated**	IFE (NTU)	Specific flux / permeability (flux/TMP)
Train 1-Cell A				NR			
Train 1-Cell B							
Train 2-Cell A				NR			
Train 2-Cell B							
Approval limits	per skid	≤100	≤ 12 (vac)	3.0	3.0	50 mNTU	

*calculated from ___ gpm x 1440 min/day)/(6500 sf/module x 3 modules)-not temperature-corrected
** from most recent PDT data (see below). Using turbulent flow assumption.

Indirect integrity monitoring (make/model, PDT trigger): Hach Filtertrak 660, 50 mNTU for ≥15 min.
Alarms:

Direct integrity testing/Pressure decay test (PDT): Also called membrane integrity test (MIT). 4.8 psi min test pressure, 10 min hold time. At least daily and when triggered by indirect integrity monitoring. Each cell tested independently. Air applied to permeate/filtrate side of the membrane.
Alarms:

Most recent PDT data:

Filter Train:	Date/Time PDT	Start (psi)	End (psi)	Decay (psi/min)
Train 1-Cell A				
Train 1-Cell B				
Train 2-Cell A				
Train 2-Cell B				
Approval limits		≥4.8	≥4.8	≤0.1 psi/min***

V_{sys} (measured):

Calibration/Verification:
    Pressure sensors:

    Turbidimeters:

Turbidimeter settings*		Signal span (NTU)	Error Hold Mode	Comments
Raw	Hach FT660-SC200			
IFE #1	same			
IFE #2	Same			
CFE**	same			

Washingto

Data to collect:

1. Operational data

2. IFE turb models, settings, maintenance

3. Direct integrity test data, most recent test ea skid

4. Observe direct integrity test

5. Pressure sensor, flow meter calibration/verification

6. Measurements for Vsys

7. Measurements for back pressure (BP)

8. Alarm setpoints

Memcor/Axia with Evoqua/Siemens S10N

- Memcor/Axia with Evoqua/Siemens S10N membrane modules

- Submerged system, recently upgraded modules from S10V to S10N

- Two skids (recently added third)

- 48 modules each skid

- DIT/PDT – air applied to filtrate side, daily

- Indirect integrity monitoring (PC on one train, FT660 on other)

Findings

Filter Train:	Flowrate (gpm)	Flux (gfd)	TMP (psi)	LRV$_{displayed}$	LRV$_{calc}$**	IFE	Specific flux/permeability (flux/TMP)
Filter #1	225	22.48	4.24	5.60	4.97	11.5 mNTU	5.3
Filter #2	226	27.19	4.78	5.36	4.92	Displays 00	5.7
Approval limits	400	≤ 80	≤ 22	3.0	3.0	50 mNTU/30 counts/mL	

** from most recent PDT data, using laminar flow assumption

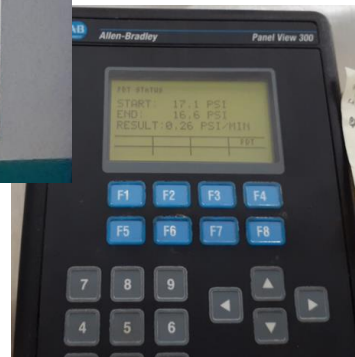| Filter Train:	Date/Time PDT	Start (psi)	End (psi)	Decay (psi/min)
Filter #1	Did not record	18.8	18.4	0.19
Filter #2	11/21/19 9:41 PM	17.1	16.6	0.26
	Approval limits:	≥14.0		≤0.39

Findings

1. Outdated MOR: no starting test pressure, old (S10V) approval limits

2. Pressure transducers never verified/calibrated* since installation (2006)

3. Particle counter sending 4mA (flatline) signal to SCADA for 10 months-our monthly review didn't catch.

4. Operator didn't know how to find the starting/ending pressure of the last PDT. Neither did we.

5. UCL (0.39 psi/min) based on fouled membrane, permeability, 0.5 gfd. Historical plant data show 4.5 to 6.1 gfd

Pall Microza UNA 620A

Calibrated Annually

- Pall Microza AP-6, UNA 620A.
- Two skids, each skid has 42 modules arranged in 4 rows (10 + 11 + 11 + 10)
- Stubs for an additional 12 modules per skid.

