Surface Water Treatment Part 3

- ❑ Advanced & intensified treatment processes
- ❑ Water Treatment Residuals Management
- ❑ Measuring & Optimizing Treatment System Performance

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What we will cover in this class:

- ❑Who is in class & types of water systems we run
- ❑Review of key stuff from Part 2 Class
- ❑ Intensified water treatment process; doing more treatment in less space and doing it faster
- ❑Managing water treatment residuals
- ❑ How to measure & optimize performance of water treatment processes taught in this class
- ❑ Fun with word problems & water treatment math

POLL: What NM Water Systems License Level do you hold?

- A. Level 1
- B. Level 2
- C. Level 3
- D. Level 4
- E. I don't; I run a wastewater system!

POLL: How many people does your system serve?

- A. < 500
- B. 500 – 3,000
- C. 3,001 – 10,000
- D. 10,001 – 50,000
- E. > 50,000

POLL: What is the class preference for working quiz questions and math problems? *(majority vote will rule!)*

- A. Individually
- B. Operator teams made of folks from same utility
- C. Teams made of the 3-5 persons closest to you

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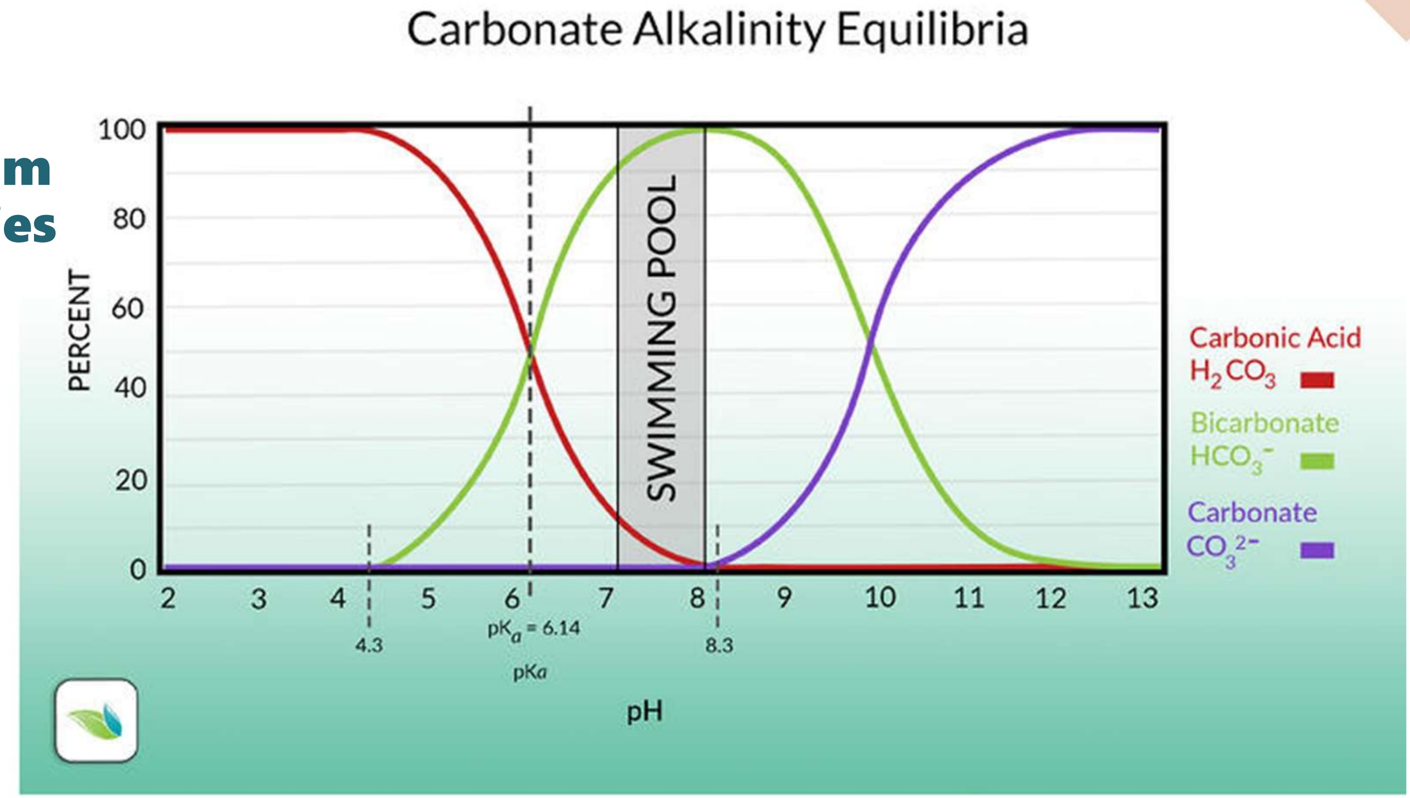
Types of Water Treatment Processes

- Why do we care about this? Pick the right tool to get rid of things we don't want in our water to keep it safe!
- Pre-sedimentation: A cheap way to remove surface water sands and silt
- Degasifying / aeration
  - Often seen in groundwater treatment with waters having odor issues or w/slightly acidic pH
  - Cheap way to strip dissolved gases like H_2S and CO_2; Stripping the CO_2 means less alkalinity
- Rapid mixing, coagulation, & flocculation
  - Series of sequential steps to add the RIGHT chemicals to de-stabilize colloidal suspensions & form precipitates that settle
- Sedimentation; settle out the formed flocs; you can't beat gravity (most of the time)
- Softening processes for hard water (easier *IF* enough carbonate alkalinity is present)

The carbonate alkalinity system

- **Useful chart for alkalinity equilibrium *or* which ionic species predominates in which pH range…**



Graph courtesy of Orenda Technologies

Types of Water Treatment Processes

- Filtration; get rid of any leftover particles to achieve SDWA turbidity standards; Ways to filter include:
  - Granular media filtration after sedimentation; pretty standard
  - Direct filtration for clean raw waters w/average turbidity < 10 NTU
    - Coagulation goal for direct filtration: create a pin floc
  - Membrane filtration (ultrafiltration) for really clean raw waters
    - Why try to make lots of floc if the water is already pretty clear?
    - Great way to remove Giardia & Cryptosporidium cysts (if present)
  - Other variations of filtration
    - Manganese greensand media for iron and manganese removal
    - After a lime softening process
- Disinfection to kill any leftover pathogens

Conventional trt scheme for "turbid" water

- Treatment goals: remove settleable & suspended sediments and pathogens in raw water
- How?

