# Class Outline

| | |
|---|---|
| 9 AM | Introduction/Overview |
| *10:15 AM – 15 minute break* | |
| 10:30 AM | Coagulation/Flocculation |
| *12 noon – Lunch (on your own)* | |
| 1 PM | Clarification/Sedimentation |
| 2 PM | Filtration |
| *2:15 PM – 15 minute break* | |
| 2:30 PM | Filtration (continued) |
| 3:30 PM | General Operations |
| *4:30 PM - End* | |

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# Clarification/Sedimentation (Conventional Filtration)

Clarification is generally considered to consist of any process or combination of processes which reduce suspended matter prior to filtration.

Sedimentation is clarification that relies on gravity to settle particles out.

# Clarification Objectives (Conventional Filtration)

Key objective is to lower the particulate load to the filters

- Accomplished with gravity or other separation processes
- Collected solids need to be physically removed
- Turbidity removal is typically in the 60-80% range (Hudson, 1981)

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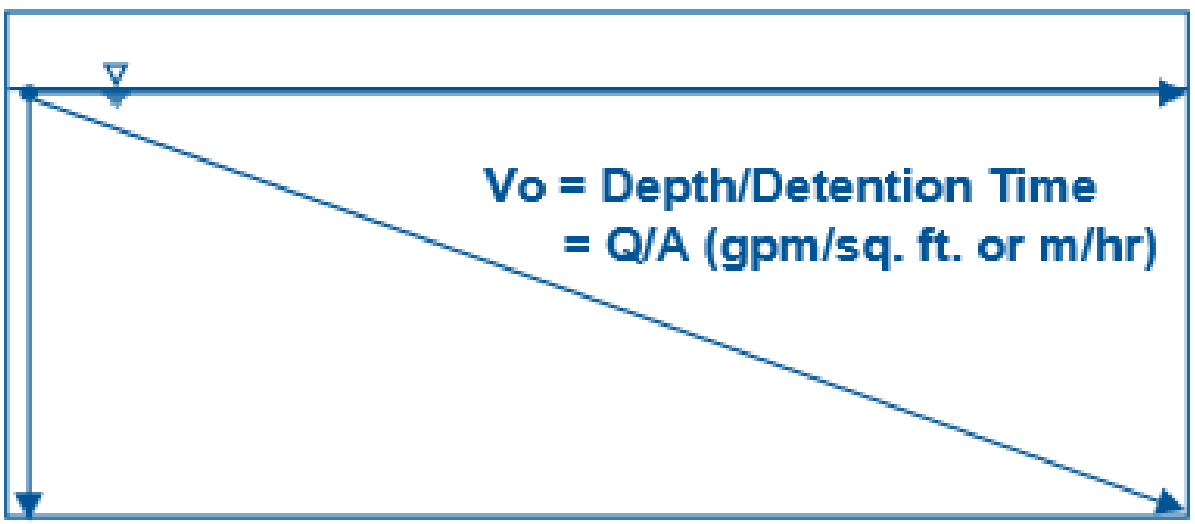
# Clarification (Conventional Plants)

Sizing is often defined by hydraulic loading rate (gpm/ft$^2$ or m/hr)

- 0.5 gpm/ft$^2$ = 1.2 m/h = 0.066 ft/min



# Clarification (Conventional Plants)

Forms of clarification include:

- Sedimentation basins (0.5 – 0.7 gpm/ft$^2$, depending on depth)
- High rate clarification:
  - Tube (1-2 gpm/ft$^2$) or plate settlers (~ 4 gpm/ft$^2$)
  - Contact adsorption clarifiers or “contact clarifiers” (8 gpm/ft$^2$)
  - Solids contact clarifiers (8-12 gpm/ft$^2$ for IDI Densadeg)
  - Sludge blanket clarifiers (2-4 gpm/ft$^2$ for IDI Superpulsator)
  - Dissolved air flotation (2-20 gpm/ft$^2$ depending on configuration)
  - Sand ballasted (15-30 gpm/ft$^2$ for Kruger Actiflo®)

# Sedimentation Basins

(baffled or unbaffled)

- Proper design allows the velocity of water to be reduced so that particles can settle out by gravity.
- The rate at which a particle settles out has to be faster than the rate at which the water flows from the basin's inlet to its outlet.
- Baffles help prevent short circuiting and lower detention times.
- Surface overflow rate $\leq$ 0.5 gpm/ft$^2$ with velocities less than 0.5 ft/min

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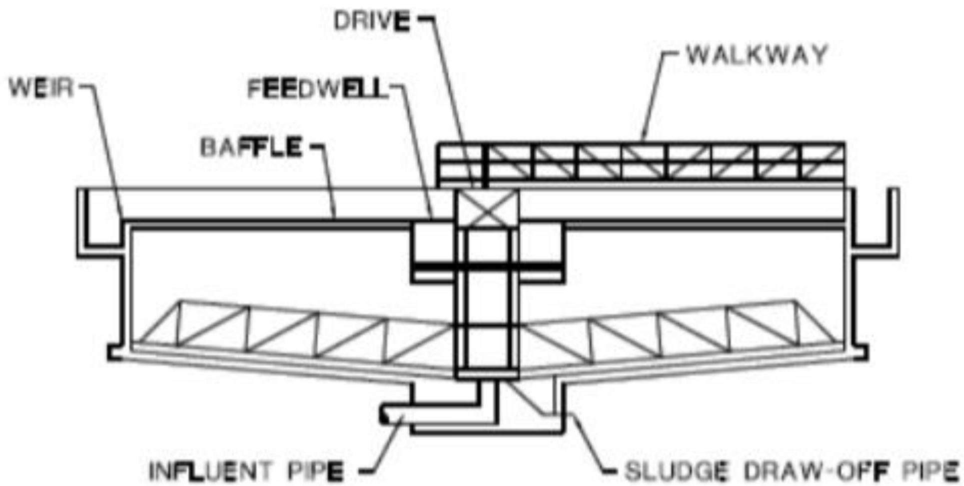
# Sedimentation – Basins (radial flow)

Circular radial-flow clarifies direct coagulated water up through the center and then into a weir trough.




Source: AWWA and ASCE, 1990.

Figure 7-6. Circular Radial-Flow Clarifier

Circular Radial Flow Clarifier

# Tube and Plate Settlers

- Same concepts as sedimentation basins, but can be operated at higher loading rates.
- Tubes and plates placed in a basin decrease the distance the particles have to settle out (i.e., particles only need to settle to the surface of the tube or plate below ~ 2 inches)
- Tubes and plates are inclined (typically 60°) to allow collected sludge to slide down to the bottom of the basin for removal.
- Generally, a space of 2 inches is provided between the tube walls or plates to maximize settling efficiency.

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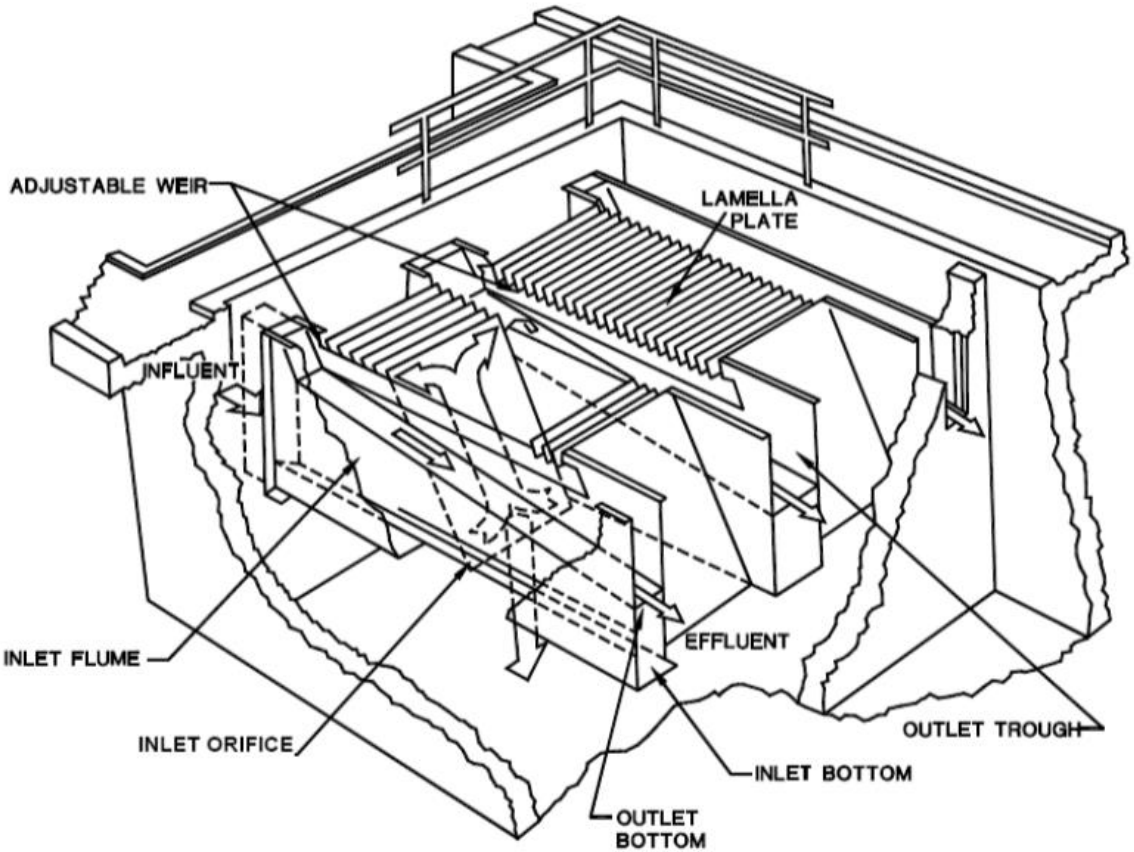
# Plate Settlers

Parallel plates set at an incline shorten the distance the particles have to settle out.

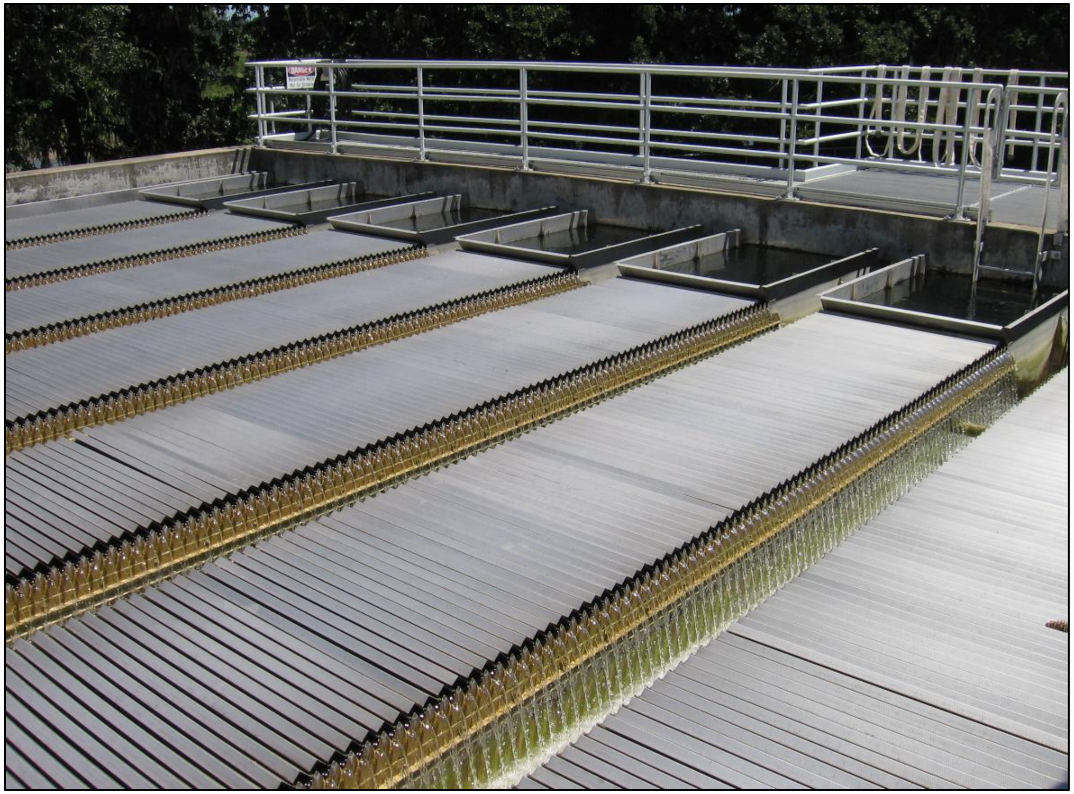
(~ 4 gpm/ft$^2$ 10-ft long @ 55 with 2” spacing)




Source: AWWA and ASCE, 1998.

Figure 7-7. Plate Settlers Used for High-Rate Sedimentation

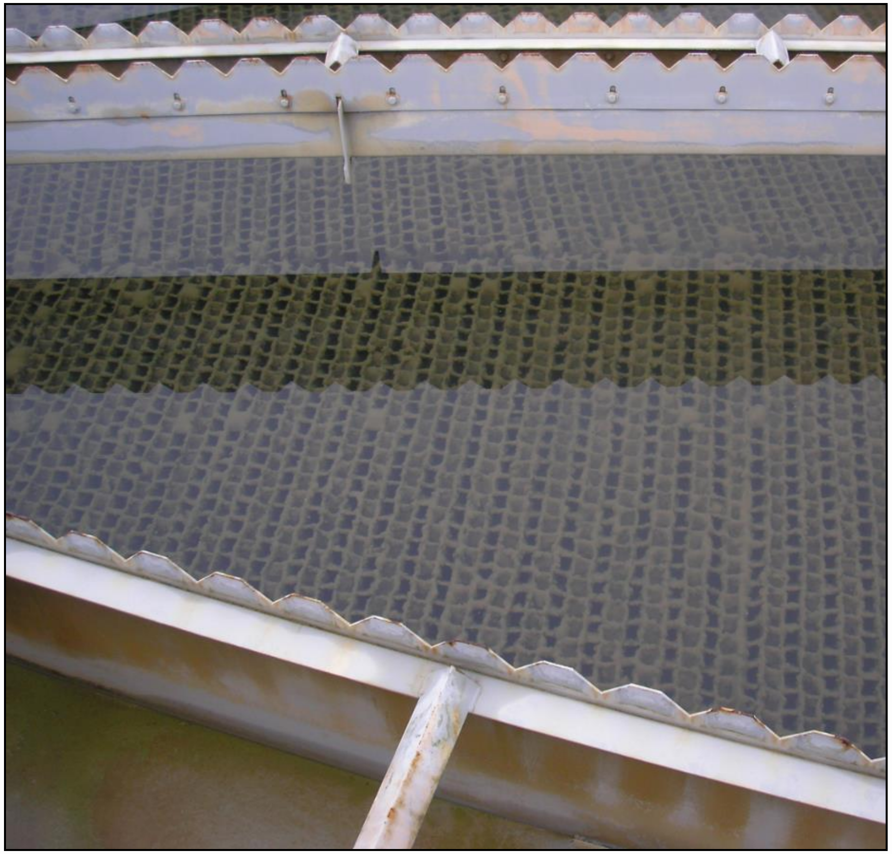
# Plate Settlers – City of Corvallis (2006)



# Tube Settlers

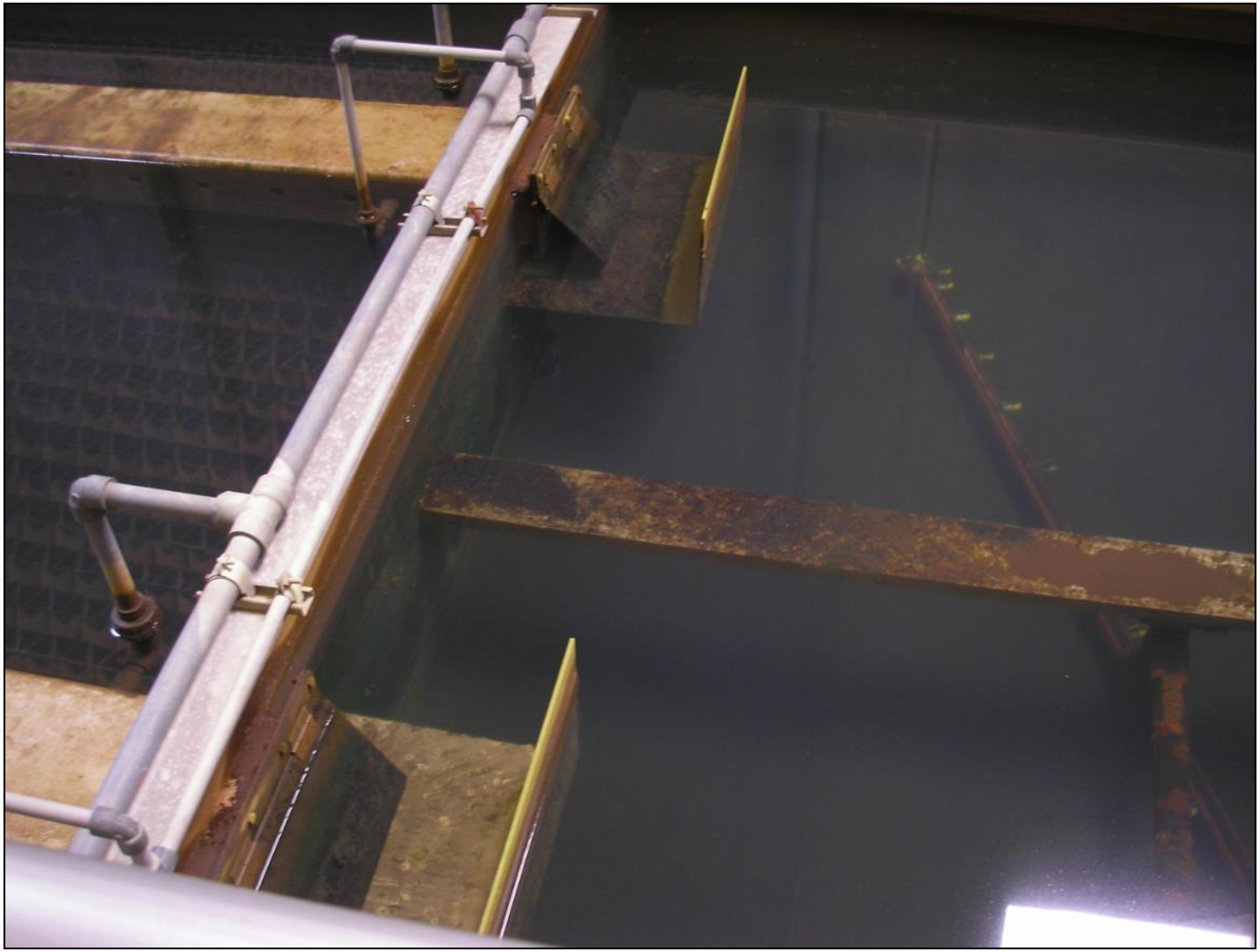
Tube settlers are basins filled with tubes set at an incline of generally 60 °. Tube openings are typically around 2” in size.

Loading rate $\leq$ 2 gpm/ft$^2$ of cross sectional area.