- Filtrate flow (white arrows)
- Four filtrate headers above with common manifold
- Plant installed 2011; module replacement 2020.

Air manifold

"XR" piping

Feed lines

Findings

Make/model: Pall Microza (AP-6, UNA 620A). Two trains, 42 modules each.

Operating data (from SCADA)

Filter Train:	Flowrate (gpm)	Flux (gfd)*	TMP (psi)	LRV-displayed	LRV-calculated**	IFE (NTU)	Specific flux / permeability (flux/TMP)
Skid A-10:51 am	200	12.75	6.6	4.2	4.3	0.013	2.6
Skid B-12.45 pm	200	12.75	6.6	4.1	4.2	Not recorded	Not recorded
Approval limits	520 per skid	≤ 120	≤ 43.5	3.0	3.0	50 mNTU	

**from most recent PDT data, turbulent flow assumption

Most recent PDT data:

Filter Train:	Date/Time PDT	Start (psi)	End (psi)	Decay (psi/min)	Water temp (C)	Flowrate*** (gpm)	TMP*** (psi)
Skid A	1/6/2020 1:00 am	29.83	29.67	0.032	7.6	200	6.4
Skid B	1/6/2020 12:00 am	29.44	29.25	0.038	7.6	200	7.1
Approval limits		≥25.0		≤0.33		520	43.5

Findings

1. PDT injects air on the feed side. We measured the filtrate side piping. Not able to verify manufacturer's Vsys, but we used it for LRV calculation.

2. PDT has five-minute hold. On MOR utility reporting <u>total pressure drop</u>, instead of psi/min.

   PDT reported: ~0.2 psi/min
   Actual PDT: ~0.04 psi/min
   UCL (max PDT): 0.33 psi/min

3. TU5300 on IFE. Should be TU5400 (double the cost) or Lovibond 6000.

4. CFE Turbidimeter controller (SC200) set to hold the last good reading.

Memcor CMF with Dupont/Evoqua/Siemens M10C

- 8 trains. Each train has 90 modules
- 65 MGD design flow
- Short membrane life (4-5 yrs)
- Membranes currently being replaced: skids 1-4 complete, 5-8 remaining (replacement modules on site).
- Prefiltration: 300 micron backwashable screens
- Coagulation: ACH
- Pressure transducers verified every 6 months by Dupont
- Reaching UCL, switching from UCL to LRV

Findings

1. Unable to view/verify IFE turbidity alarm setpoints
2. Raw/CFE turb controller: error mode set to hold the last good reading
3. CFE sample pumped from clearwell
4. MOR needs revision
5. LRV calculation uses min test pressure, should use ending pressure of last DIT test

Zenon/ZeeWeed 500C

- Zeeweed 500C, installed 2007
- Veolia (prev Zenon, GE, Suez)
- PVDF (Polyvinylidene fluoride)
- Hollow fiber, outside-in
- Pore size: 0.04 um nominal/0.1 um absolute (UF)
- Submerged/vacuum (open basin)
- Two trains
- Two cells/train
- Two cassettes/ cell
- 26 elements/cassette
- 250 sf/element (6500 sf/cassette)
- DIT (MIT) pressurize the filtrate (permeate) side Done on each cell. Reporting each separately
- Indirect integrity: monitoring each train, TU5400
- Membranes never replaced!

Findings

Summary Information:

Make/model: Zeeweed/Zenon 500C, installed 2007. Hollow fiber, outside-in, submerged/vacuum system. Two trains. Each train has 2 groups or cells, 3 cassettes per group (6 cassettes total). Each cassette has 26 modules, also called elements. Membrane surface area 250 sf/module = 6500 sf/cassette = 39,000 sf/train. Pre-treatment: basket strainer-1mm (1000 microns) slots. Down in a vault, not self-cleaning, must be disassembled to maintain. No coagulant used. Membranes never replaced-still performing well; replacement budgeted for 2024 based on age of component parts.