1. Start with a BIG pond to store diverted water; remove settleables
2. Add chemicals to destabilize suspended colloidal solids so they stick together & settle: Use rapid mixing, coagulation, and flocculation to get something that will gravity settle
3. Gravity settle the flocs; Target clarity is 2-4 NTU for settled water
4. Filter out remaining solids to achieve ≤ 0.3 NTU for filtered water turbidity in 95% of all filter cell turbidity readings
5. Disinfect the water to kill remaining pathogens

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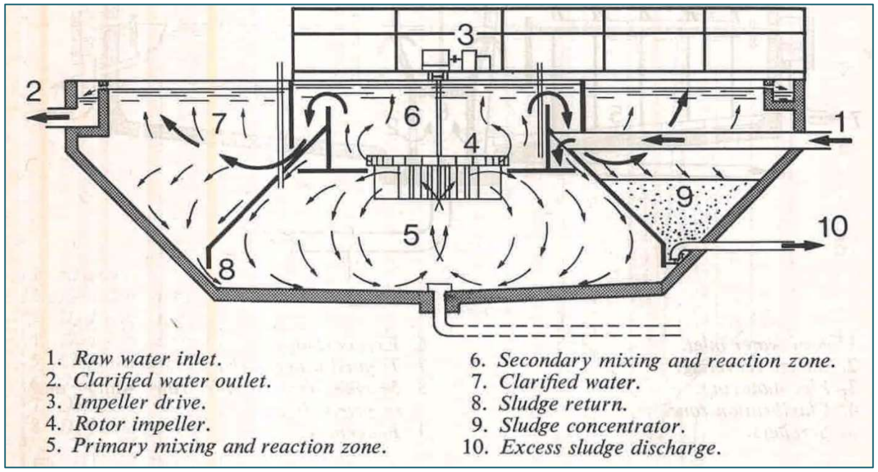
What are intensified processes?

- They provide treatment faster and with smaller footprints than conventional systems
  - Often used to expand a facility with limited land space
  - They may also give a better overall result e.g., less chemical use or better quality finished water

- Examples of intensified treatment processes we will cover:
  - Solids Contact / Slurry Recirculation Clarifier
  - Buoyant Upflow Media Clarification
  - Dissolved Air Flotation
  - Sand Ballasted Flocculation
  - Membrane Filtration

Solids Contact / Slurry Recirculation Clarifier

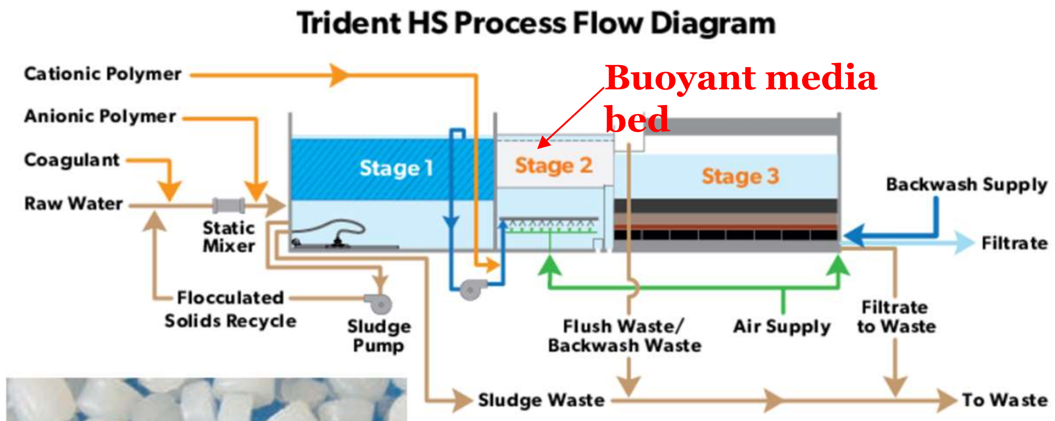
- ❑An "old school" intensified process developed in the 1950s
- ❑Efficiently combines rapid mixing, coagulation, flocculation, & settling in a single, *circular* tank
- ❑Recirculates settling sludge to the flocculation zone for more efficient use of coagulants
- ❑Promotes denser, more compact sludges, particularly in softening applications
- ❑Ideal for lime softening; also sediment-laden river water



Images courtesy of Veolia-Suez

Buoyant Upflow Media Clarification

- An intensified process developed in the early1980s
- Uses buoyant coarse plastic media to trap flocs ahead of granular media filter
- Nominal rise rate: 10 gpm/ft^2
- Screens trap media in the tank
- Uses air scour and water wash to clean plastic media
- Sometimes combined with a tube settler equipped-clarifier
- Used at Bloomfield, NM WTP



Adsorption Clarifiers use buoyant media in an upflow system design.

Images courtesy of WesTech Engineering

Dissolved Air Flotation Clarification

- An intensified process borrowed from wastewater treatment
- Sometimes "gravity is overrated" when goal is remove algae or low-density solids
- Nominal rise rate: 10-20 gpm/ft^2
- Uses fine dissolved air bubbles to float material to be removed; Smaller air bubbles are more efficient at floating the material
- Makes a compact pre-treatment solution for membrane filtration

Image courtesy of Veolia-Suez

Sand Ballasted Flocculation

“Making gravity work better”

- ❑First used in Rocky Mtn Region in mid-1990’s in Colorado
- ❑Adds powder-like sand with specific gravity = 2.65 during flocculation to get denser, heavier flocs
- ❑Nominal rise rate: 35-50 gpm/ft^2
- ❑Uses cyclone separator to recover sand from the flocs and re-use in the process
- ❑Completes rapid mix, coagulation, flocculation, & settling in just 30 minutes!