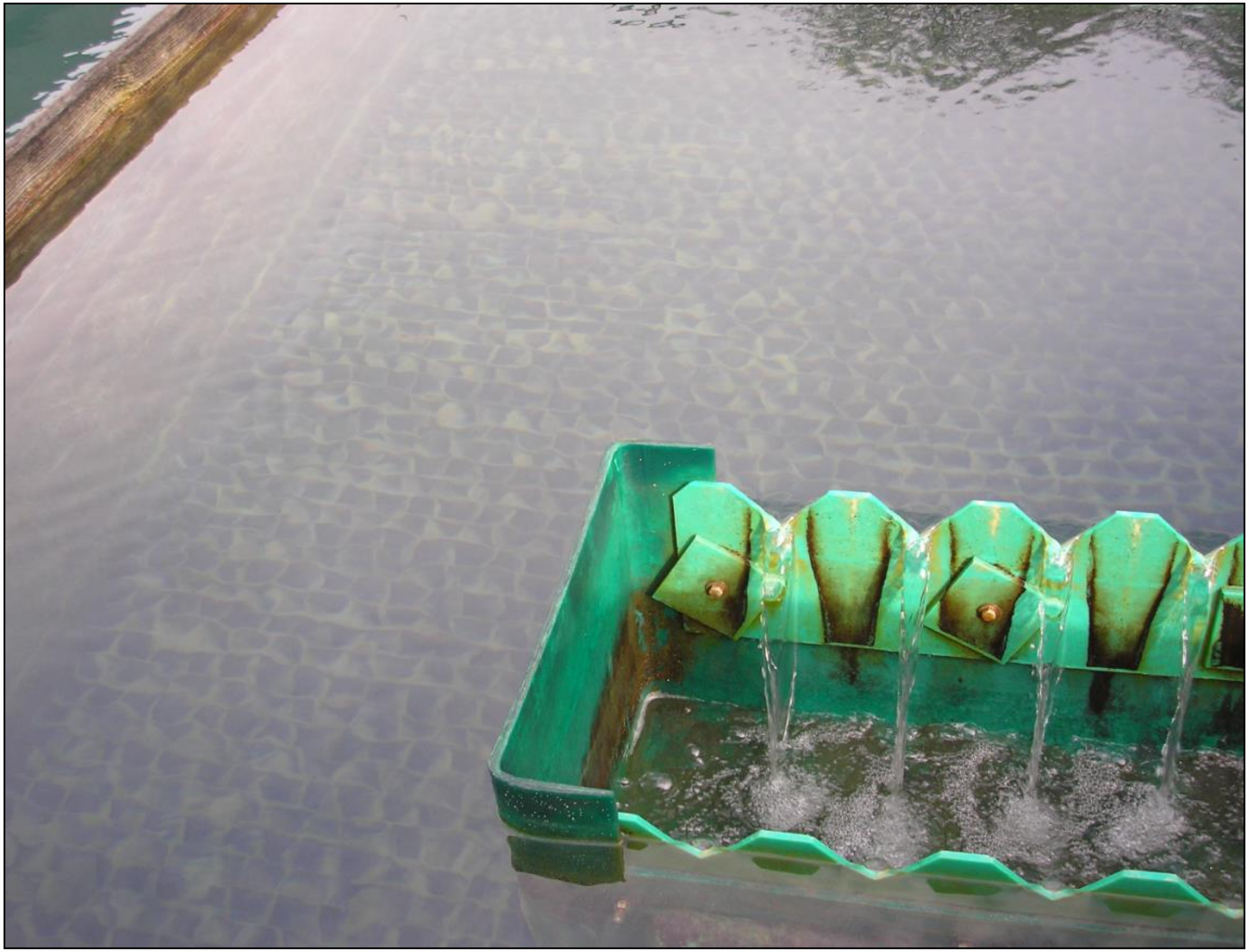
City of Albany (2014)

# Tube Settlers



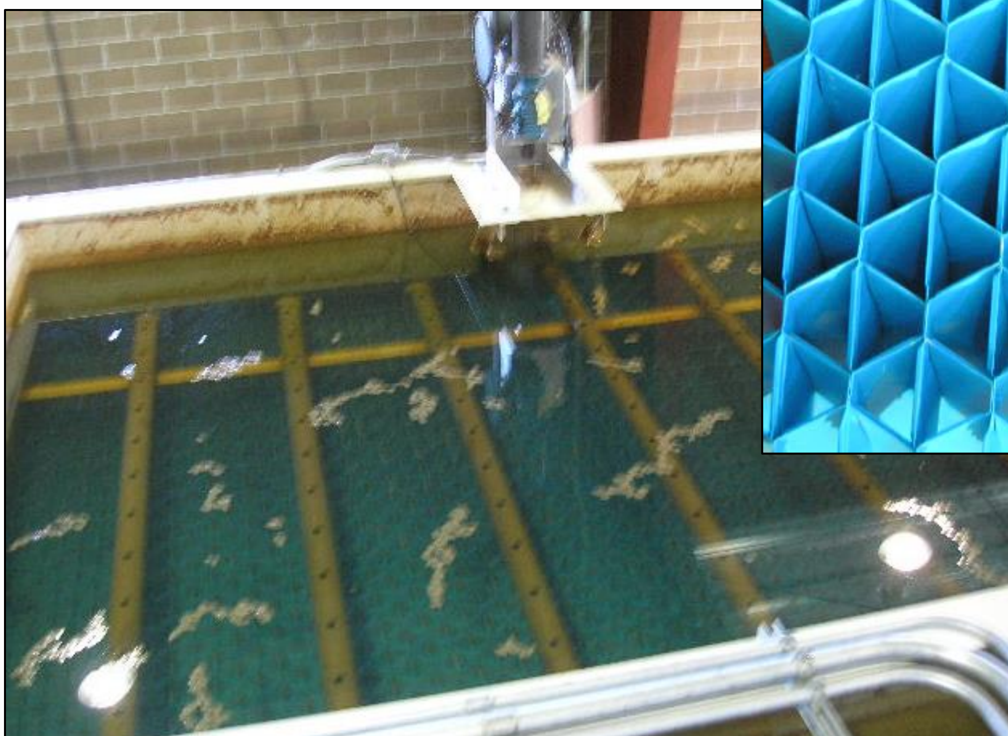
City of Scappoose, 2013

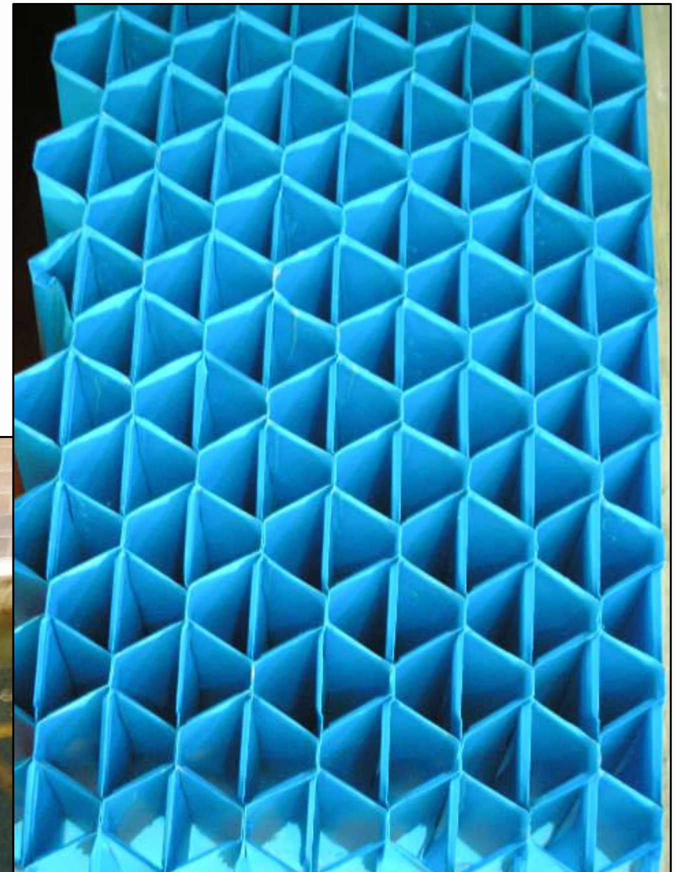
# Tube Settlers



City of Corvallis, 2010

# Tube Settlers

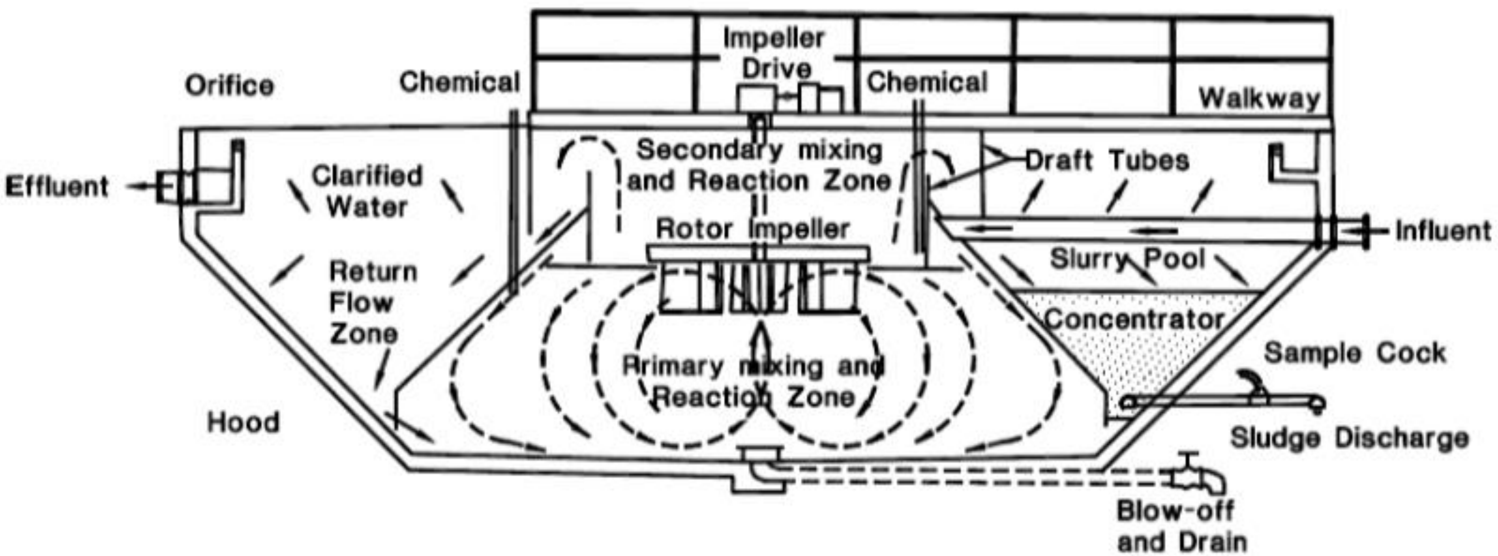




City of Sweet Home, 2015

# Solids Contact Clarifiers

- Accelator® Solids Contact Unit has two mixing zones.
- Raw or coagulated water enters the primary mixing zone where coagulation and flocculation begin.
- The resulting particles are pumped up into a secondary mixing zone where more gentle mixing allows the completion of the flocculation process.
- Water then flows down a draft tube, where particles settle on the hood to the sludge blanket at the bottom of the basin.
- Clear water flows upward at constantly reducing velocity to allows small particles to settle out.




Source: AWWA and ASCE, 1998.

# Solids Contact Clarifiers

Accelator® Solids Contact Unit with tube settlers is shown for the City of Albany (2012)

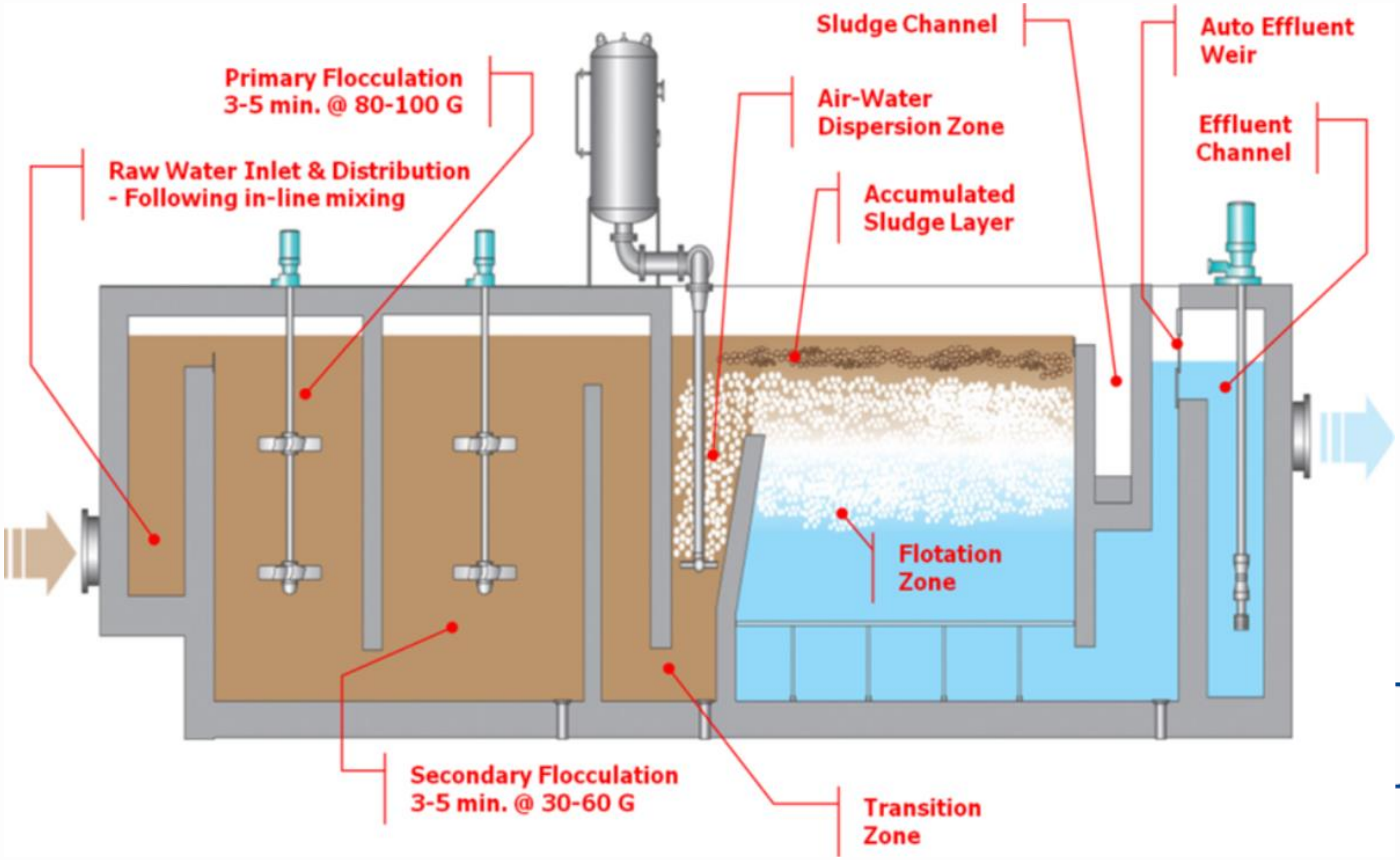
# Sludge Blanket Clarifiers

- A variation of solids contact units in which coagulated water flows up through a blanket of previously formed solids.
- The floc grows in size and becomes part of the blanket, which can develop to a depth of several feet for efficient clarification.
- In both sludge and solids contact clarifiers, solids management is key to their efficiency.

Solids analysis for the City of Albany, 2012

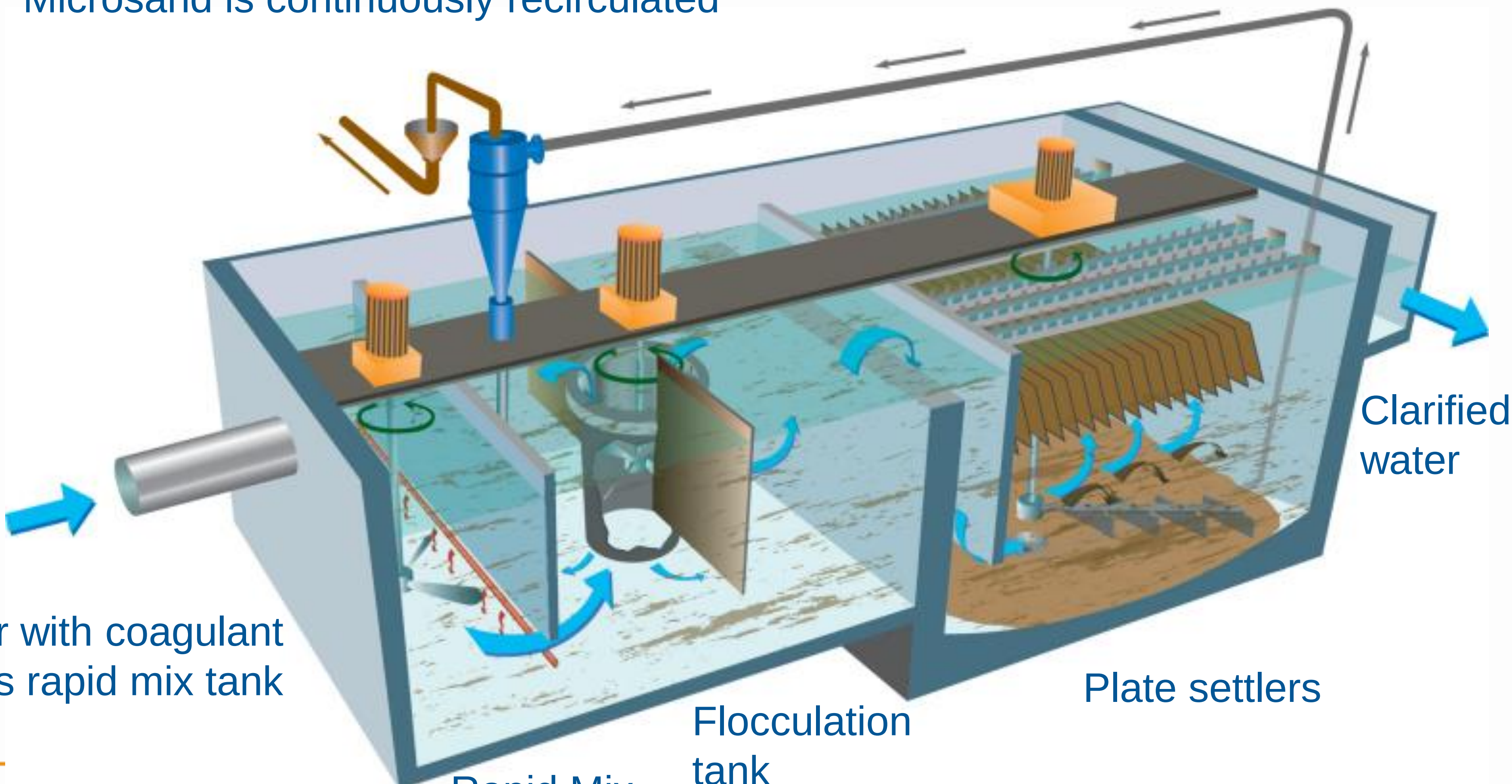
# Dissolved Air Floatation

- In use since the late 1960's
- Uses micro air bubbles to attached and float flocculated particles and solids to the surface for removal.  Primarily for low solids and algae
- Loading rate is 2-6 gpm/ft$^2$ (6 – 20 gpm/ft$^2$ for high rate)



# Sand Ballasted Flocculation

- Introduced in 1989, the Actiflo® process from Kruger uses microsand and polymer injected into the floc chamber that allows the flocculated particles to settle out much faster through parallel plates.
- Microsand is continuously recirculated