Current raw water turbidity = 0.24 NTU. Current raw water temperature= 9 °C
Very low chlorine demand. Finished water UVT = 91.9

Operating data (from SCADA) date/time:

Filter Train:	Flowrate (gpm)	Flux[1] (gfd)	TMP (psi)	LRV-displayed	LRV-calculated[3]	IFE (NTU)	Specific flux / permeability (flux/TMP)
Train 1-Group A 2/8/2023	865	31.9	-7.48 Max does not trend	NR		12	NR
Train 1-Group B 2/8/2023							
Train 2-Group A 11:50 am 2/16	790	29.1	-6.2[2]	NR	5.0	10	NR
Train 2-Group B 11:50 am 2/16							
Approval limits	per skid	≤100	≤ 12 (vac)	3.0	3.0	50 mNTU	

Findings

1. Use manufacturer's secondary standard for weekly turbidimeter verification

2. CFE turbidity limits for all membrane plants, 95th %-ile 0.1 NTU, max 1.0 NTU; recommend to change shutdown alarm to 0.1 NTU

3. Recommendations for membrane upgrade
   a) Install two-way or DBBV on permeate pressure transducer
   b) Set MIT to run on entire train
   c) Add valve on permeate/filter piping Group A to reduce pressurized volume during MIT
   d) Program SCADA to continuously calculate LRV
   e) Include flux & permeability trends in SCADA
   f) Design approval needed for new replacement membranes

Seccua Phoenix 7

- One unit, with two modules

- Inside-out

- Ultrafiltration

- 2150 fibers per module

- Indirect integrity monitoring Hach 1720E

- Did not go through prior approval by DOH, system started as a Group B (state regulated) system

Summary Information:

Make/model: Seccua Phoenix 7/Dizzer XLO.9MB60. Single train, 2 modules. Installed 2013. Surface area: 645 sf/module.

Operating data, previous day (9/11/2022, 11 am) (from SCADA)

Filter Train:	Flowrate (gpm)	Flux (gfd)	TMP (psi)	LRV$_{displayed}$	LRV$_{calc}$**	IFE	Specific flux/permeability (flux/TMP)
1	40.64	45.1	8.2	4.7		Not measured	5.5
	exceeds	o.k.	o.k			CFE 0.043	
Approval limits	40	≤ 59	≤ 36	3.0	3.0	50 mNTU/30 counts/mL	

**from PDT data on 9/12 (see below). Using laminar flow assumption.

Indirect integrity monitoring:

Hach TU5300: 0.043 NTU (measured after intermediate tank, need TU5400 or equivalent)

Direct integrity testing/Pressure decay test (PDT): 23 minute hold time

| Filter Train:	Date/Time PDT	Start (psi)	End (psi)	Decay (psi/min)	Water temp (C)	Flowrate (gpm)- see above	TMP – see above
1	9/12/2022, 3:21 pm	22.57	21.69	0.0382 (2.64 mbar/min)	20.3	40.6	8.2
		o.k		o.k			
	Approval limits:	≥21.75 (1.5 bar)		≤0.25 (17 mbar/min)		40	

Findings

1. Reporting issues on MOR
   a. Reporting flow rate rather than flux rate (gfd)
   b. Reporting design maximum TMP rather than the actual daily max
   c. Reporting normal test pressure rather than the actual minimum initial test pressure for PDT
   d. Reporting total pressure decay rather than decay rate