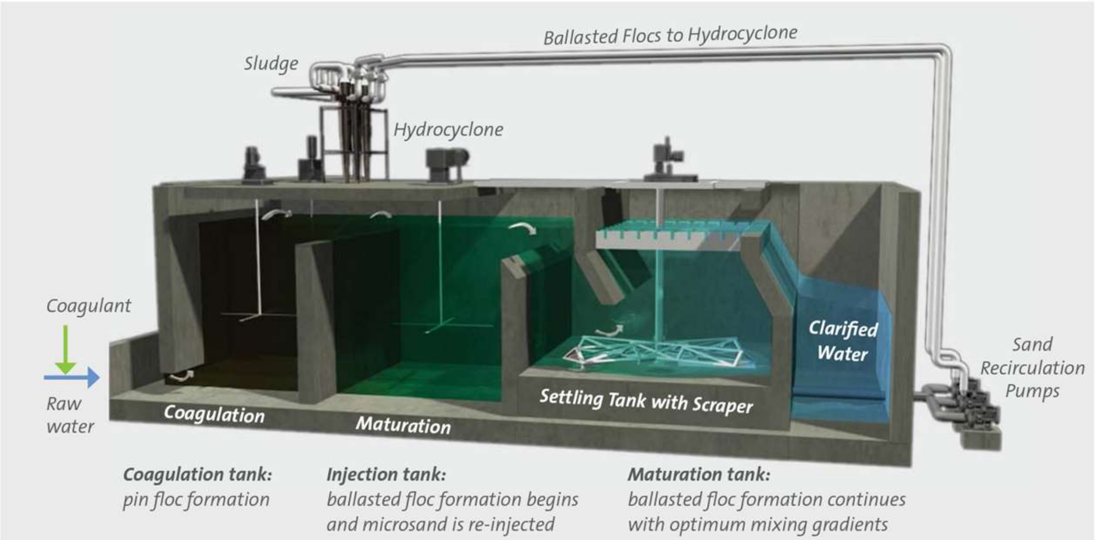
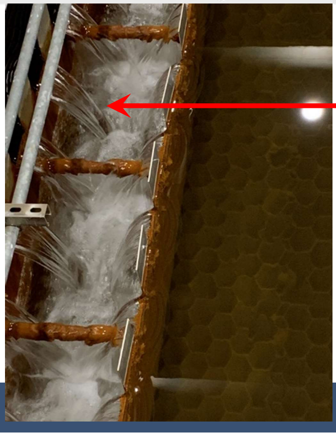


Image courtesy of Veolia



Turbidity = 1.25 NTU in effluent at SJCWTP

Membrane Filtration

- First used in Ft. Lupton, CO in late1990's; 4.3 MGD plant
- Great for clear cold waters with cysts or dissolved organics issues
- Membrane flux rate: 30-35 gpm/ft^2
- Combine w/varying types of pre-treat e.g., coag/floc or coag/floc /settling to convert dissolved stuff into filterable material ≥ 0.02 μm (Ultrafiltration)
- Periodic air scour / water backwash & chemical cleaning of membrane modules to maintain design flux rate
- Automated testing of membrane integrity; Whole system is automated!

Image courtesy of Pall Water

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Managing Water Treatment Residuals

- Questions for a holistic approach to residuals management:
  - Quantify the issue you want to manage:
    - Backwash water management: high volumes of low solids content water that you may be able to re-use after some liquid/solids separation
      - What is the volume generated per cleaning? # cleanings per day? Seasonal variability?
      - Where and how will you re-introduce this "free water" back into the treatment process without upsetting finished water quality? Filter Backwash Recycling Rule
    - Clarifier sludge management: low volume sidestreams w/high solids content which may not be as useful to reclaim
      - *Will recycling this water introduce trace contaminants not found in the raw water?*
  - Once you've collected & processed the solids, what do they contain and how will they be disposed or possibly re-used?

Managing Water Treatment Residuals

- ❑Questions for a holistic approach to residuals management
  - ❑What regulations apply to the handling & disposal of the solids?
  - ❑Does the clarifier sludge volume to be managed justify a permanent on-site facility for dewatering?
    - ❑ Will dewatering facility be operated intermittently or continuously?
  - ❑Is there a nearby sanitary sewer with hydraulic capacity available?
    - ❑How will your residual discharges impact the sewer and the downstream wastewater treatment system?
    - ❑What are the charges for disposal in the sewer? Is the "price right"?

Managing Water Treatment Residuals

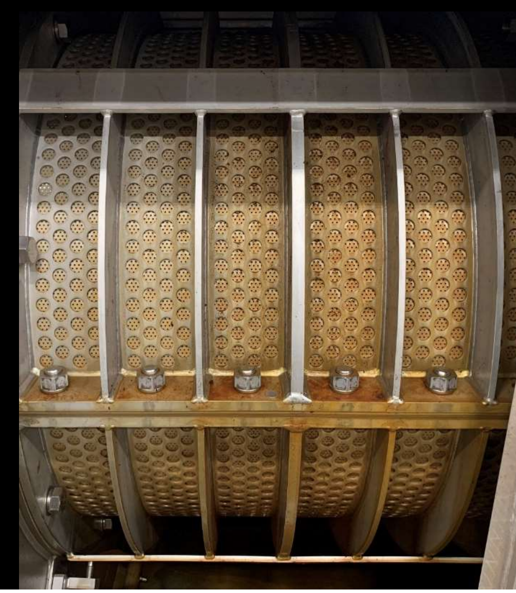
- Observations from my experience in water treatment and sludge management:
  - Provide enough flow equalizing storage if you plan to recycle all of plant's backwash flows
    - Don't want to hold up filter cleaning when needed for lack of a place to process backwash flows…is the tail wagging the dog?
  - Alum sludges are harder to thicken & dewater compared to ferric
    - Limited prospects for re-using alum sludges; Something to think about if sewer discharge isn't an option & you want to switch from using iron salt coagulants!