# Contact Adsorption Clarifiers

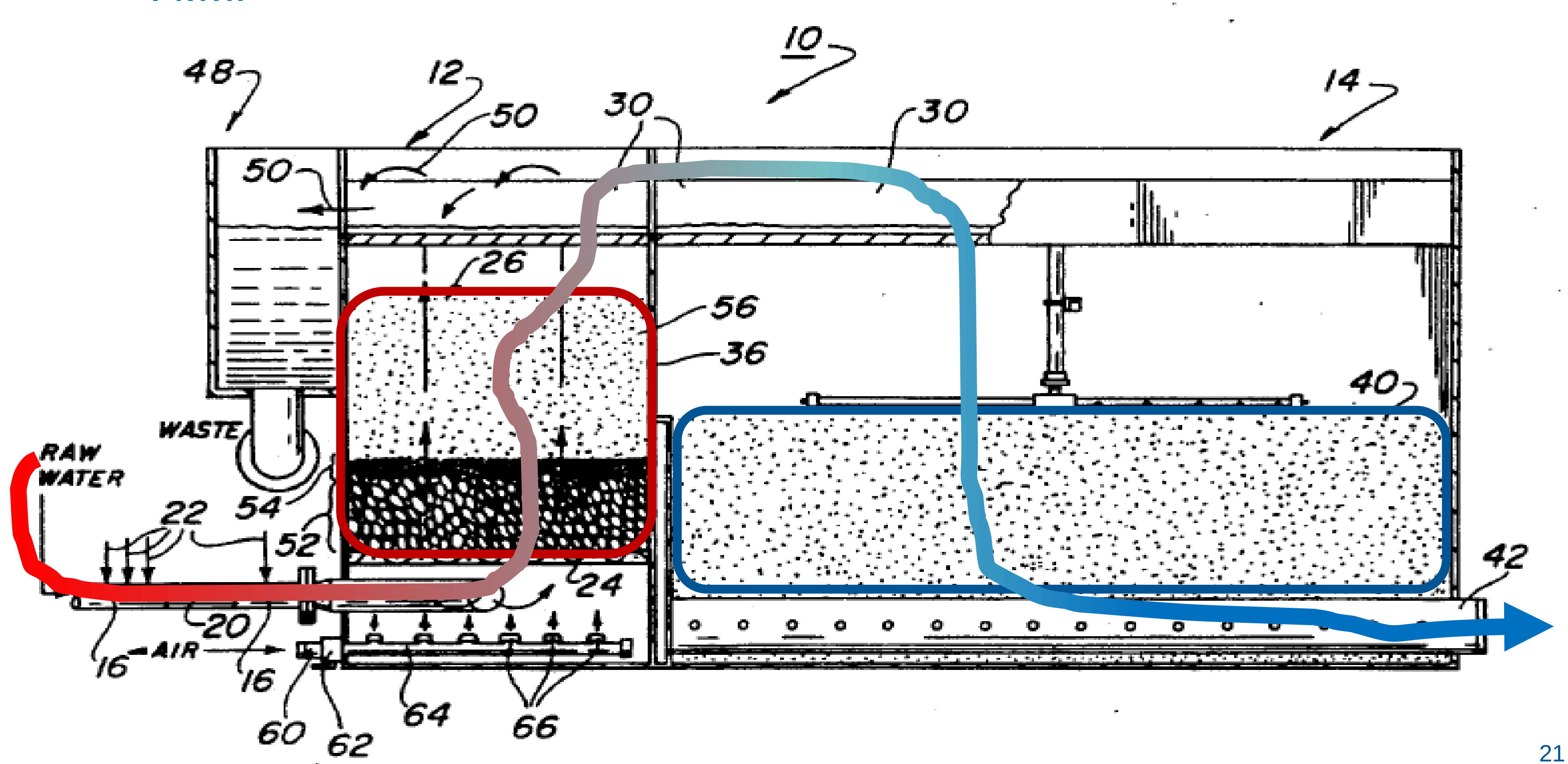
- Coagulated water flows up through clarifier.
- Clarifier media either gravel or plastic beads.  Clarifier is periodically “rinsed” of solids.
- Clarified water flows onto filter.
- Configured as a package plant, small footprint, easy to increase the capacity.

# Contact Adsorption Clarifier

Roberts Filter Group Pacer II (model P-1400) ContaClarifier™

52 = flocculation layer
54 = transition layer
56 = filtration layer
} Contact Adsorption Clarifier (ContaClarifier™ )

40 = Tri-media rapid sand filter (anthracite, sand, garnet) } Polishing Filter



# Contact Adsorption Clarifier

Units are backwashed or “rinsed” at the same rate and direction that they filter, except rather than the water going to the top of the filter, it is diverted to waste.

ContaClarifer™ rinse initiated at 5-6 psi (26 – 31 inches head)

1st Stage of Rinse:

- 4.5 min air/water flush
- Air Scour Rate @ 840 cfm (140 $ft^2$ x 6 $cfm/ft^2$)
- Water rinse @ 10 $gpm/ft^2$ (1,400 gpm/140 $ft^2$)

2nd Stage of Rinse:

- 6 min water rinse only @ 10 $gpm/ft^2$

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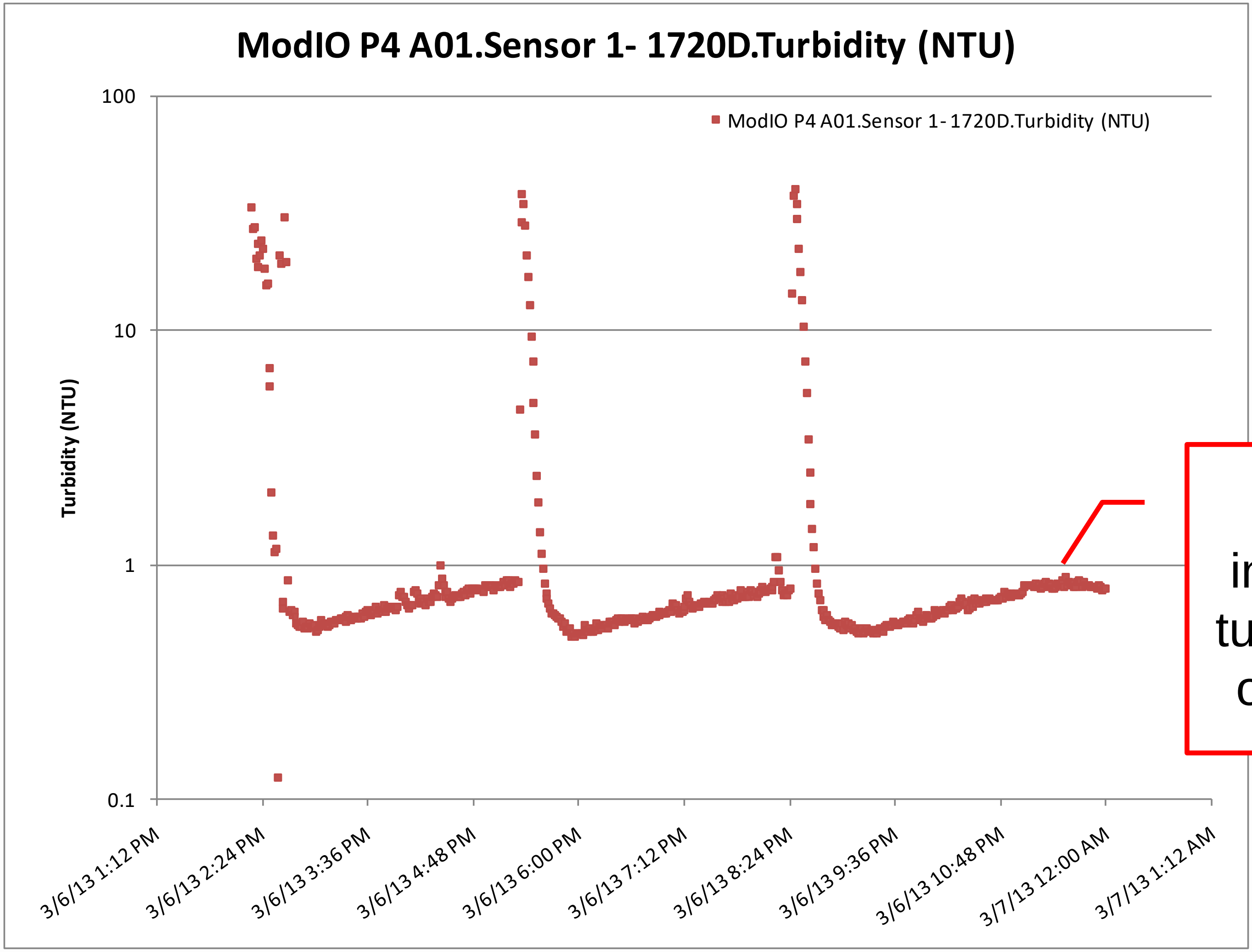
# Contact Adsorption Clarifier

Individual CAC Unit Turbidity Data (HACH 1720D)




CAC units exhibit similar characteristics as normal filters

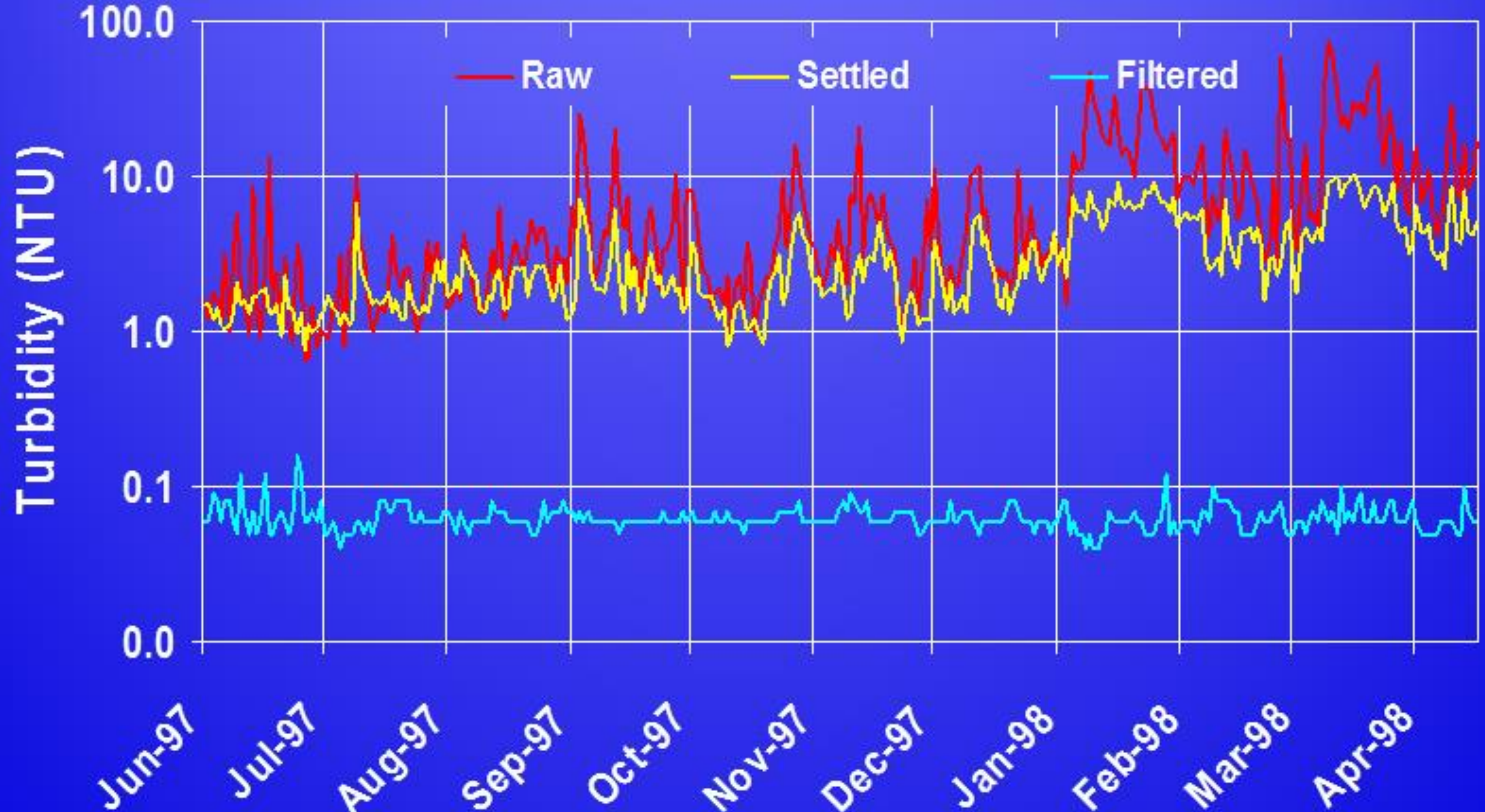
Data shows slight increase of clarified turbidity towards end of run prior to rinse

# Clarification Optimization Objectives

- Achieve clarified/settled water performance goals.
- Maintain consistent performance during varying source water conditions.

Oregon Health Authority

# Example Data For Plant With Uncontrolled Settled Water Turbidity

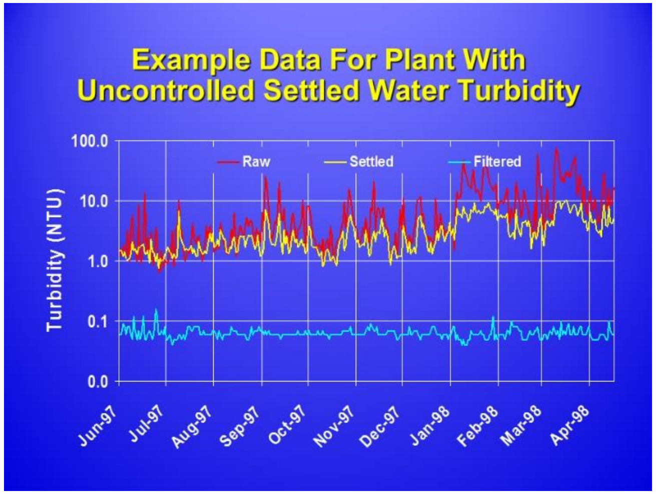


# The filtered water is less than 0.1 NTU, so what is the problem?

1) The objective is to provide multiple barriers for pathogen removal – this performance relies heavily on the filters.

2) Could the good filter performance be due to a low filter loading rate (gpm/sf). What will happen when flow through the plant increases?

3) What will happen if there is a heavy rainfall or flooding? Will the filters continue to meet 0.1 NTU when raw water turbidity spikes?



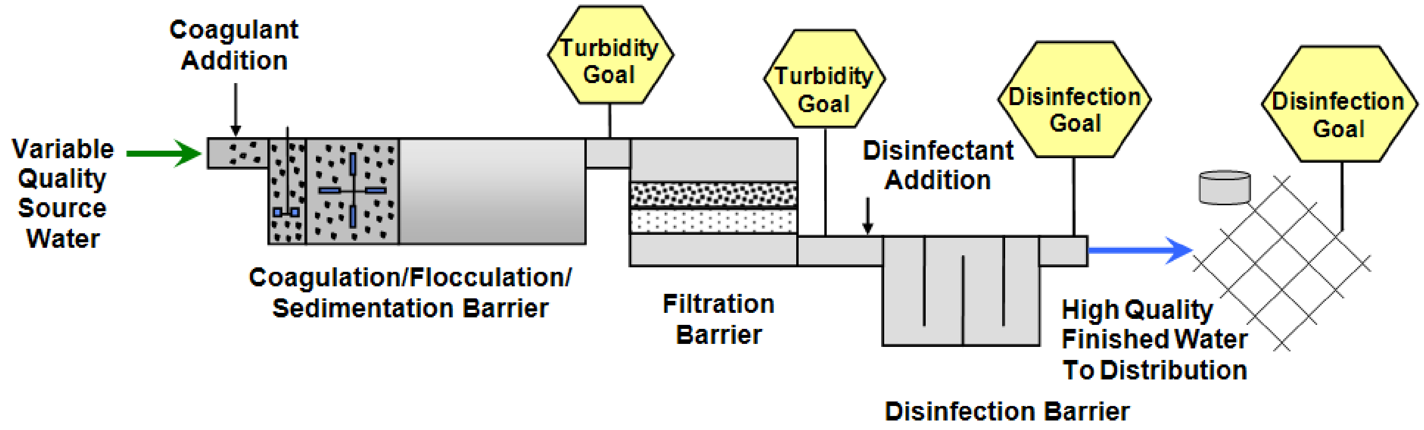
# Sedimentation Optimization
# Possible Special Studies

- Inadequate coagulation/overfeed.
- Unequal loading to multiple units.
- Turbidimeter data integrity (i.e., sample line cleaning issues).
- Mass control in solids contact units
  (unit start-up and sludge wasting).
- Polymer type and dose impact on contact adsorption clarifiers.
- Impact of “floc-bubble” aggregate characteristics on dissolved air flotation.

# Optimization Goals for Settled Water Turbidity

Practice should embrace the multiple barrier approach, meeting optimization goals 95% of the time.

| Water Treatment Plant Optimization Goals | | |
|---|---|---|
| SEDIMENTATION (for conventional systems) | Turbidity Goal | Criteria |
| Settled water | ≤ 2.0 NTU, 95% of the time. | If average annual raw water turbidity is > 10 NTU |
| Settled water | ≤ 1.0 NTU, 95% of the time. | If average annual raw water turbidity is ≤ 10 NTU |



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# Conventional and direct filtration

- Commonly called “rapid sand” or “rapid rate” filtration (as opposed to slow sand filters at 0.1 $gpm/ft^2$)
- Filtration rate typically 2-4 $gpm/ft^2$
- Requires controllable backwash with water and perhaps air scour.
- Mixed media filters: layers of support gravel, sand, anthracite.

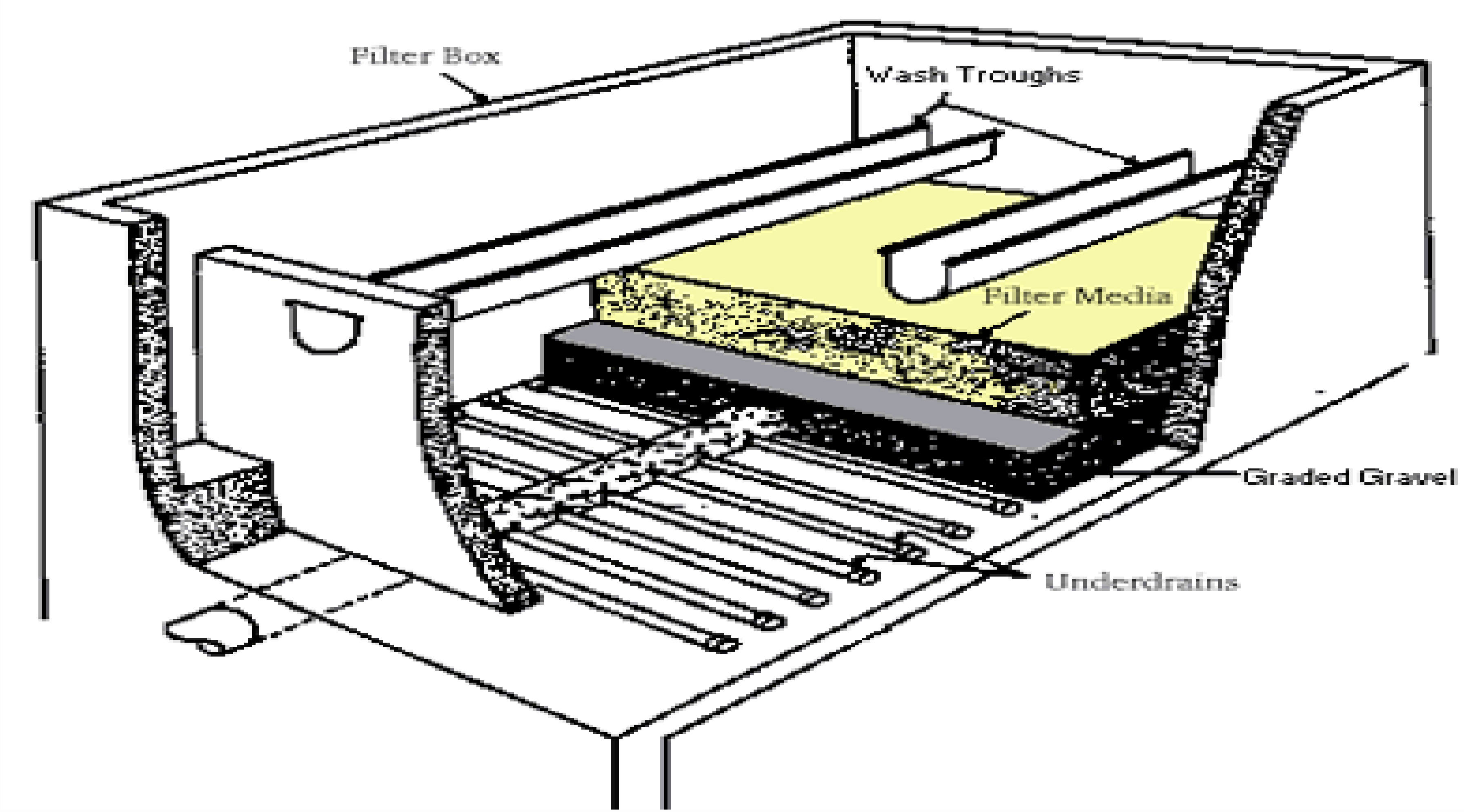
| Typical Filtration Loading Rates | |
|---|---|
| Sand Media | 2.0 $gpm/ft^2$ |
| Dual/Mixed Media | 4.0 $gpm/ft^2$ |
| Deep Bed (Typically anthracite >60 in. in depth) | 6.0 $gpm/ft^2$ |

# “Ten States Standards”


Ten States Standards
http://10statesstandards.com/index.html

| Member States and Provinces | |
|---|---|
| Illinois | New York |
| Indiana | Ohio |
| Iowa | Ontario |
| Michigan | Pennsylvania |
| Minnesota | Wisconsin |
| Missouri | |

# Typical Filter “Box”



# Media

Water flows through progressively larger pores as it passes from coal to sand to gravel.