2. Indirect integrity monitoring – Hach 1720E is not acceptable; need to install a high resolution turbidimeter

3. System is a 'black box'
   a. Calculated PDT = 2.64 mbar/min, system reporting 5.3 mbar/min (roughly double); need to check with manufacturer and reconcile
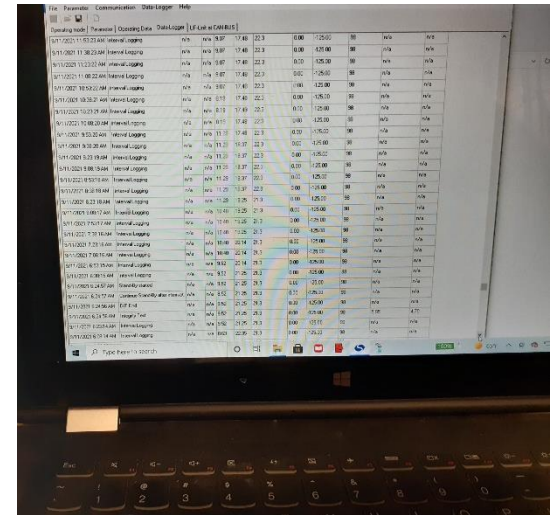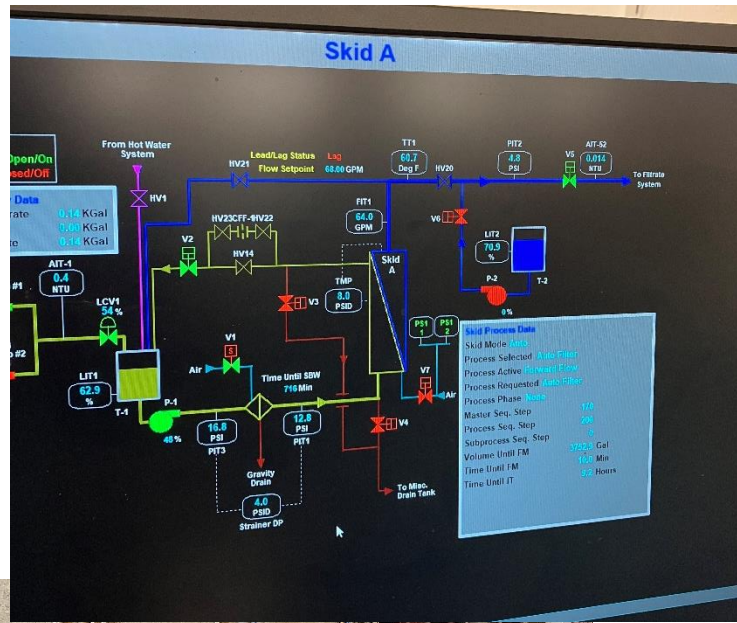
Pall Microza USV-6203

- Two trains, 6 modules each train

- FilterTrak 660 turbidimeter on each train, no CFE sample

- Installed 2009

- Prescreening with old 'package plant' and strainer

- Modules have never been replaced!

Findings

1. Pressure gauges have never been calibrated
2. Online turbidimeters are not properly recording that latest calibration date
3. Incorrect monitoring and reporting of max day NTU
4. Raw water NTU sample location should be moved to common inlet header to capture a representative sample for both skids
5. Verify with Pall and/or SCADA that 50mNTU triggers a PDT
6. Verify that failed PDT triggers alarm and shut down of the plant
7. Sample delay on CT sample point (90 minutes)
8. Strongly recommend getting the TU5200 turbidimeter to compare to the online Filtertrak 660 laser turbs
9. Online chlorine analyzer did not match grab samples within 0.05 mg/L, operator and DOH also did not match

Summary/Common Findings

- Pressure gauges need more attention

- IFE turbidimeter requirements

- Use correct parameters for pressure decay test – psi/min, not total psi change

- We need to update/improve our MORs

- Able to 'mostly' verify that plants are operating within approved design parameters

- Not always able/eady to verify LRV number reported in SCADA

- Identified needed improvements in our program/internal staff training opportunities

Next Steps

- Continue with remaining membrane plants

- Final membrane commissioning guidance for new plants

- Update monthly operating reports (MOR)

- Continue looking for more opportunities on improving data integrity

Questions?

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Engineering & Technical Services
Office of Drinking Water

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Washington State Department of **HEALTH**