Managing Water Treatment Residuals

- Thoughts about dewatering water treatment plant sludges:
  - Drying beds w/concrete bottoms may work if enough space is available
    - Don't expect to decant much water or collect much filtrate in a drying bed
    - Limit the thickness of liquid sludge applied to 12 inches or less else drying will take "forever"
  - Mechanical dewatering systems work best when fed continuously with "unlimited supplies of homogeneous materials"
    - How close can you come to providing this desired type of feedstock?
    - If continuous operation isn't a choice, How will sidestreams from start-up and shutdown conditions of the dewatering system impact the water treatment plant?
    - Centrifuges are NOT a good choice if routine operation will involve a lot of starting and stopping cycles;

Dewatering iron sludge at SJCWTP

- Things that make this system work well:
  - 500,000 gallons of **MIXED** equalizing storage
  - 40% active liquid emulsion polymer for flocculant; **NSF/ANSI-60 rated!!**
  - 2 mixed tanks in series for flocculating the sludge
  - Screw press technology; much simpler to operate compared to a belt press



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Optimizing arsenic removal using absorption media

- ❑ Why do we care? Media replacement is expensive so get the most from what you have in the vessels!
- ❑ Blend with untreated water to achieve an arsenic level < 10 µg/L
  - ❑ Need accurate flow metering on both treated flow and bypass flow
  - ❑ Carefully track the volume treated and compare to manufacturer's projected Bed Volume & bed life
  - ❑ Check for arsenic breakthrough once at 90% of mfr's. projected Bed Volume
- ❑ Adjust pH of water into treatment vessels to the range recommended by media supplier; it <u>WILL</u> help preserve media life!
  - ❑ Adjusting pH using CO2 feed systems is *MUCH BETTER* than using liquid mineral acids like HCl

Optimizing floc.-sed. in conventional water treatment systems

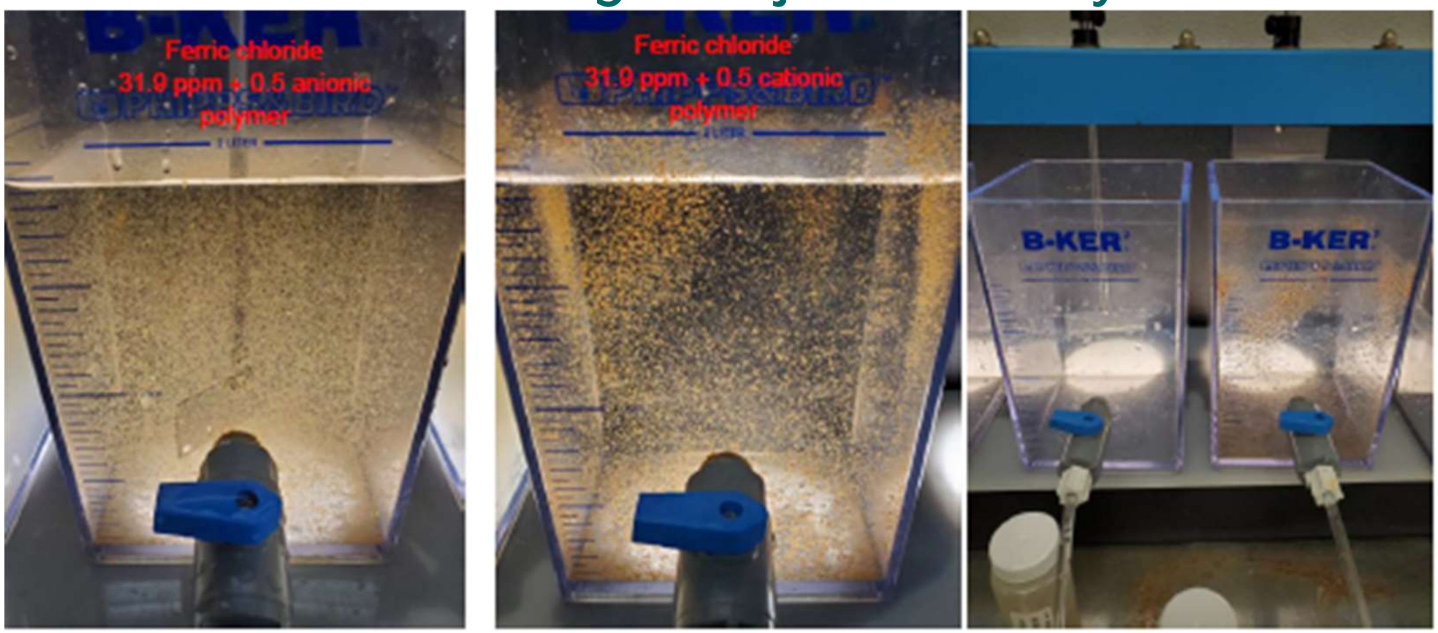
- Why do we care? Save on chemical costs, produce less waste to manage, & improve downstream filter performance & run times!
- Variables to adjust to improve floc-sed performance include:
  - Physical location where coagulant chemicals are added
  - Flocculator speed adjustments
  - Rate of withdrawal for settled sludge
  - A little turbidity carryover from settling at 3 NTU might be OK if it lets the filter ripen faster and IF you can maintain it steady at 3 NTU
- Any seasonal changes in water temp. & viscosity? These will impact coagulant performance; Optimal feed rates & locations for summer vs. those for winter; These may change!

Optimizing floc.-sed. in conventional water treatment systems

- Optimizing flocculation is all about creating the right surface charge conditions in the floc
  - Assess by measuring Zeta potential which measures surface charge of floc particles; streaming potential can also be useful
  - Floc particles w/negative charge will get removed on the filter *BUT* they won't get "glued" to media grains; easier to flush out during filter backwash!
- Assess coagulant performance using jar tests
- Sometimes, it's just time to change the coagulant you use!

Optimizing floc.-sed. in conventional water treatment systems

- ❑Picture from circa 2022 coagulant jar test study at SJCWTP



- ❑The anionic polymer together w/ferric chloride creates a floc that is less “sticky” than with cationic polymer; look at jar walls!

QUIZ: Turbidity in water...