This example shows the following from top to bottom (as the water would flow)

1. Anthracite
2. 2 layers of sand
3. 3 layers of support gravels
4. “Block” underdrain

# Media

Example shown is from the City of Grants Pass

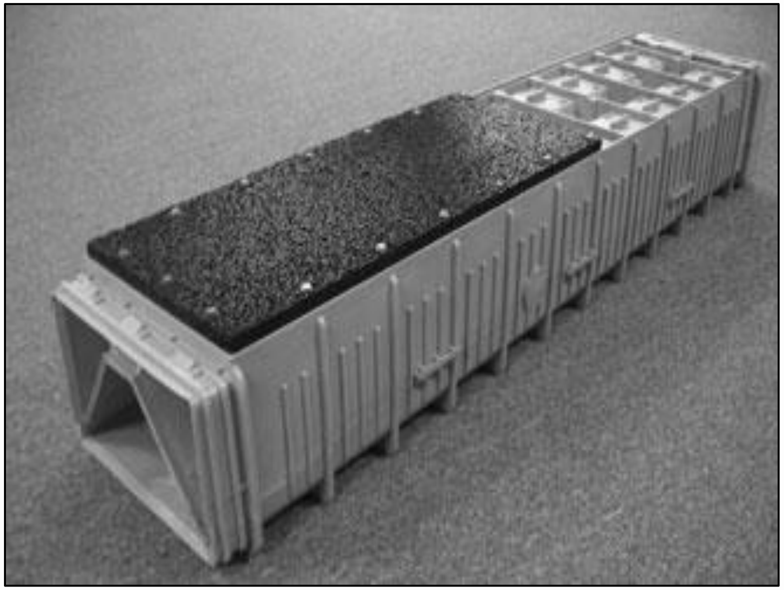
- Top Layer Anthracite
- Layer 2 Filter sand

  (Silica sand w/ D10 = 0.45 mm- 0.55 mm)
- Layer 3 #50 garnet sand
- Layer 4 #12 garnet gravel
- Layer 5 3/8” x 3/16” gravel
- Layer 6 3/4” x 3/8” gravel
- Bottom layer 1-1/2” x ¾” gravel

# Conventional and direct filtration

Underdrains can be a series of perforated pipe or proprietary underdrain “block”, or “folded plate” underdrains.

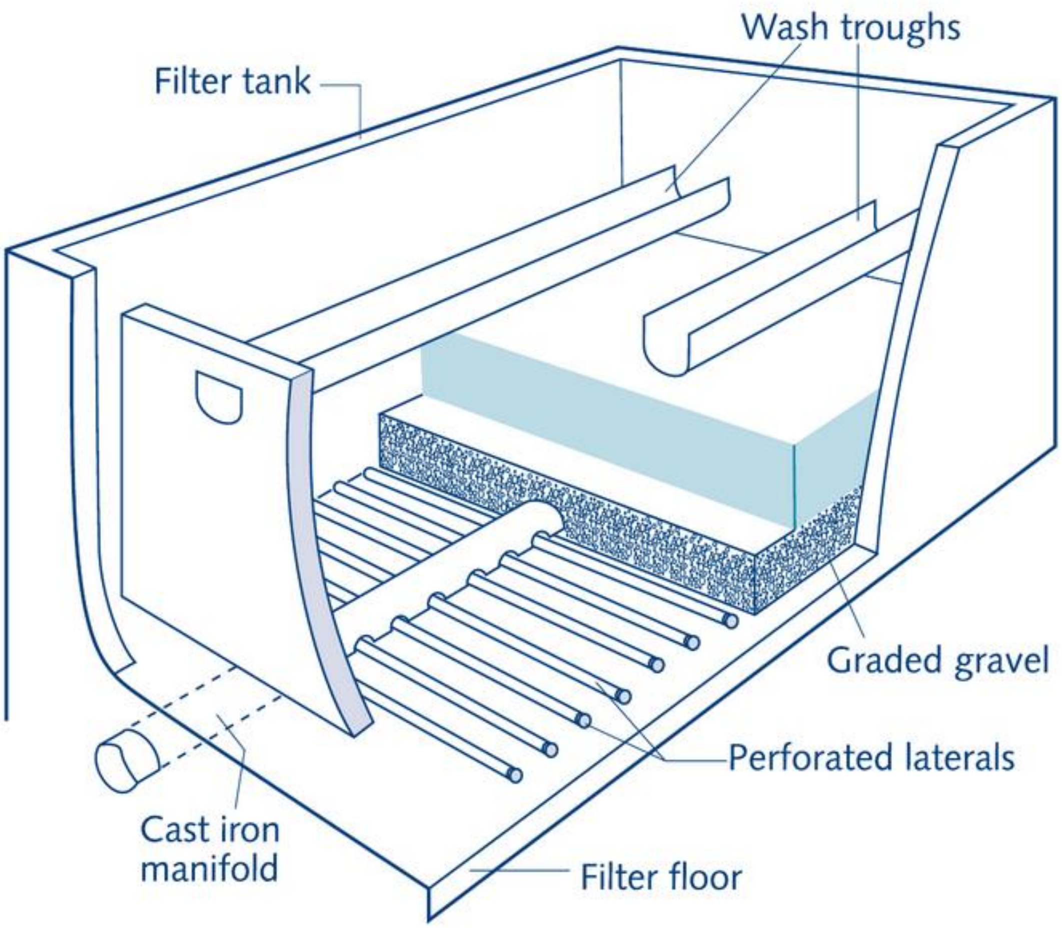
Ovivo Flexscour® “folded plate”



Xylem Leopold® “block”

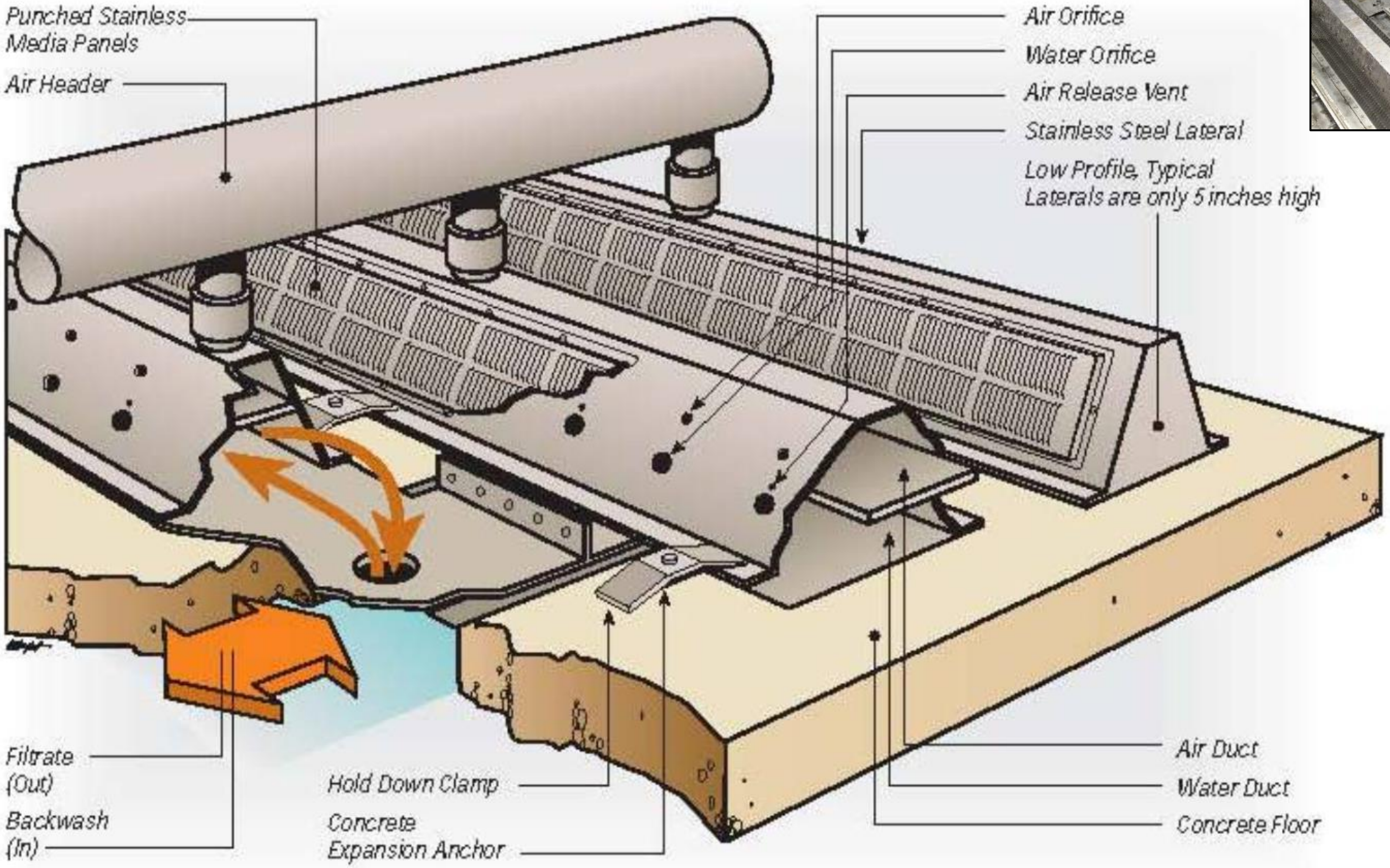
Oregon Health Authority

# Conventional and direct filtration



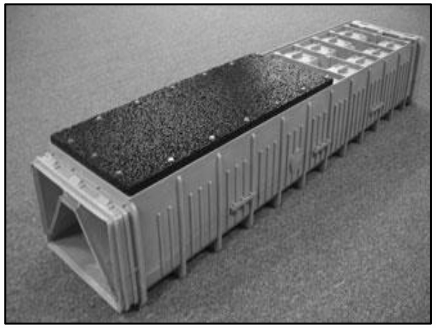

Perforated Pipe Underdrains

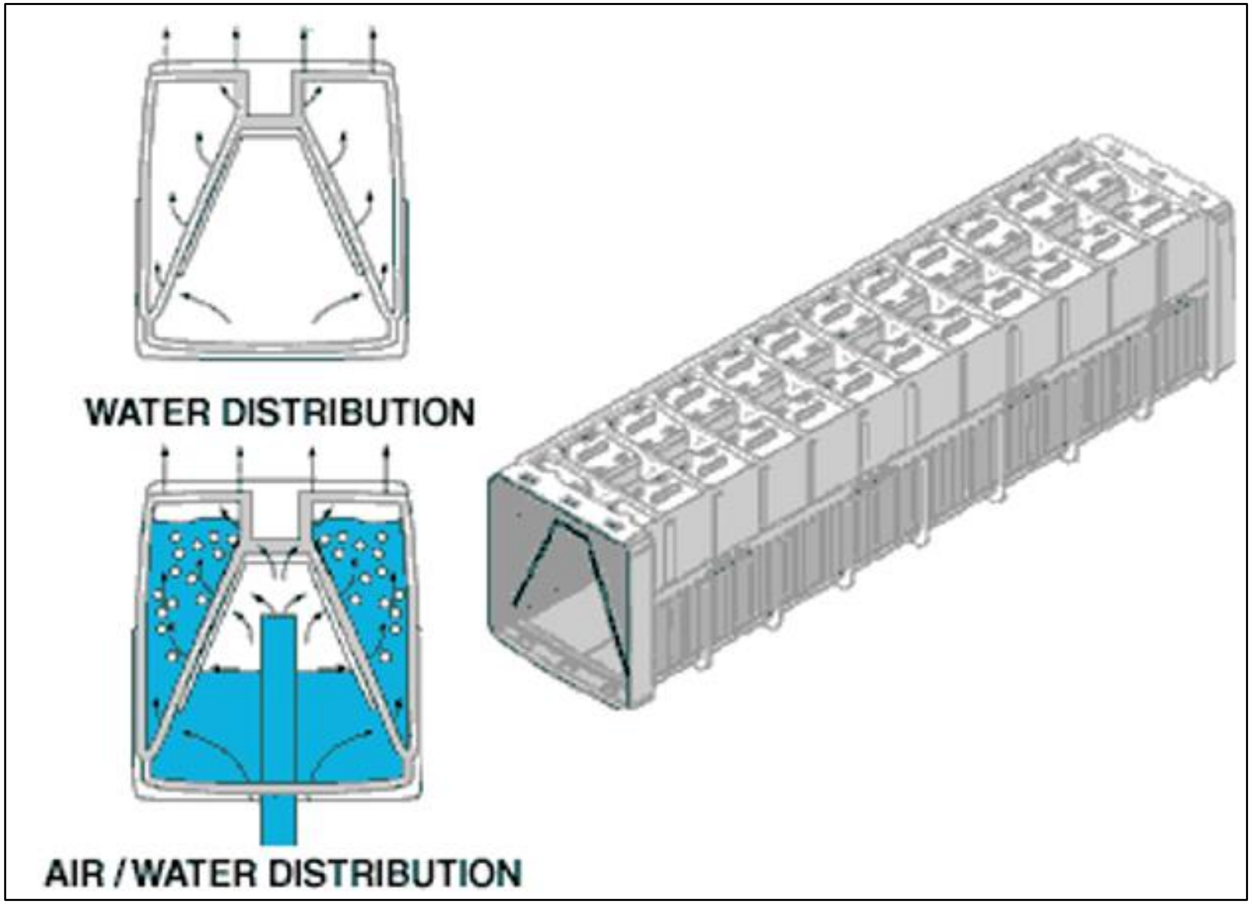
# Conventional and direct filtration




Ovivo Flexscour® Folded Plate Underdrains

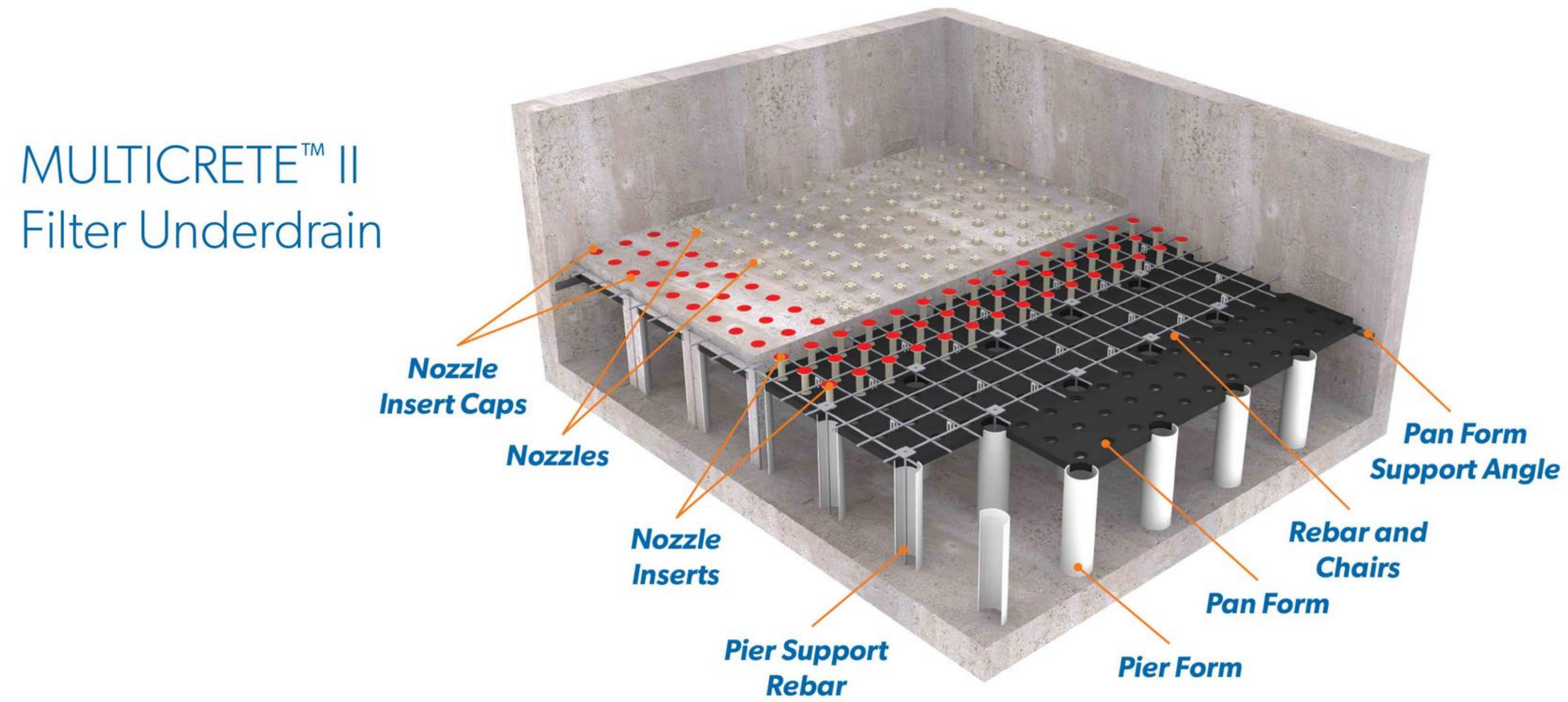
# Conventional and direct filtration






Xylem Leopold® "Block" Underdrains

# Conventional and direct filtration



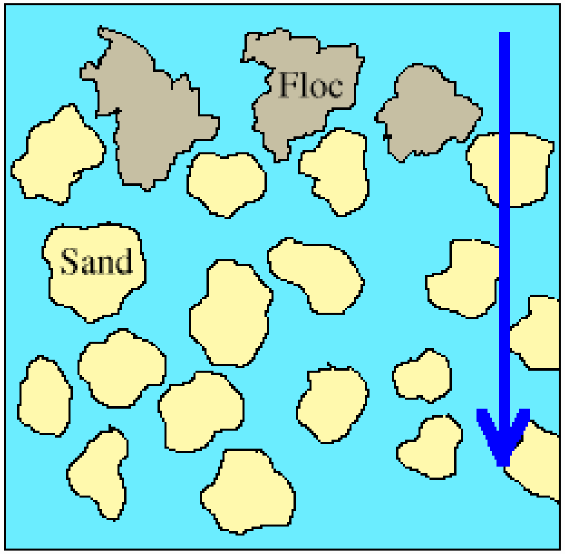

WesTech® Multicrete™ II Filter Underdrain

# Conventional and direct filtration

Involves adsorption and physical straining of flocculated particles.

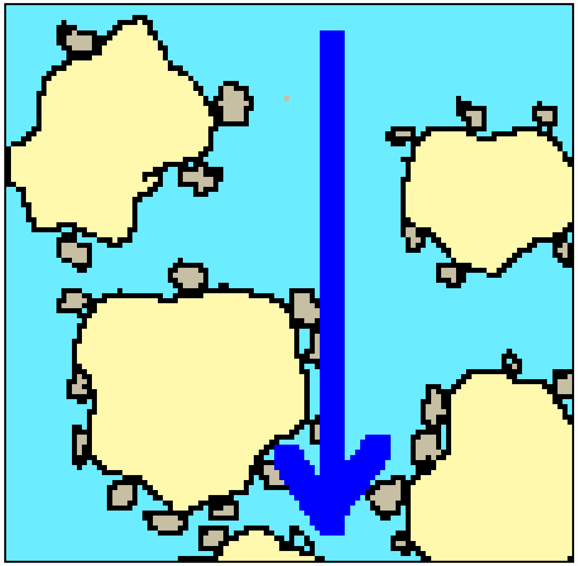
Straining:

Passing the water through a filter in which the pores are smaller than the particles to be removed

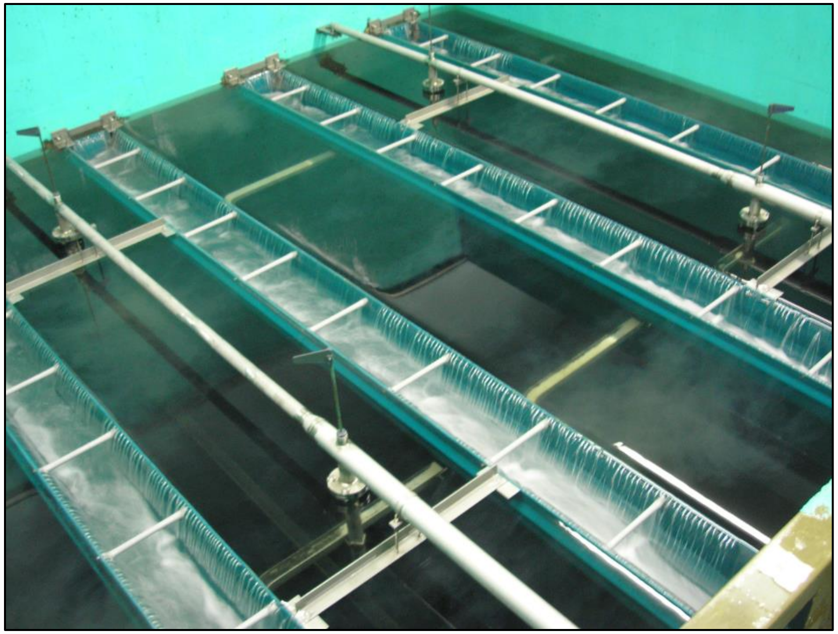



Adsorption:

The gathering of gas, liquid, or dissolved solids onto the surface of another material

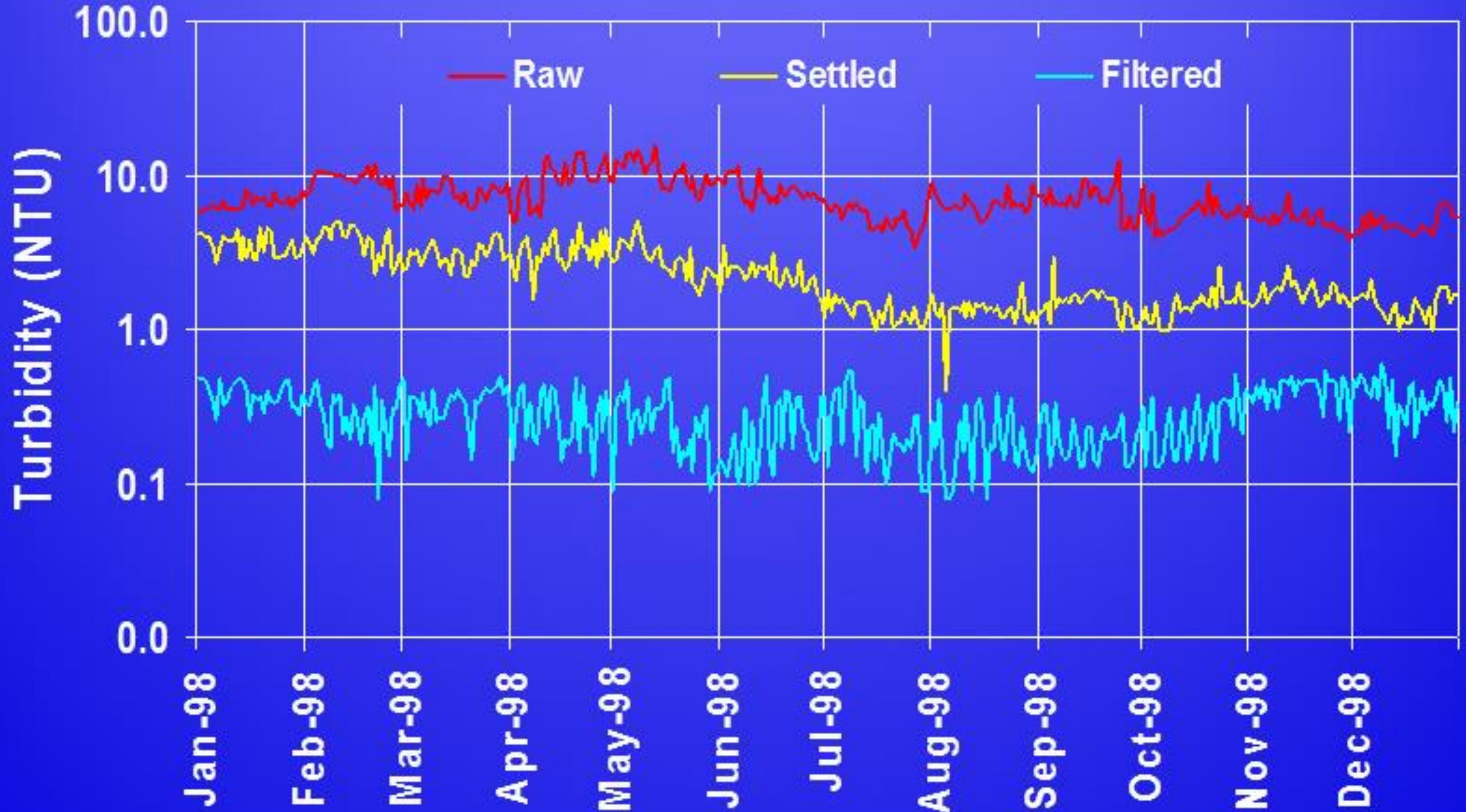


# Filtration Optimization Objectives



- Achieve filtration performance goals.
- Minimize turbidity spikes during routine filter operation.
- Minimize turbidity spikes following filter backwash.

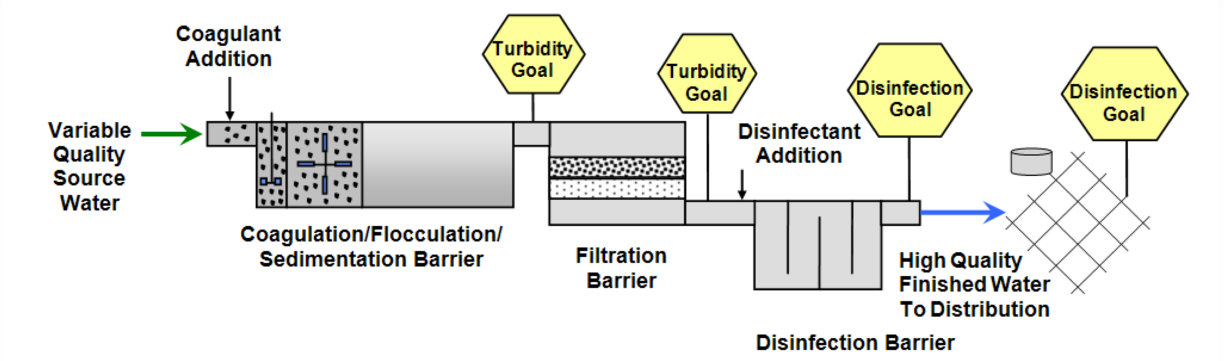
# Example Data For Plant With Uncontrolled Filter Effluent Turbidity



# Optimization Goals for Filter Effluent Turbidity

Practice should embrace the multiple barrier approach.

| FILTRATION (conventional and direct systems) | Turbidity Goal | Criteria |
|---|---|---|
| IFE and CFE filtered water | • Turbidity ≤ 0.10 NTU, 95% of the time<br>• Max turbidity ≤ 0.30 NTU. | Based on maximum values recorded during 4-hour increments (excluding the 15 minute period following backwash) |
| IFE filtered water after backwash | • Turbidity returns to ≤ 0.10 NTU within 15 minutes after backwash.<br>• Max spike ≤ 0.30 NTU.<br>• Turbidity at return to service ≤ 0.10 NTU. | Goals apply to both systems with and without filter-to-waste capability.<br>Goals apply to the backwash recovery period starting immediately after backwash. |



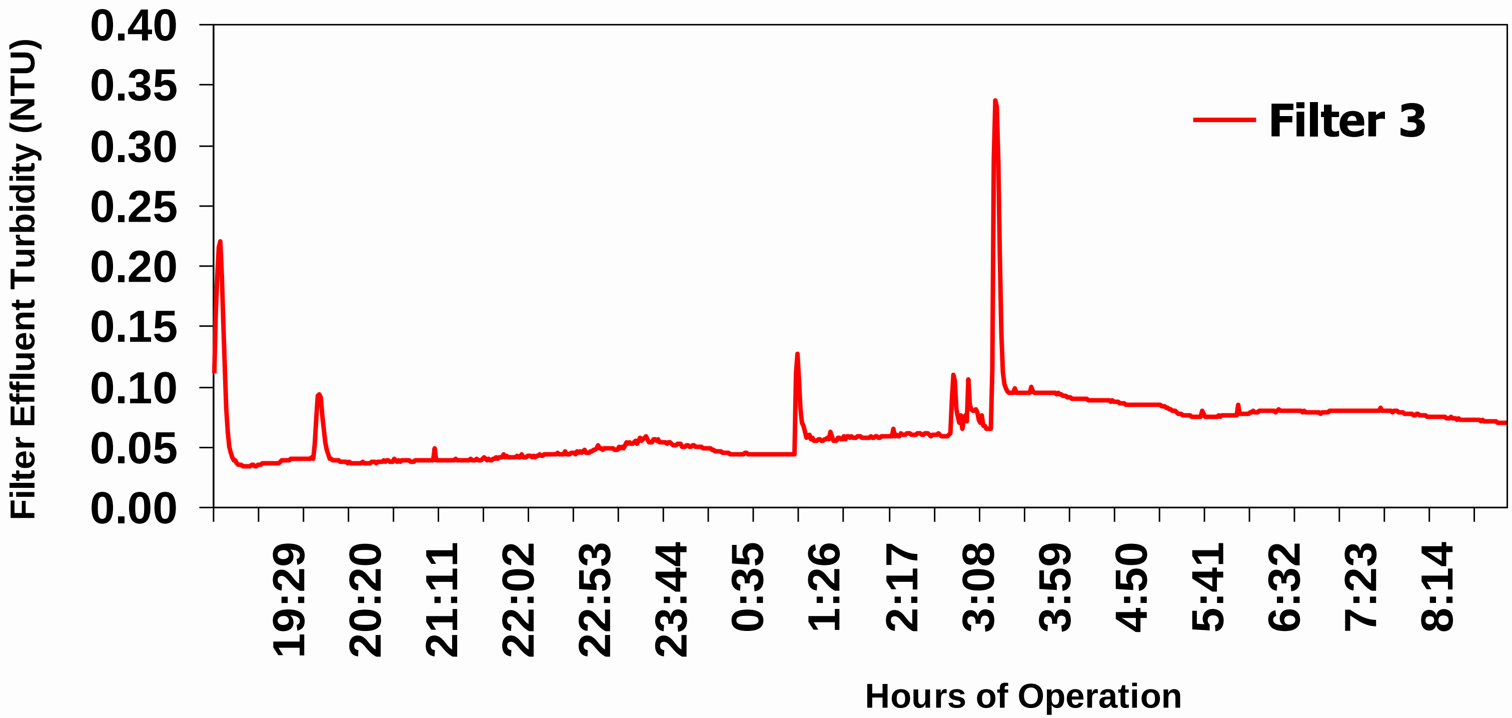
# Filtration Optimization

## Lowering Filter Effluent Turbidity

- Possible Special Studies:
  - Coagulation control (use your calibrated jar test procedure!)
  - High settled water turbidity (solids loading)
  - Initiation of backwash (before breakthrough)
  - Media depth and type of media
  - Impact of manganese removal on filter performance (oxidation of manganese with chlorine or permanganate can result in small $MnO_2$ particles that are difficult to settle and filter out).

Oregon Health Authority

# Example Data Showing Turbidity Spike Control Problem



# Filtration Optimization
## Spike Control During Routine Operation

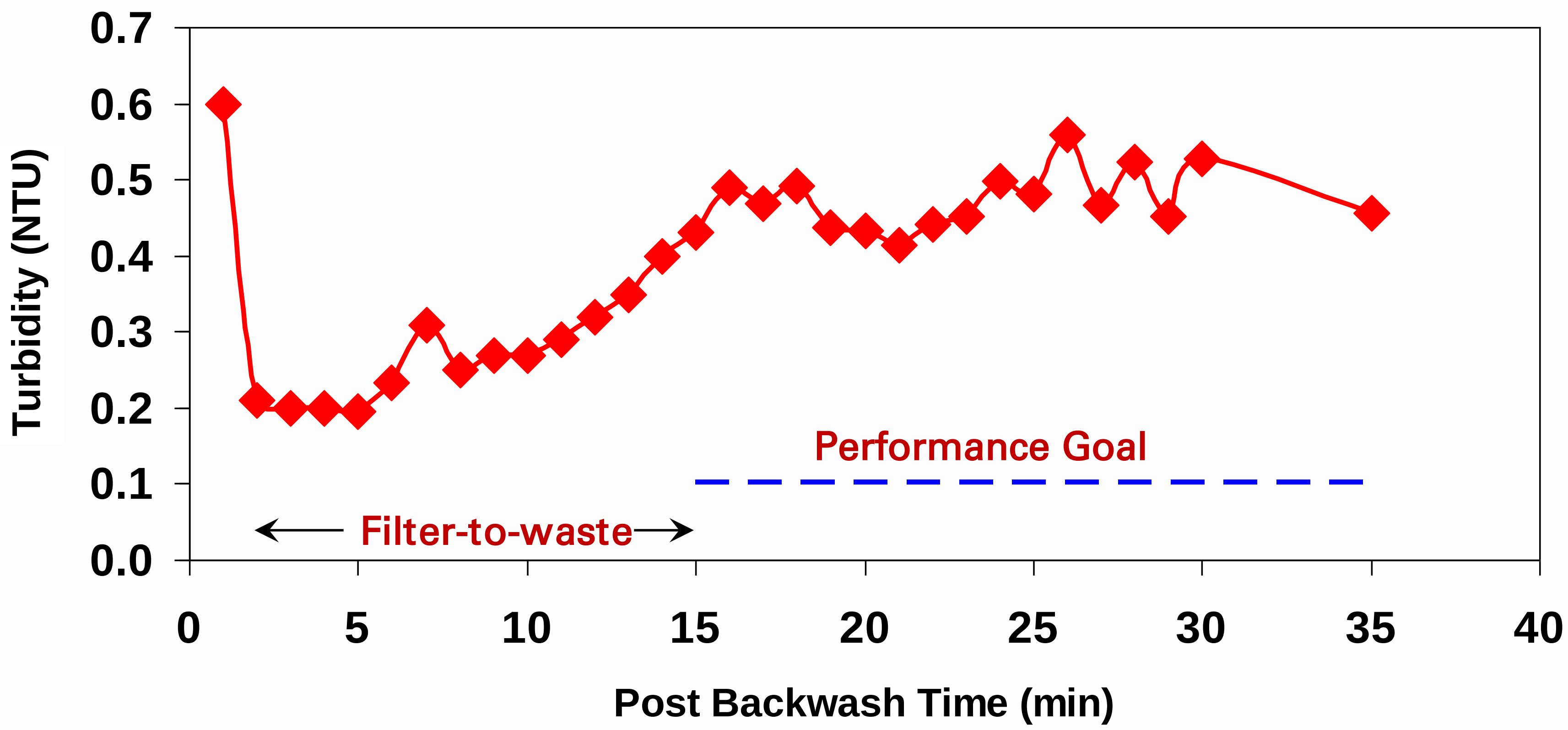
- Possible Special Studies:
  - Raw and settled water quality variations (storm events)
  - Hydraulic surges due to flow rate changes
  - Start-up/stop operation (small plants)
  - Filter backwash effects on loaded filters
  - Turbidimeter data integrity (e.g., sample line, sample flow rate). Long sample lines increase signal delay and can allow particles to settle out causing periodic spikes.

# Filtration Optimization

## Spike Control During Routine Operation (cont.)

- Possible Special Studies (cont.):
  - Unequal flow splitting between unit processes
  - Return of plant recycle flow
  - Malfunctioning filter rate control valves
  - Others?

# Example Data For Post Backwash Turbidity Spike Control Problem



# Filtration Optimization

## Spike Control Following Backwash

- Possible Special Studies:
  - Inadequate chemical conditioning of water
  - Backwash procedures:
    - Lack of or inadequate surface wash or air scour
    - Backwash flow rate (media expansion)
    - Backwash duration<br>(too short → dirty filters; too long → too clean)
    - Rapid start-up/shut-down of backwash flow (gradual ramping allows for media to gradually expand and re-stratify)
    - Applying an extended sub-fluidization (not enough to fluidize media) step at end of backwash (~1 bed volume)
    - Length and rate of filter-to-waste
    - Lack of or length of filter resting period

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# Filtration Optimization
## Spike Control Following Backwash (cont.)

- Possible Special Studies (cont.):
  - Use of filter aid
  - Addition of coagulant or polymer to backwash supply water at the end of the backwash cycle to “condition” the water remaining in the filter.
  - Loss of filter integrity:
    - Loss of media
    - Damaged underdrains
    - Mud balls in media
    - Cracks or sidewall channels in media
  - Others?