- A. Is an accurate measure of a water's cloudiness
- B. On average, should measure 1-3 NTU in the water entering filters
- C. Is exactly equivalent to TSS; 1 NTU = 1 mg/L of TSS
- D. Can cause filtrate NTU to spike if the filter loading rate changes suddenly
- E. All of the above
- F. A, B, and D

Hints that granular media filter performance is “sub-par”

- Shorter filter run times between cleanings?
- Poorer results for filtrate turbidity?
- Too long to ripen a filter?
- Turbidity spikes from remaining filters when washing a filter?
- Cratering of media, uneven media surface, or cracking of surface?
- Air release from filter bed during backwash?
- Filter media observed in the wash troughs?

Hints for improving filter performance

- Track Unit Filter Run Volume; Filtrate gallons/SF of filter area
  - UFRV should be > 5,000; If not, determine why not!
- Colder water temps allow for slower backwash rates
  - Have you adjusted your backwash flow rates if BW water is colder?
- Performance of clarifiers; too much polymer in the floc creates stickier flocs that are hard to remove during backwash
- Check Zeta potential of water onto filter; Do the particles to be filtered out have a negative charge? (The filter media usually does)

Hints for improving filter performance

- ❑"Downshift" plant production rate when cleaning a filter; Greater flow through remaining filters can cause turbidity spikes if plant production flow is left constant
- ❑Are backwash cycles too long? Check BW turbidity at even time intervals thru the whole sequence; Once BW washwater NTU is 15-30 NTU, consider ending backwash
  - ❑A clean filter is good. A "squeaky clean" filter? Not so much!
- ❑Stepwise approach to evaluating filters: AWWA DVD: Filter Surveillance Techniques For Water Utilities
  - Upcoming RMSAWWA seminar on 10/23/25 at San Juan Chama Water Treatment Plant

Trouble improving filter performance?

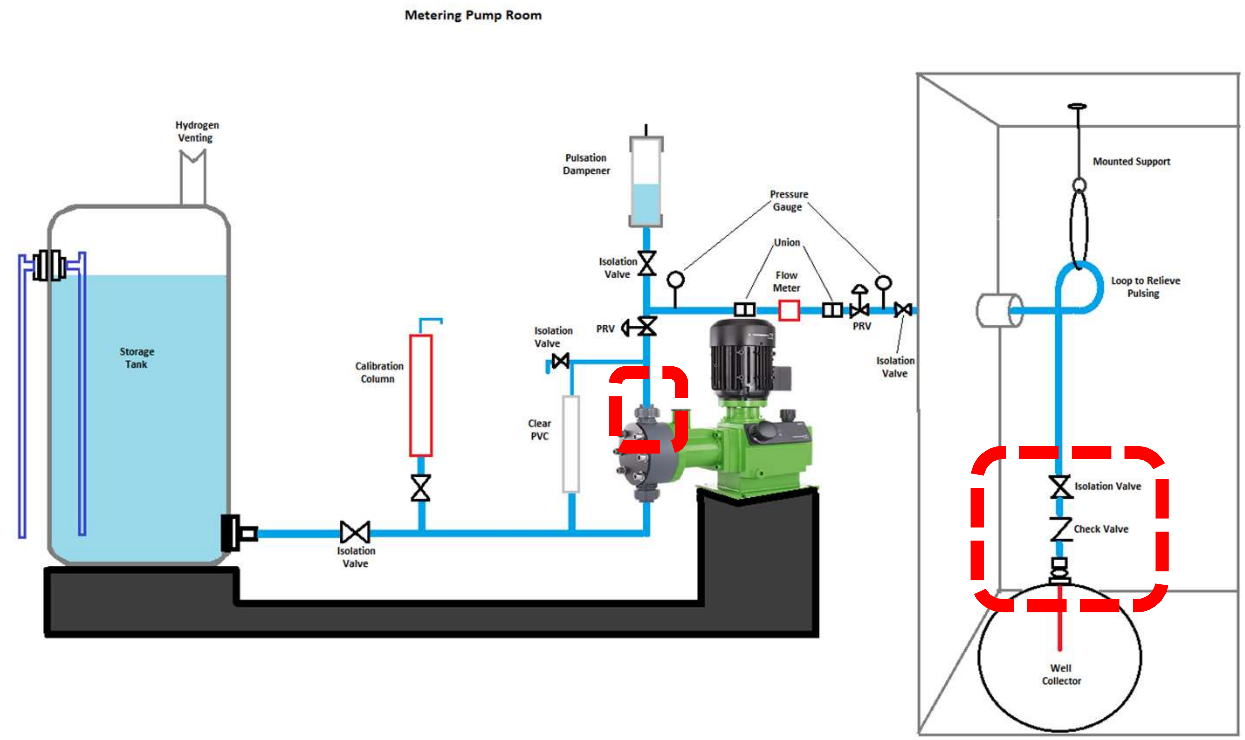
- ❑ Consider joining AWWA Partnership for Safe Water-Treatment
- ❑ A way to achieve compliance by optimizing operations

  (more $$ for capital improvements may just be part of the answer)
- ❑ PSW-Treatment main goal: Are ≥ 95% of all filtered water turbidity readings < 0.10 NTU? *If not, WHY NOT??*
- ❑ PSW-Treatment has 4 key steps:
  1. Sign up & commit; *Only $50/year for small systems!*
  2. Collect & submit filter turbidity data on PSW-Treatment website
  3. Complete detailed self-assessment & submit to AWWA Partnership program folks; *146 "easy" questions*
  4. Commit to making incremental improvements each year on those items you select to make better

POLL: What chemical does your system use for disinfection?