Oregon Health Authority

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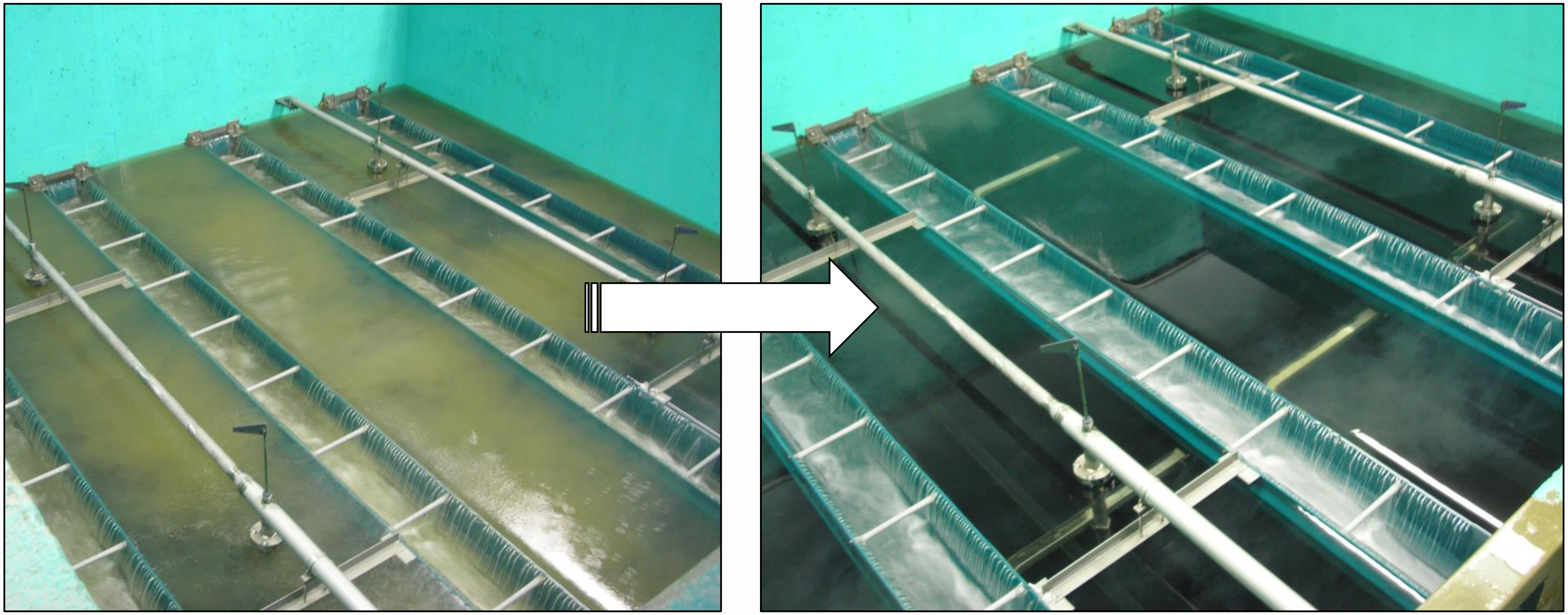
# Optimizing Backwash

- Backwashing is conducted in order to remove particulates built up in the filter.
- Headloss, time, and turbidity can all be indicators of when to backwash.



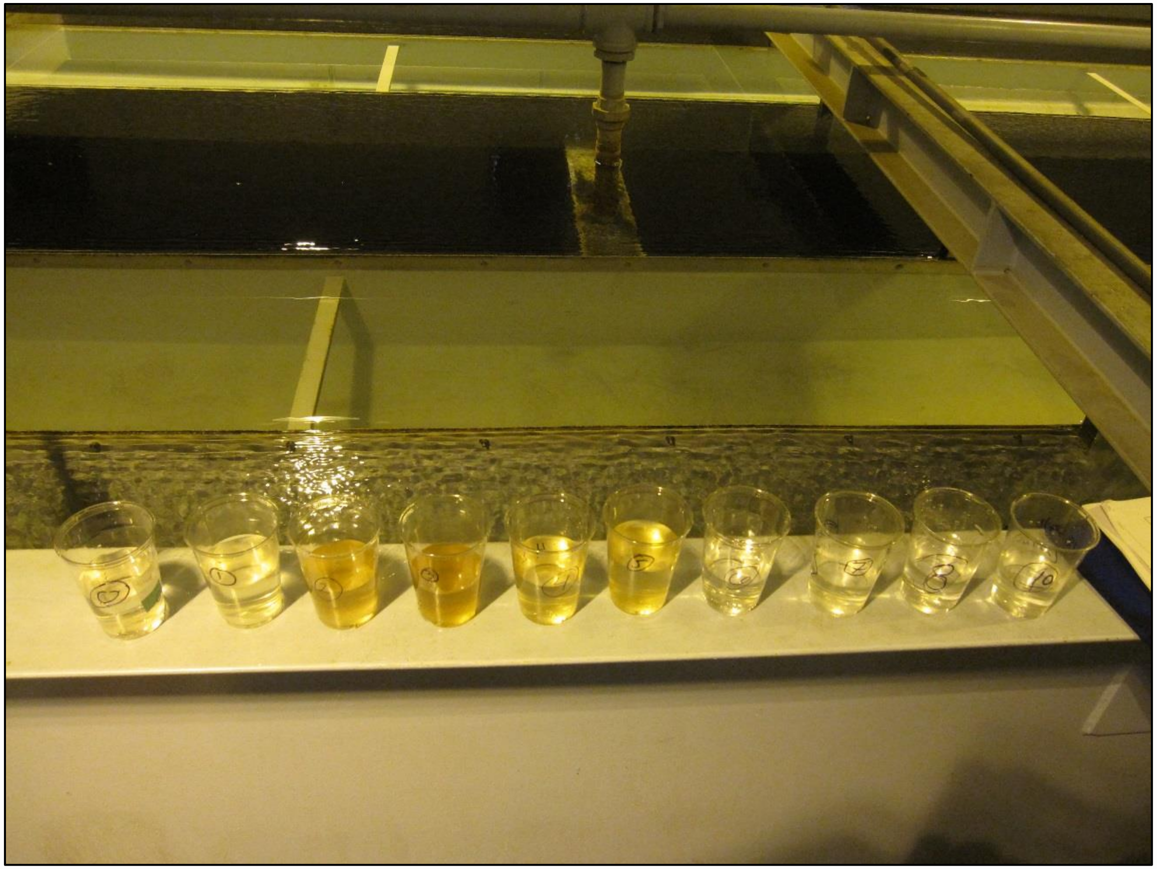
Fort Richardson, AK

# Optimizing Backwash

If backwashing is ineffective, mud balls can develop in the filter, which results in plugged portions of the filter and high localized loading rates (due to the plugged portions).

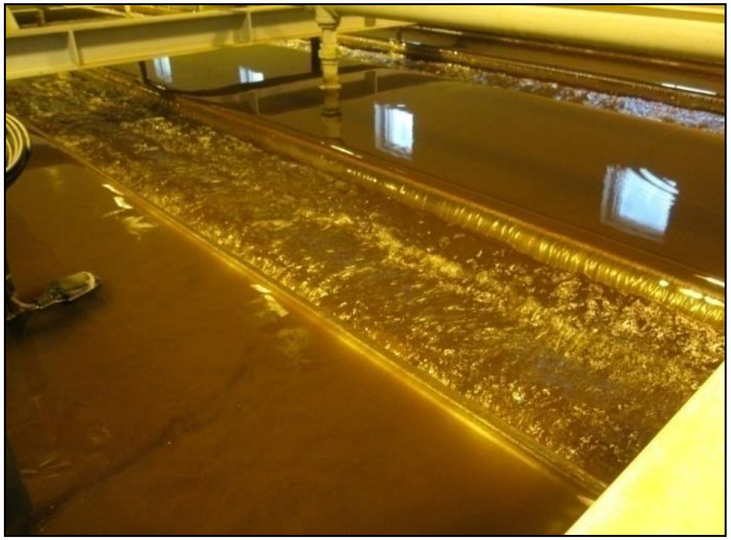
# Optimization Studies - Backwash

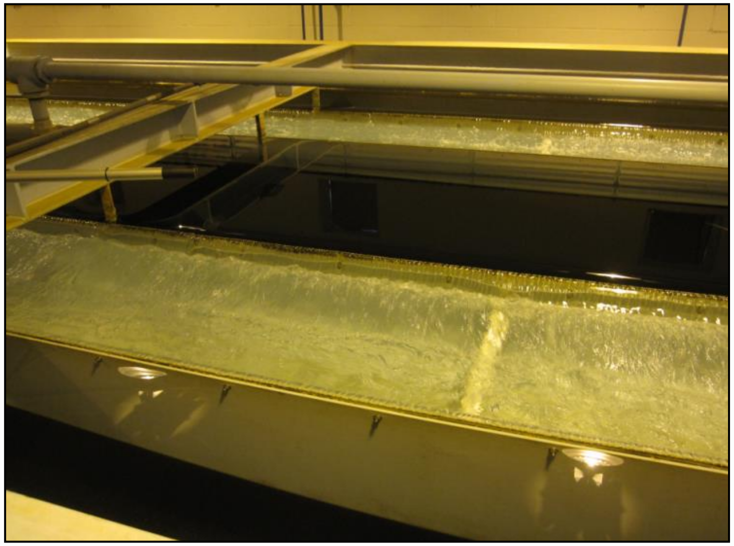
Backwash trough turbidity can provide a quick evaluation of how well your backwash process is working and where to optimize the process.



# Backwash Trough Turbidity Profile

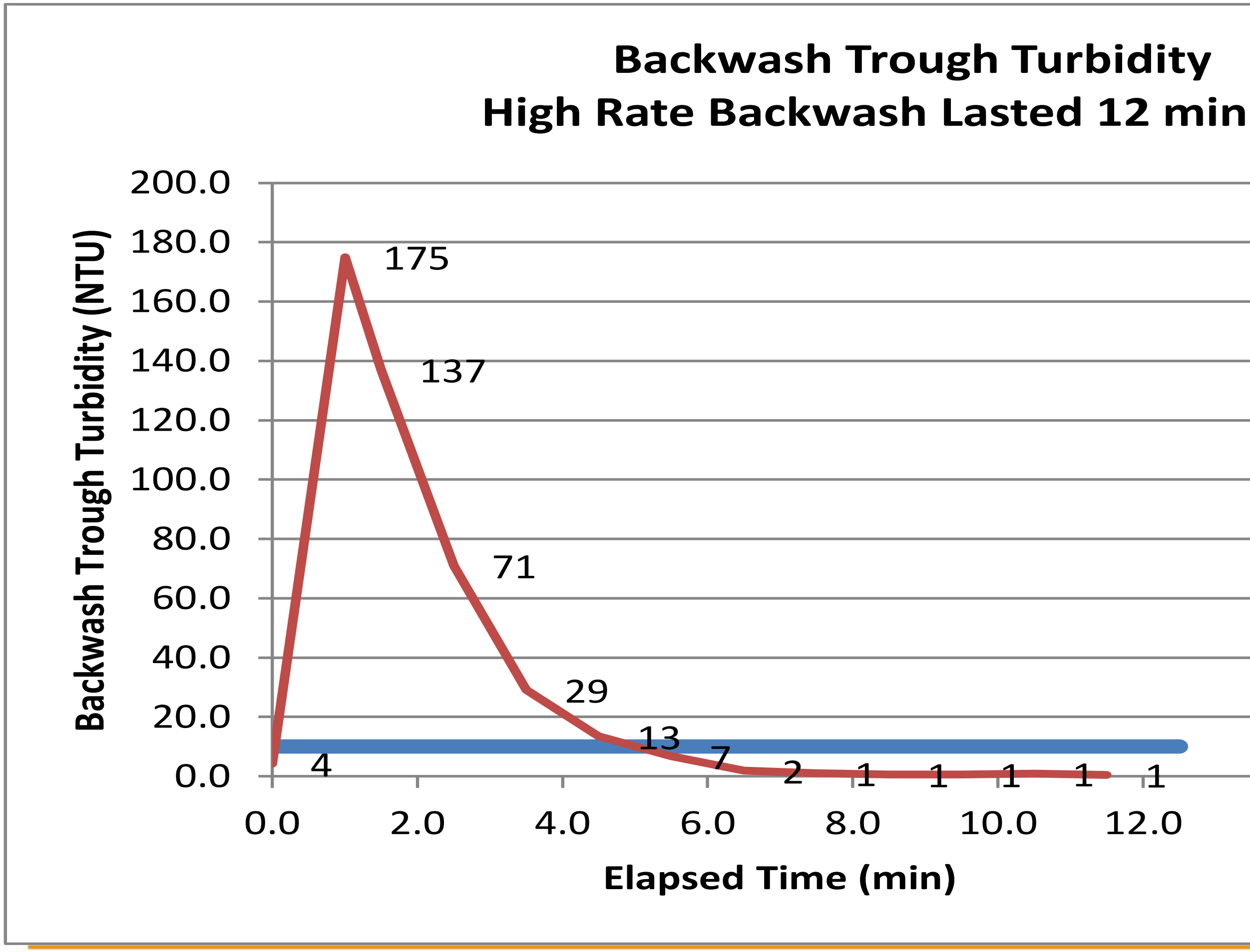
1. Measure grab samples for turbidity at 1 minute intervals during high rate backwash.
2. Record and plot results to see how fast the filter cleans up.





# Backwash Trough Turbidity

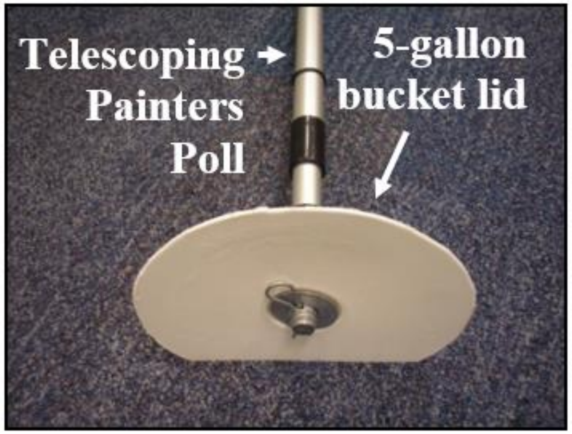
- Develop a graph of your results to help in your evaluation.
- Backwashing to where the trough turbidity is below 10 NTU has little benefit and wastes water. 10-15 NTU at the end of the backwash is a reasonable target.

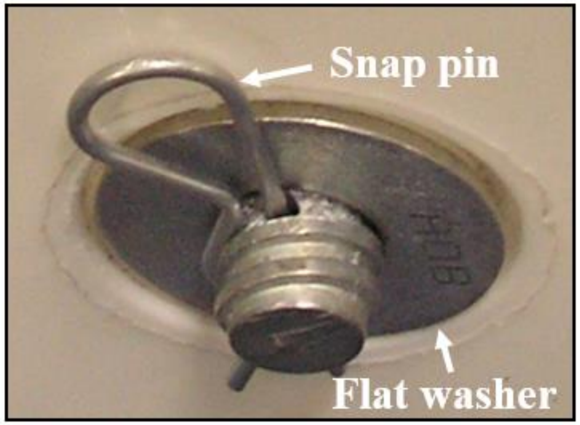


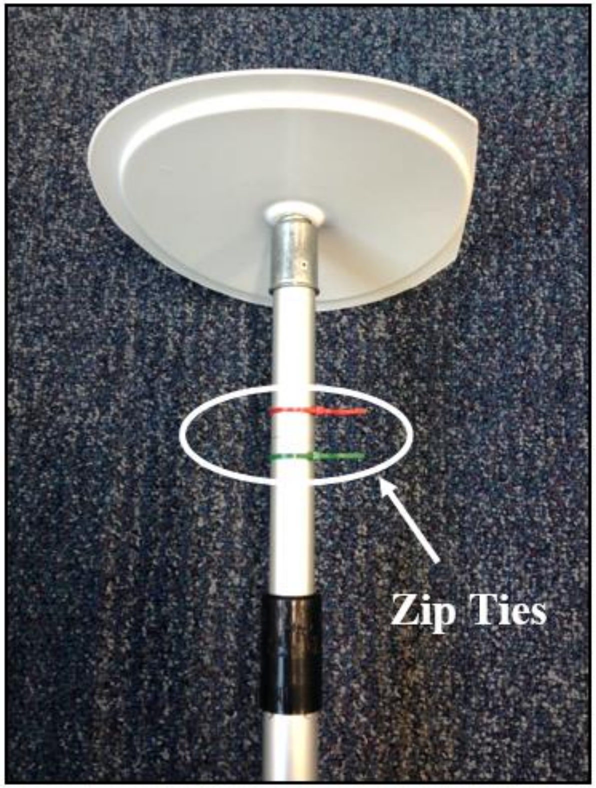

# Measuring Bed Expansion During Backwash

Measured bed expansion should be about 20% and such that media is not lost out the backwash trough.

Measurements are easy using a tool you can make yourself.



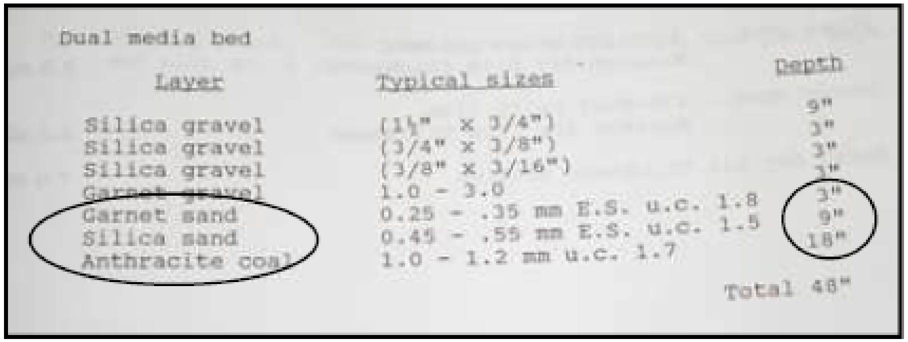




# Bed Expansion

The calculation is simple.

Measure the distance of expansion and divide by the depth of expandable media



Dual media bed

| Layer | Typical sizes | Depth |
|---|---|---|
| Silica gravel | (1½" x 3/4") | 9" |
| Silica gravel | (3/4" x 3/8") | 3" |
| Silica gravel | (3/8" x 3/16") | 3" |
| Garnet gravel | 1.0 - 3.0 | 3" |
| Garnet sand | 0.25 - .35 mm E.S. u.c. 1.8 | 3" |
| Silica sand | 0.45 - .55 mm E.S. u.c. 1.5 | 9" |
| Anthracite coal | 1.0 - 1.2 mm u.c. 1.7 | 18" |
| | | Total 48" |

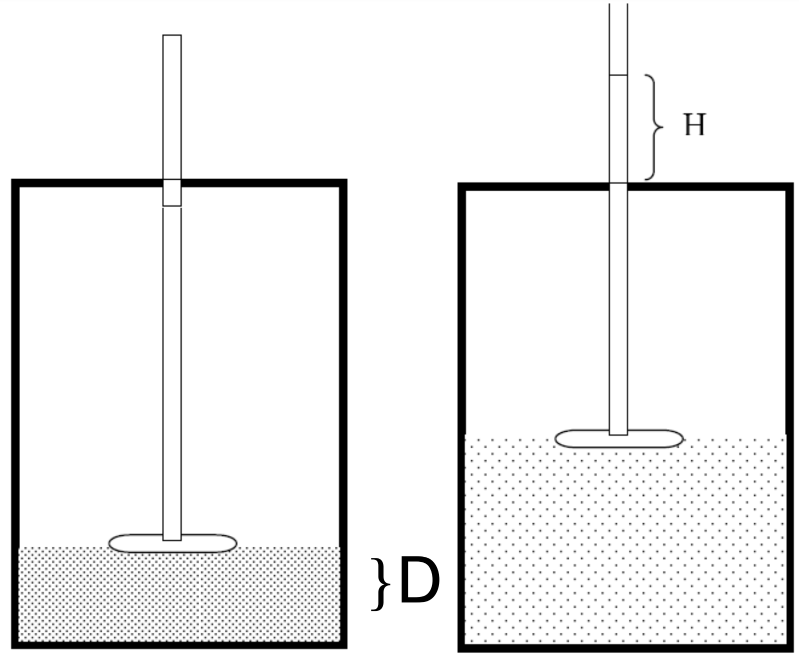
H = 7-inches (measured)

D = 30-inches (sand & anthracite depth)

% Expansion = 100% * (H / D)

% Expansion = 100% * (7/30) = 23%

<u>**Expansion should be 20% or more**</u>

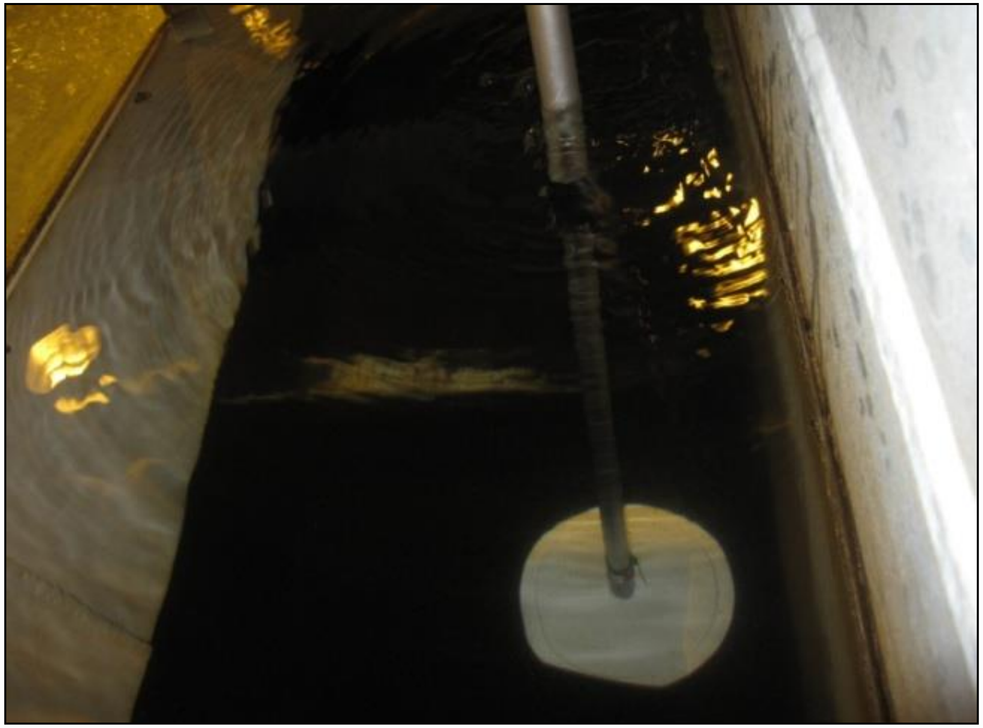


# Bed Expansion

1. With the filter at rest, measure media depth to a fixed reference (filter side wall)
2. Move the top zip tie level with the fixed reference

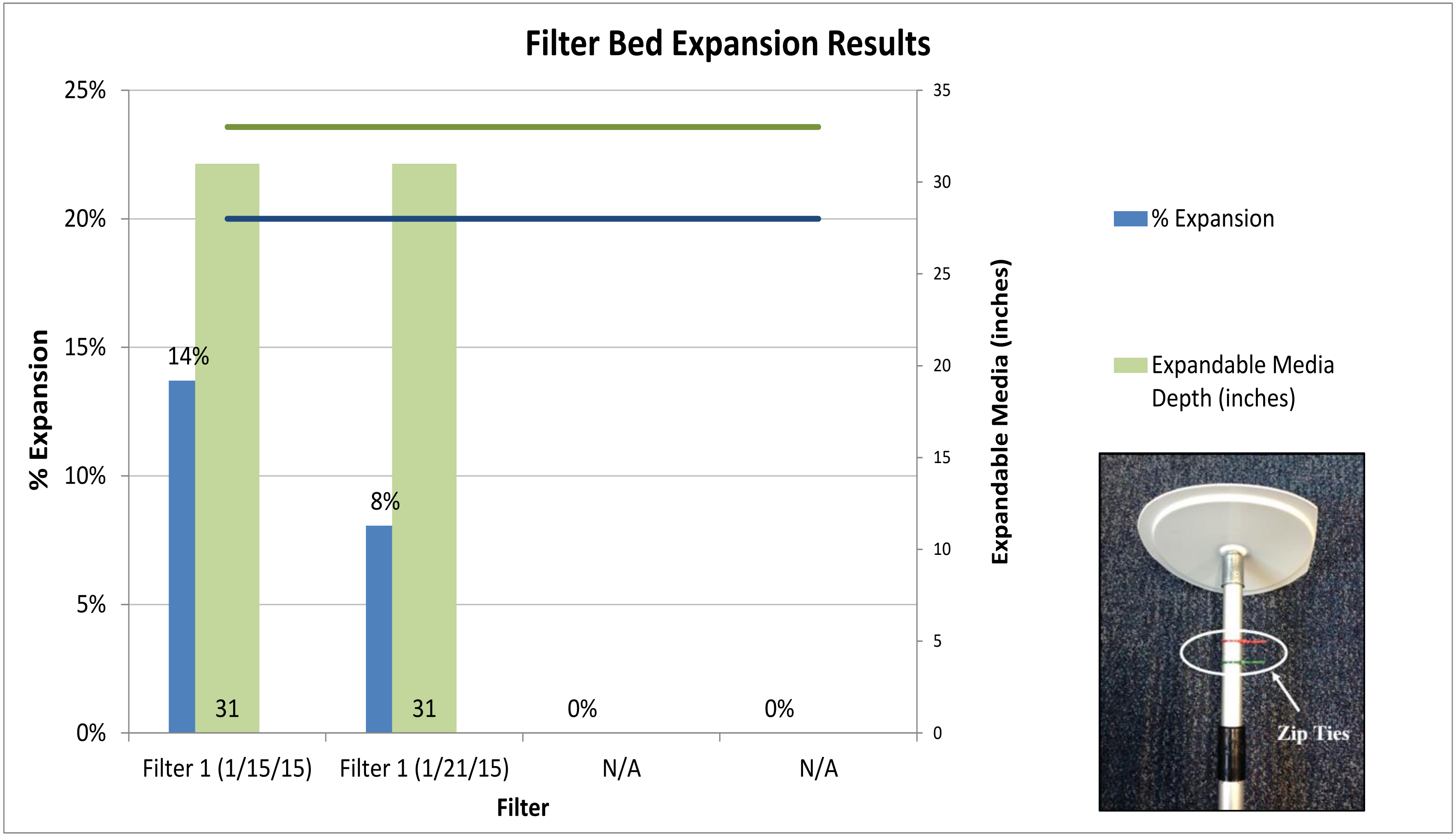
# Bed Expansion

3. During backwash, move bed expansion tool upwards until expanded media is just able to float over the white disk
4. Move the bottom zip tie level with the fixed reference
5. Measure the distance between the zip ties (the expansion) and divide by the depth of expandable media



# Graph of Bed Expansion Results

## Bed expansion was 8-14%



# Other Observations During Backwash

Check operation and condition of surface wash.

- Surface wash arm should rotate during the first phase of the backwash, but not continue throughout the backwash.
- This system had a surface wash that continued through to the end of the backwash, causing mounding in the filter bed.

# Other Observations During Backwash

Mounding of media after a backwash due to continuous surface wash.

# Other Observations During Backwash

Mounding of media after a backwash due to continuous surface wash.

# Other Observations During Backwash

Check operation and condition of surface wash.

- Surface wash arm should be around 2” above the top of the media
- Corrosion may develop at junctions of dissimilar metals – use dielectric coupling
- Nozzles may be plugged or gasket may be leaking at arm junction causing weak jet as evidenced by slow or lack of arm rotation



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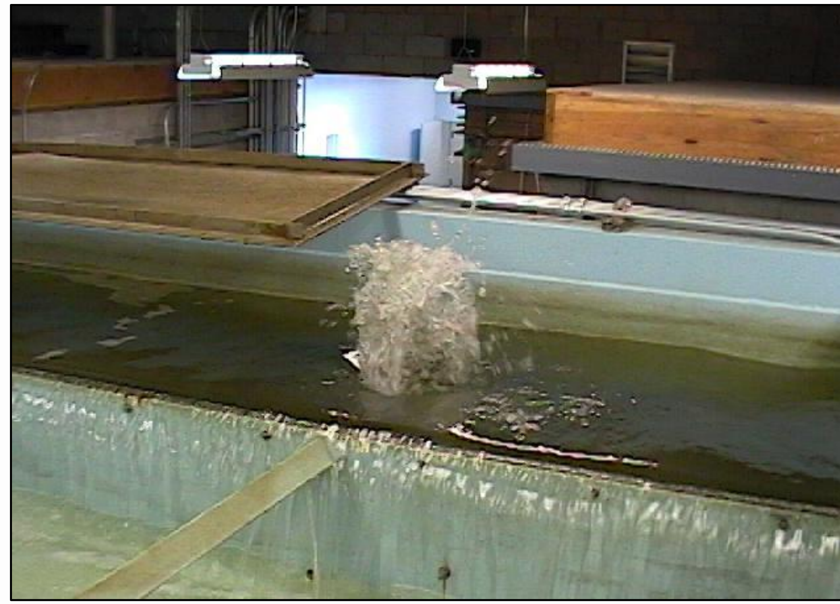
# Other Observations During Backwash

Look for evidence of air binding that may be due to high dissolved oxygen in colder waters being released inside a warmer plant or air binding as a result of vacuum conditions created in a clogged filter.



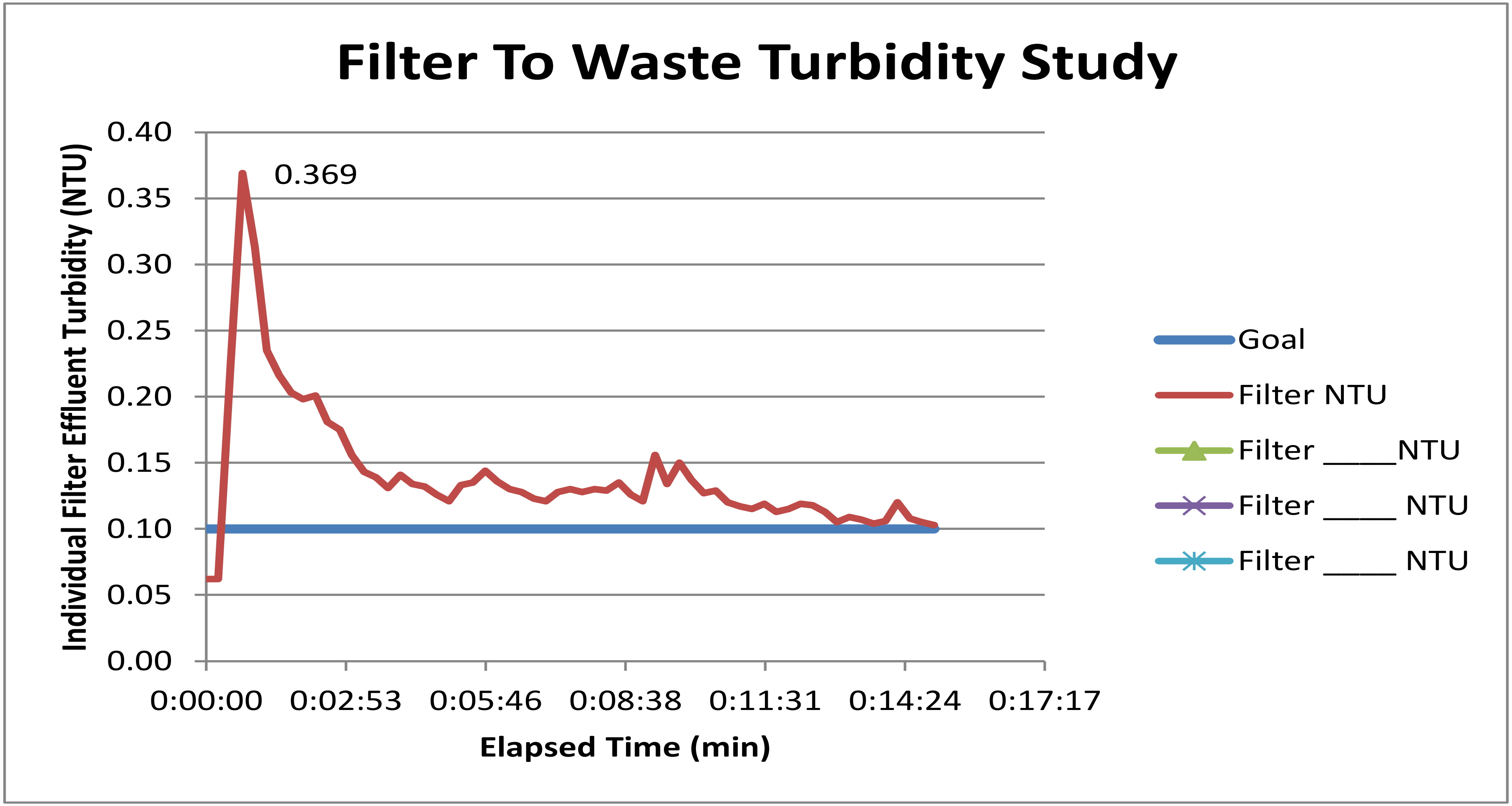
Air binding in a contact adsorption clarifier in California

# Filter-to-waste Turbidity

Measure filter-to-waste turbidity and plot data

Goal is to minimize post backwash spikes and return filter to service at

≤ 0.10 NTU.



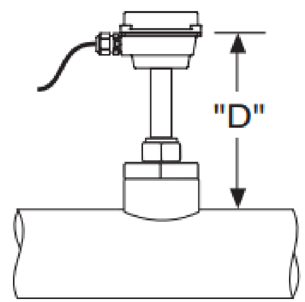
# Verify Plant Flows

Verify Plant Flows – 195 gpm or 4,700 gpm???

| | |
|---|---|
| Math error in converting to gpm: | 195 gpm => 4,700 gpm |
| Wrong calibration factor (K): | 4,700 gpm => 243 gpm |
| Wrong insertion depth (D): | 243 gpm => 217 gpm |

1 ≠ K = 19.545

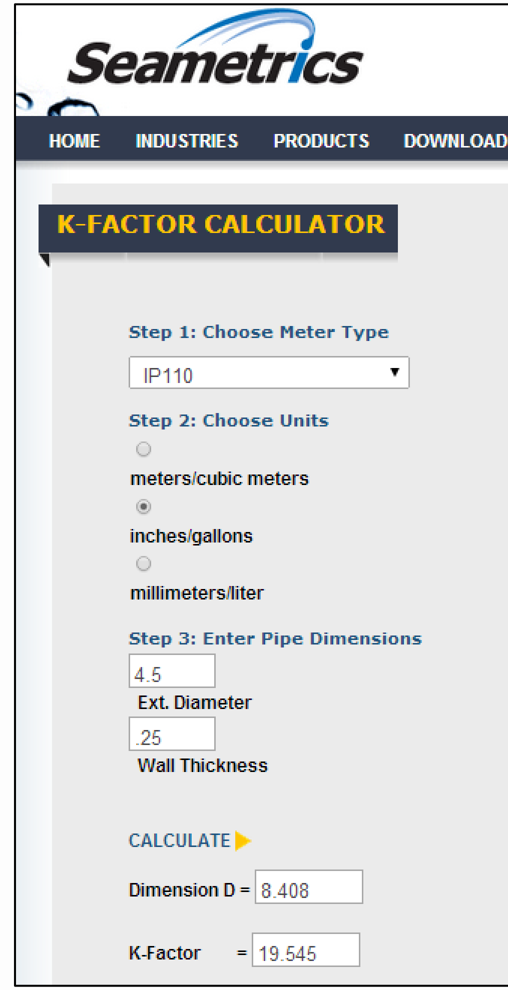
6.5 ≠ D = 8.408”

**Depth Setting.** It is important for accuracy that the sensor be inserted to the correct depth into the pipe.



1. Please visit **www.seametrics.com** and select the **K-factor Calculator** located at the bottom of the home page to find dimension 'D' (insertion depth setting) above.*
2. Measuring from the outside of the pipe to the joint in the housing, as shown in the diagram above, adjust the sensor to Dimension D and hand-tighten compression nut.

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# Challenges to optimization

Challenges to optimizing treatment plants include:

- Management and staff buy-in on optimization goals
- Optimization limitations consist of multiple “small” issues
- Duration is multi-year
  (requires patience and tenacity)
- Lack of optimization “tools”

# Process control is in your control

- Process control is any activity required to develop a capable plant and take it to the desired level of performance.
- By applying what you learn at your plant, you can demonstrate that it is capable of meeting optimized performance goals.
- Meeting optimization goals improves public health protection and can often result in cost savings.

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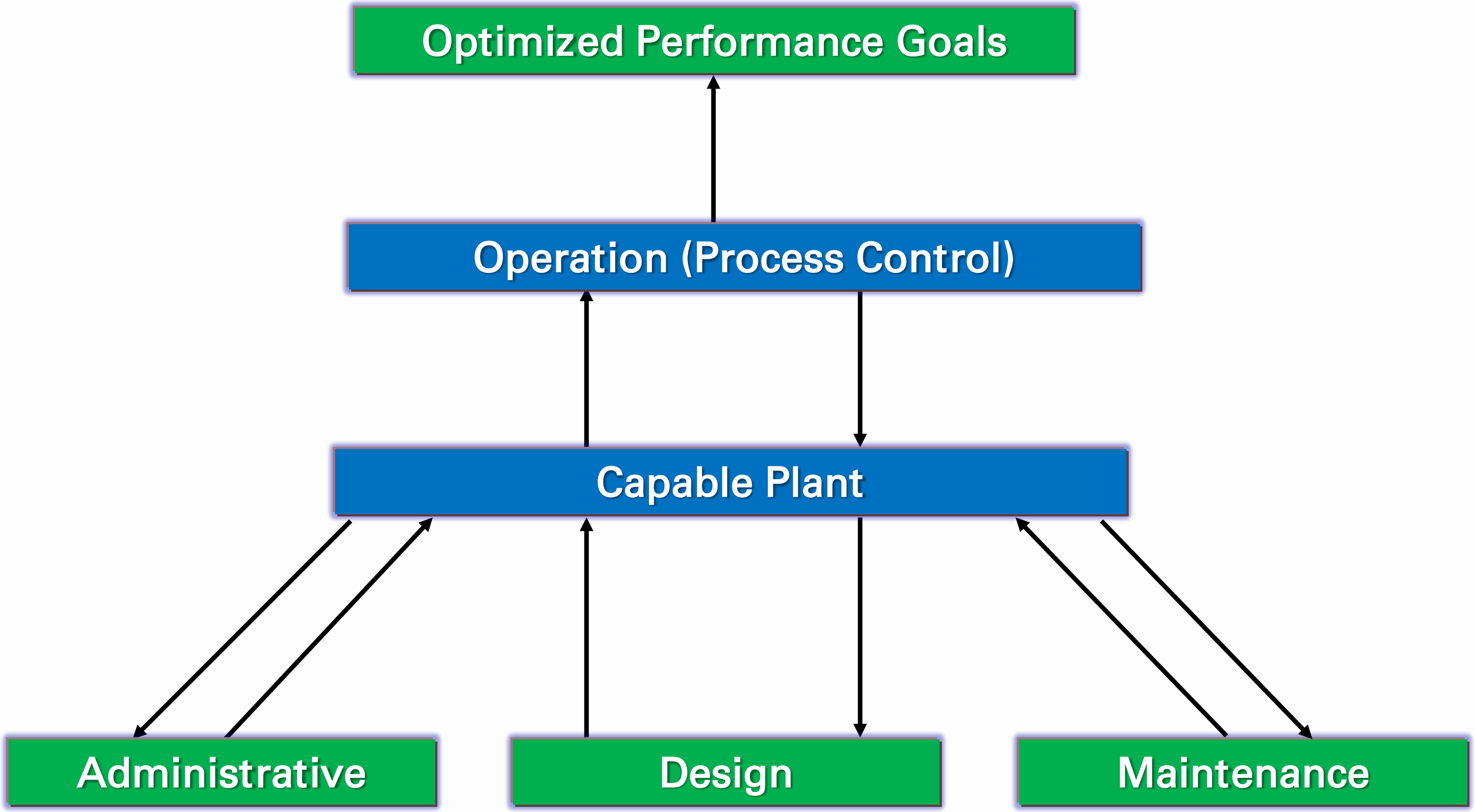
# Process control is key to a capable plant



# Priority-Setting

- Relate activities you do to achieving goals:
  - Always start by initiating operations-based activities (within operators' control!).
  - Address administration, design, or maintenance limitations to support capable plant, as needed.
- Reassess efforts routinely.