- A. Chlorine gas
- B. Liquid sodium hypochlorite (NaOCl or bleach)
- C. On-site generated hypochlorite (HOCl)
- D. High Test Hypochlorite (HTH) tablets disinfection
- E. Chloramines

Potential issues with liquid sodium hypochlorite feed

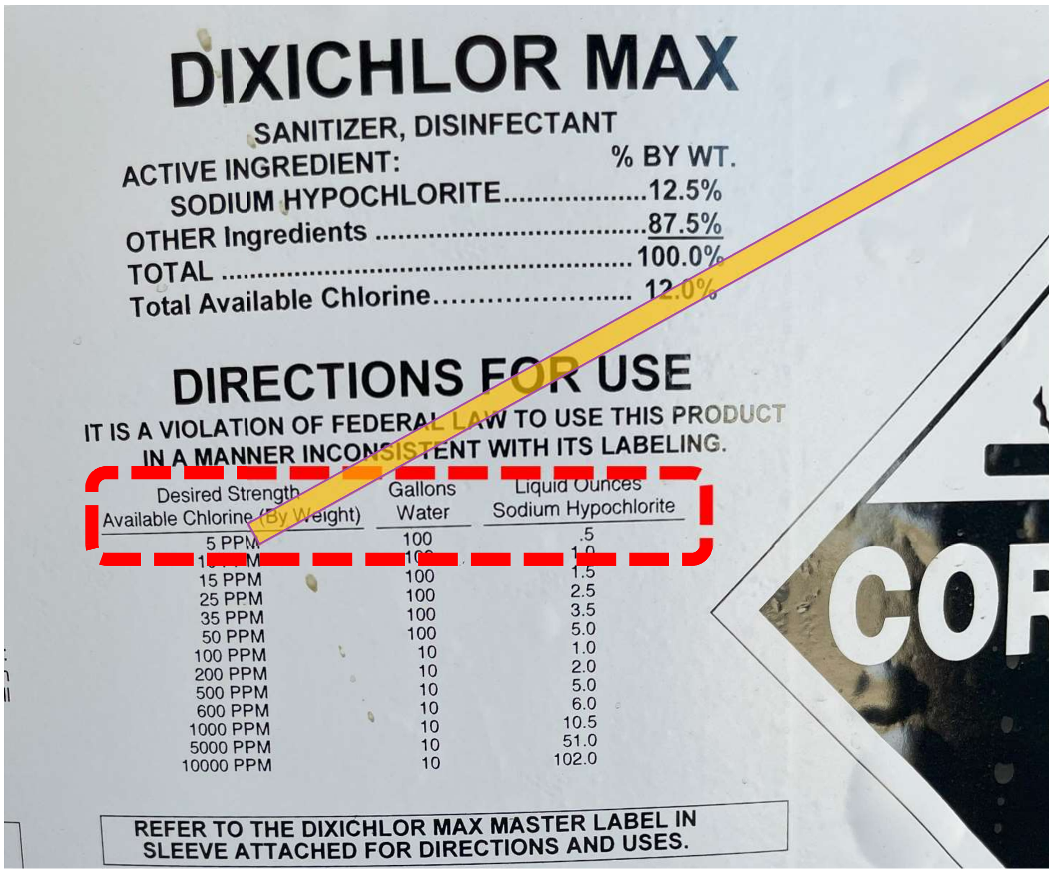


- **A. Off-gassing of NaOCl solution can be a problem; Pumps can vapor lock w/typical 12.5% solution**

Possible solution: peristaltic feed pump

- **B. 12.5% solution degrades w/time; worse if temp > 70°F**
- **C. Plugged injector quills**

Recipe for getting the desired chlorine dose at a 1 MGD treatment plant starting with 12.5% liquid NaOCl



- **Wanted: 2 PPM dose of available Cl**
- **0.5 * (2/5) = 0.2 liquid ounces in 100 gallons or 2,000 liquid ounces in 1,000,000 gallons**
- **2 PPM dose in 1 MG requires (2,000/128) = 15.6 gallons of DIXIECHLOR MAX product** (Remember, there are 128 fluid ounces in a gallon)
- **15.6 gals/day of DIXIECHLOR covers 2 PPM dose for a 1 MGD finished water flow**
  - **(15.6 gallons/day) x 128/1440 = 1.39 oz/minute**
  - **1.39 oz/minute x (29.57 ml/oz) = 41 ml/minute**

Lots of metering pumps for sale to feed 0 - 100 ml/min! Running it at 41% of full speed makes a 100 ml/minute capacity pump a good choice!

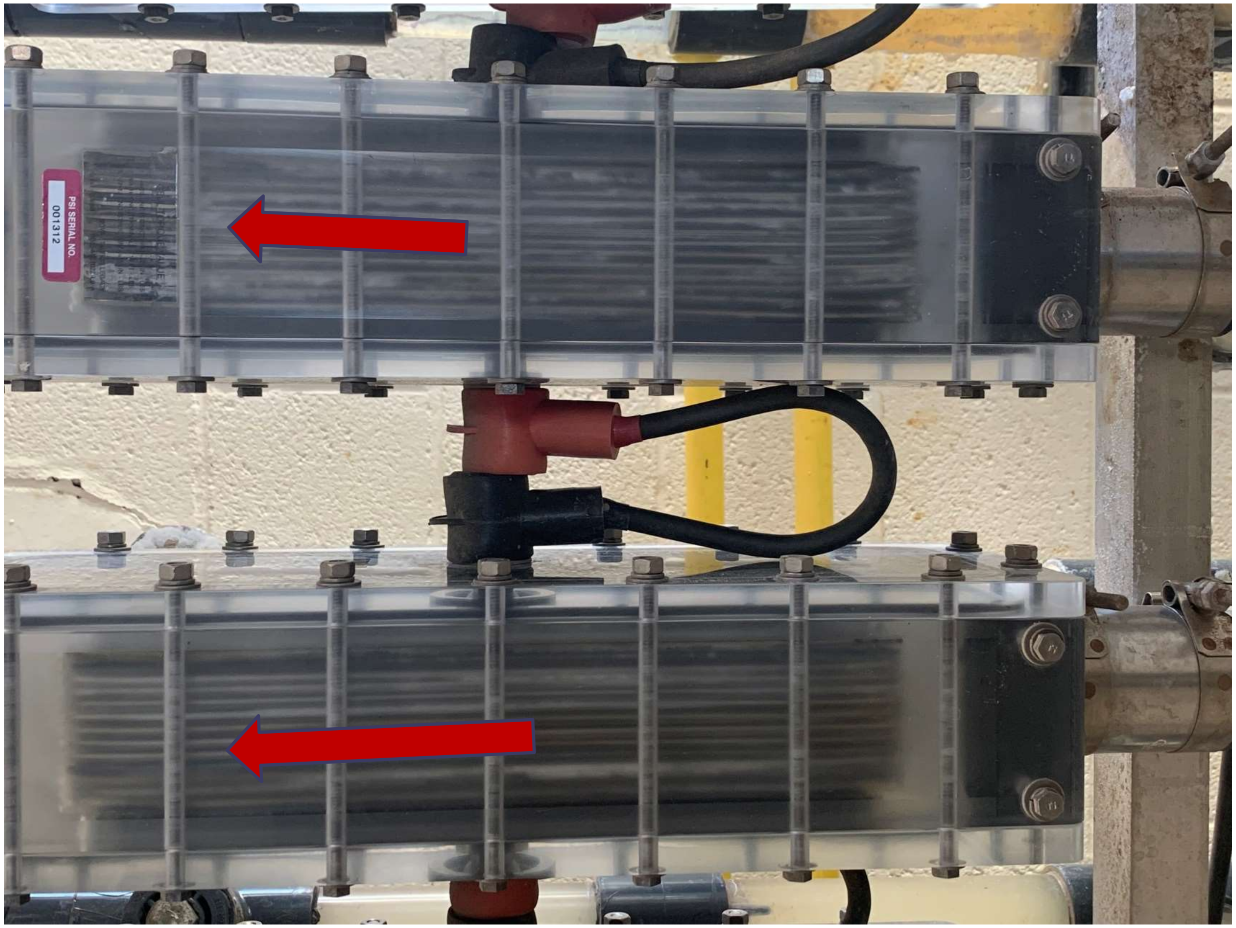
Keeping on-site HOCl generators reliable

- Softened water *is a must* for brine make-up supply and dilution water flow into generator; Softened means 0 mg/L = 0 grains/gal of hardness

- Softener sizing needs to be matched to the flow rate of the generator brine feed pump; critical for correct micro nozzle sizing in the softener vessel control head

- Even w/soft water & good quality salt, on-site generator cells will need periodic muriatic acid cleaning

On-site HOCl generator cells up close:

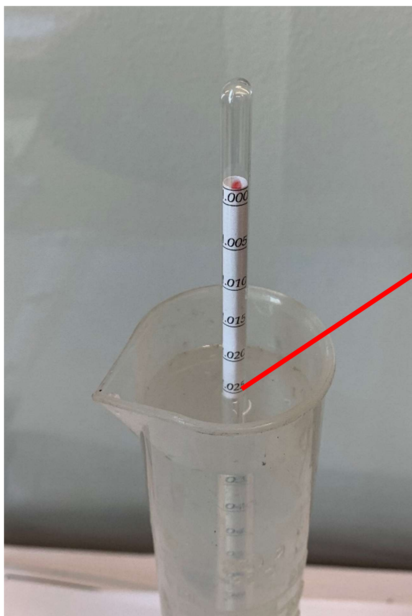


KPI's for On-site HOCl generators

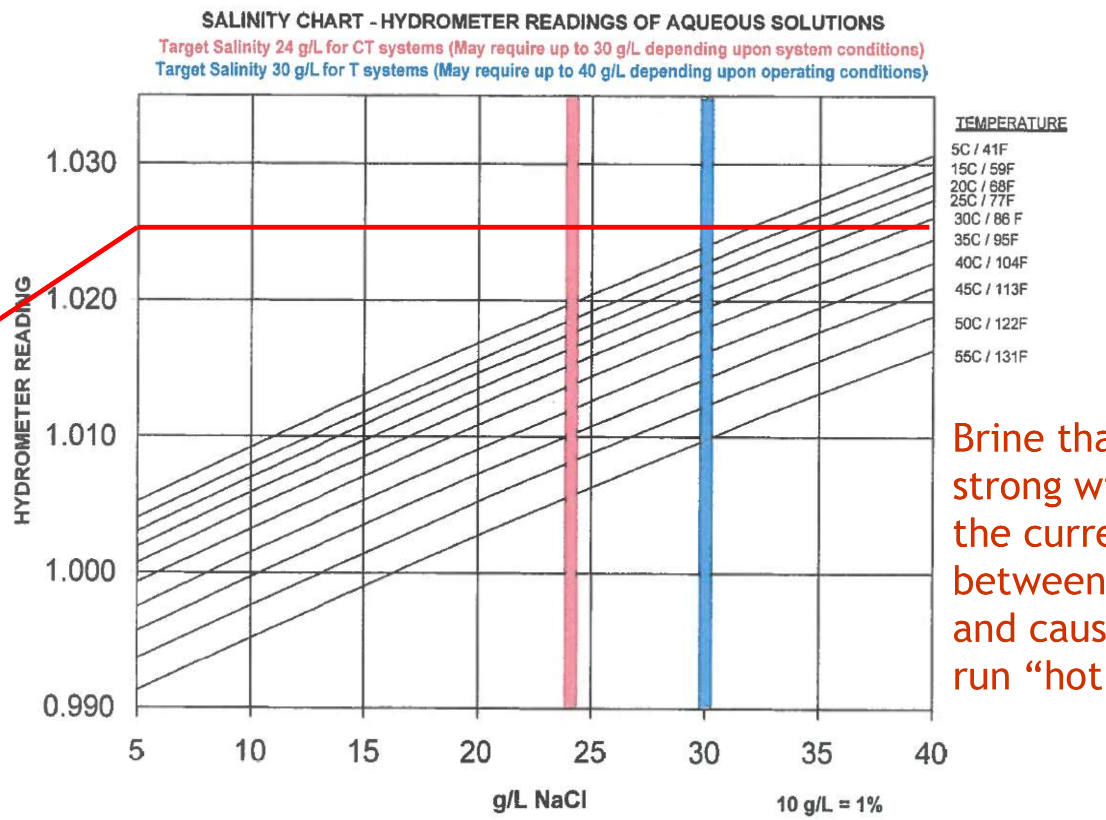
- Make-up water hardness (Is the softener working right?)
- Run hours between chemical cleanings
- Amperage draw of generator
- Amperage draw & voltage per generator cell
- Brine strength using a hydrometer
- HOCl solution strength (check by titration)
- Temperatures of generator cells & power supply cables

KPI's for on-site HOCl systems

Brine strength



Someone made the brine too strong!



Brine that is too strong will increase the current flow between cell plates and cause the cell to run "hot"

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QUIZ: A well field produces 465 gpm for 90 hours each week & uses 12.5% liquid bleach (avail. NaOCl). If the dose = 1 mg/L Cl_2 how many 50-gallon barrels of 12.5% bleach are needed every 12 weeks? Assume 12.5% NaOCl contains 1.2 lbs of Cl_2 per gallon

Not enough w/just 2 barrels! You're short 9 gallons!

A. Three (3) barrels

B. Four (4) barrels

C. Six (6) barrels

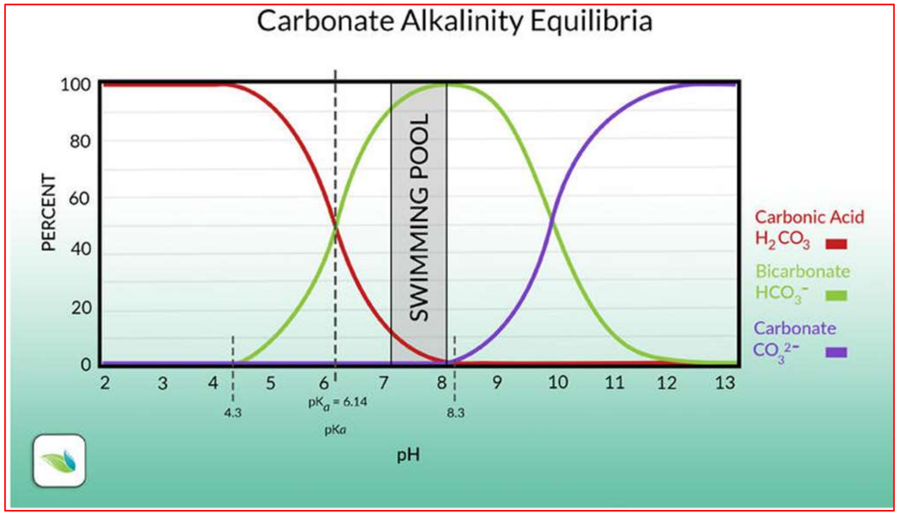
Solution Hints:

1. Calculate the total volume of water treated in 12 weeks = Q x T = V
2. Calculate the lbs of Cl_2 needed to achieve the 1 mg/L of Cl_2 dose = Vol treated in Million Gallons x mg/L dose x 8.34 = total lbs Cl_2 = ???
3. Calculate the equivalent gals of 12.5% NaOCl bleach using the conversion factor provided of 1.2 lbs avail Cl_2 per gallon
4. Knowing the total # of gallons of 12.5% bleach required, convert to equivalent # of 50-gallon drums

QUIZ: **The Sunnyside WTP in Florida uses lime softening. Of late, filter run times after softening have been much shorter. The pH of softener effluent onto the filters has been trending upwards to 9.6. The most likely explanation for shorter filter run times is…**

- **A. Inadequate filter cleaning procedures**
- **B. Overdosing of polymer feed that's used together with lime addition**
- **C. Feed of CO_2 into the recarbonation tank that follows softening is too low**
- **D. Feed of CO_2 into the recarbonation tank that follows softening is too high**

Hint: The plant feeds CO_2 after softening to form H_2CO_3 or carbonic acid and **STOP** precipitation caused by softening



Graph courtesy of Orenda Technologies

QUIZ: **Each vessel in a 3-vessel arsenic removal system has 314 CF of media. It runs 24/7/365 at 5 MGD with 50% the flow being bypassed for blending. If the media is rated for 150,000 bed volumes, how many days before a media change is required?**

- **A. 471 days**
- **B. 211 days**
- **C. 423 days**
- **D. 141 days**

Solution Hints:

1. Draw a picture of this system and label it with the correct flow rates including the portion of flow that is ***NOT*** going through the vessels!!
2. At 314 CF of media per vessel, the total available media volume is…
3. Convert total media volume in CF to media volume in gallons
4. With 150,000 bed volume rating, the 3-vessel system can treat ??? gallons before change out
5. V / Q; Max volume that can be treated ÷ flow rate = days of service

QUIZ: **Based on SCADA data, the Purewater WTP's 8 filters each w/10'x20' of surface area produced 12.8 MG of filtrate in January 2024 just before a media change-out project. What was the Unit Filter Run Volume (UFRV) for this set of 8 filters?**

- **A. 8000 gal/SF**
- **B. 1000 gallons/SF**
- **C. 4000 gallons/SF**

Solution Hints:

1. Draw a picture of this system and label it with the data given!
2. The total available filter area for the 8 filters is ??? SF
3. The total volume of filtrate produced was ???? gallons
4. Therefore, the UNIT FILTER RUN VOLUME in gallons/SF was ???

FINAL QUIZ: The filter media vendor for the Purewater WTP media change-out project claimed UFRV would increase by 30%. If the measured UFRV after media change was 10,000 gal/SF, calculate the corresponding filtrate volume produced. Was the vendor's claim realized?

- **A. 16.64 MG and YES the vendor's claim was valid**
- **B. 16 MG and NO, the vendor's claim wasn't valid**
- **C. 20.32 MG and YES the vendor's claim was valid**
- **D. 8 MG & NO the vendor's claim wasn't valid**

Solution Hints:

1. Draw a picture of this system and tag it with the data given!
2. The improved UFRV after media change out was 10,000 gal/SF
3. With the battery of eight 10'x20' filters, the total volume of filtrate produced by these 8 filters after media change out, V = UFRV x Total Area = ???
4. Compared to the old filtrate volume, the new filtrate volume is ???? % greater / smaller than before
5. Therefore, the vendor's claim that there would be a 30% improvement was… **False!**

THANK YOU AND WISHING YOU SUCCESS IN YOUR UTILITY OPERATIONS CAREER!

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