# Operational guidelines are an important tool

- Formalize and provide consistency for plant activities.
- Developed by the plant staff (skill development).
- Used as communications/ training tool (field test on other plant personnel).
- Encourage continuous modification and improvement.
- Development of a sampling guideline is suggested as homework from this training.

# Sampling Guideline

*Example Table from a Plant Sampling Guideline*

| Sample | Sample Location | Sample Type | Data Recording |
|---|---|---|---|
| Plant Raw Water | Tap by raw water sink | Grab every 4 hours | Maximum daily value |
| Sedimentation Basin Effluent | Individual basins at exit location | Grab every 4 hours | Maximum daily value |
| Filter Effluent | Individual filters (membrane trains) | Continuous (max. each 15 minutes logged on SCADA) | Maximum daily value |
| Combined Filter Effluent | Entrance to clearwell | Continuous (max. each 15 minutes logged on SCADA) | Maximum daily value |

- Describes how to do a specific operator activity.
  - Also describes the what, who, where, and when details.
- Don't make developing guidelines *"hard."*

# Special Studies

- Tool for conducting plant *"research"*
- Powerful tool for teaching problem-solving skills
- Structured approach for assessing and documenting optimization efforts

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# Special Study Format

## *"The Scientific Method"*

- Hypothesis
- Approach and resources
- Duration of study
- Expected results
- Summary and conclusions
- Implementation

# Special Study Approach

- Identify topic (look at factors that impact ability to meet water quality goals)
- Gather information/data.
- Don’t make the process intimidating.
- Involve plant staff in development.

# Special Study Approach (cont.)

- Hypothesis:
  - Minimize variables to allow determination of a cause/effect relationship.
- Approach and resources:
  - Develop site-specific aspects of conducting the study.
  - Document historical data.

# Special Study Approach (cont.)

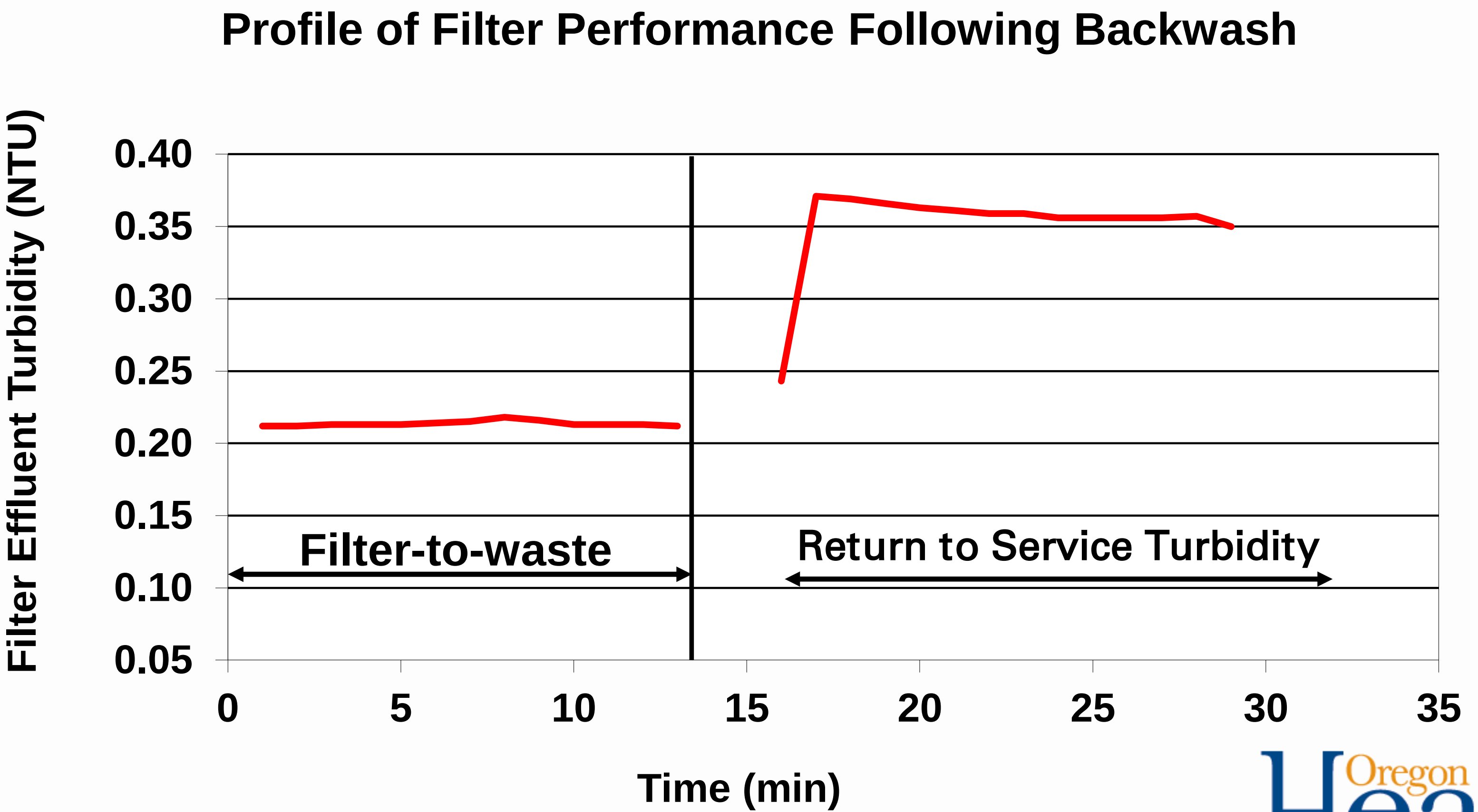
- Duration of study:
  - Allow time to collect background performance data (before/after process change).
  - Establish timeframe that will allow development of reliable results.
- Expected results:
  - Define expected results and limitations of the study.

# Special Study Approach (cont.)

- Summary and Conclusions:
  - Complete after special study activities.
  - Summarize data (tables, charts).
  - List key findings relative to hypothesis.
  - Use as foundation for changing current practices (operations, design, administrative, etc.).
- Implementation:
  - Completed after conclusions have been developed.
  - Basis for full-scale plant operational changes.
  - Demonstrates to staff and administration site-specific problem- solving approach (efforts result in verification or change).

# Special Study Example – Post Backwash Spikes

- Identified Problem:
  - After filter-to-waste, turbidity spikes to more than 0.3 NTU and it takes another 15 minutes to drop below 0.1 NTU.

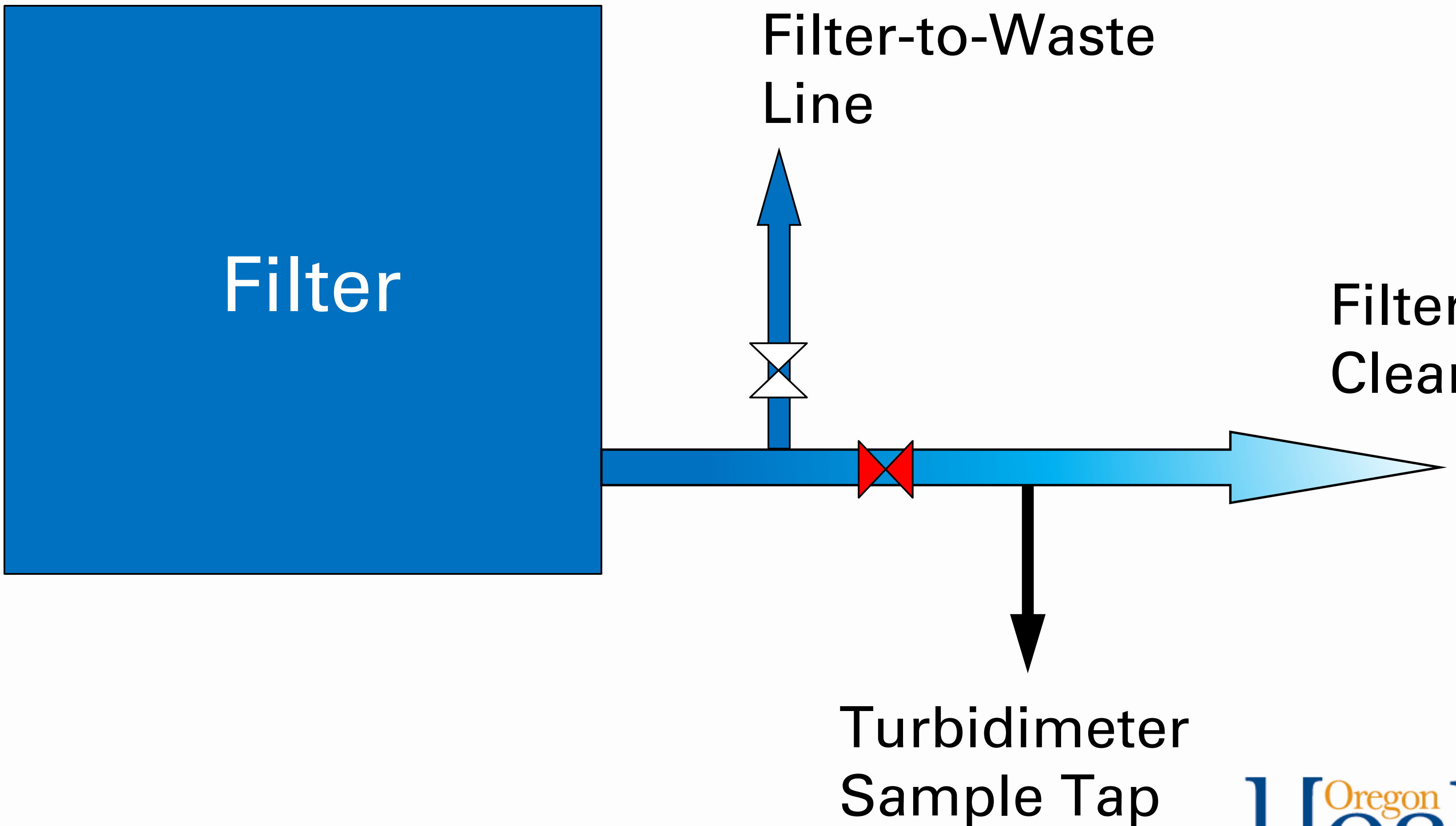


# Special Study Example – Post backwash spikes

- Hypothesis:
  - Since filter-to-waste turbidity was always very stable and usually less than 0.1 NTU, the integrity of the turbidity data was suspected.
- Approach:
  - Investigate source and transmission of filter effluent turbidity data.

# Special Study Example – Post Backwash Spikes

Sample tap does not reflect filter-to-waste turbidity during filter-to-waste.



# Special Study Example – Post backwash spikes

- Conclusions:
  - Optimized filter performance was not demonstrable with current sampling location
- Implementation:
  - Change sample location and modify data handling to be able to account for filter-to-waste turbidity.

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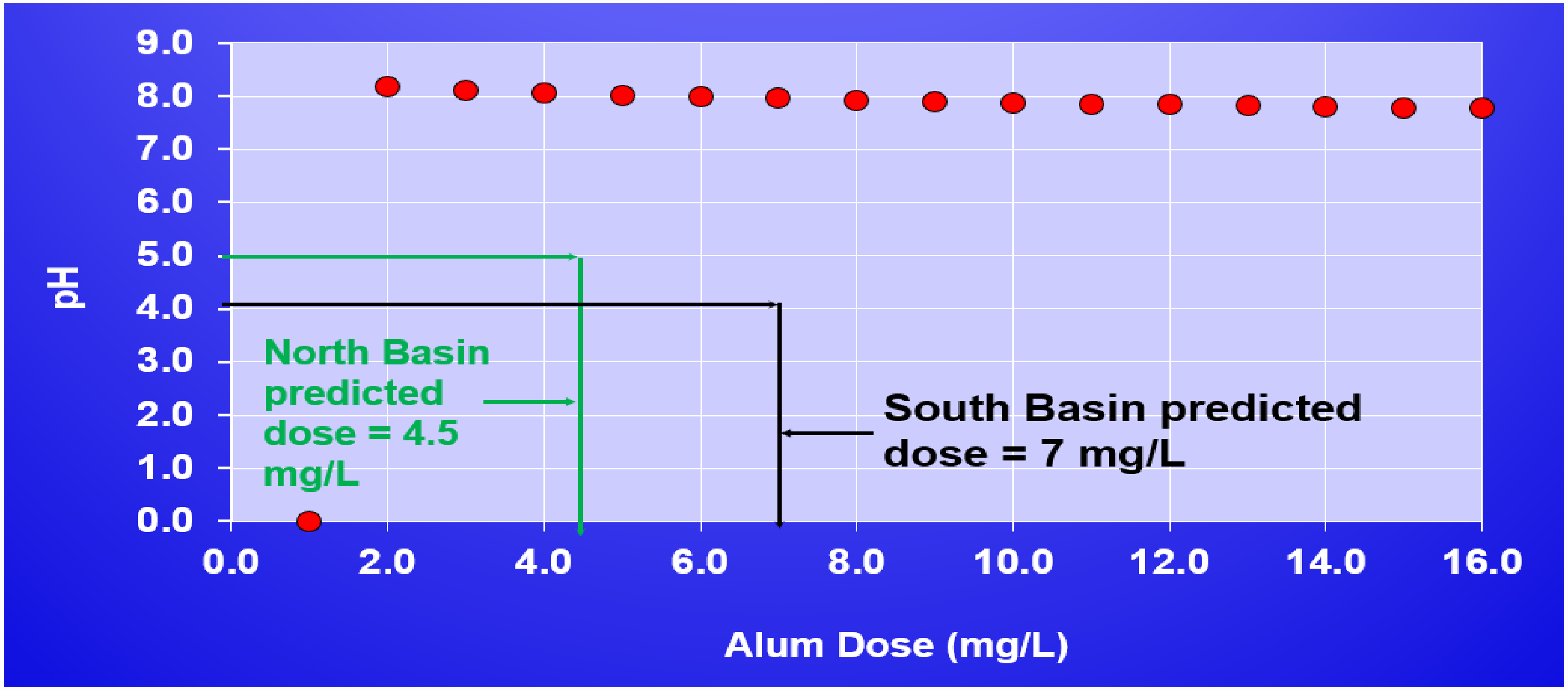
# Special Study Example – Coagulation

- Identified Problem:
  - Performance differences were observed between the north and south filters in a direct filtration plant.
- Hypothesis:
  - Filter performance discrepancies were caused by different performance from the north and south floc basins.
- Approach:
  - In the floc basins, monitor variables that could cause performance deviations (e.g., mixing energy, pH).
- Conclusions and Implementation:
  - pH measurements were different between the two floc basins.
  - Develop an alum dose versus pH curve to determine alum dose to north and south basins.

# Special Study Example – Coagulation

Based on the differences in pH measured in both basins, the dose would have been:

- 4.5 mg/L in the North Basin
- 7 mg/L in the South Basin



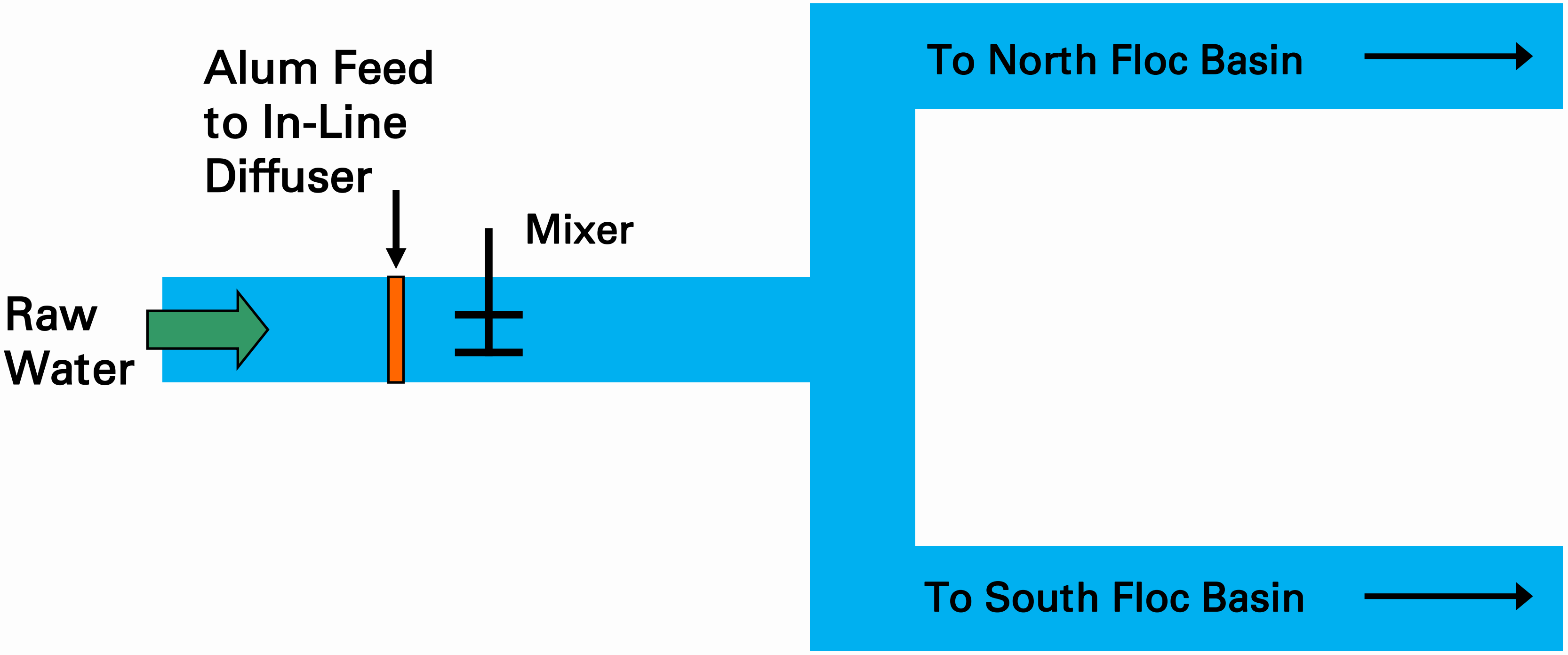
# Special Study Example – Coagulation

Special studies breed new special studies….

- Identified problem:
  - Coagulation (Alum dosage) was not equal to each floc train
- Hypothesis:
  - The rapid mix unit was not adequately mixing the alum in the raw water
- Approach:
  - Inspect the rapid mix unit and assess potential mechanical or plugging problems

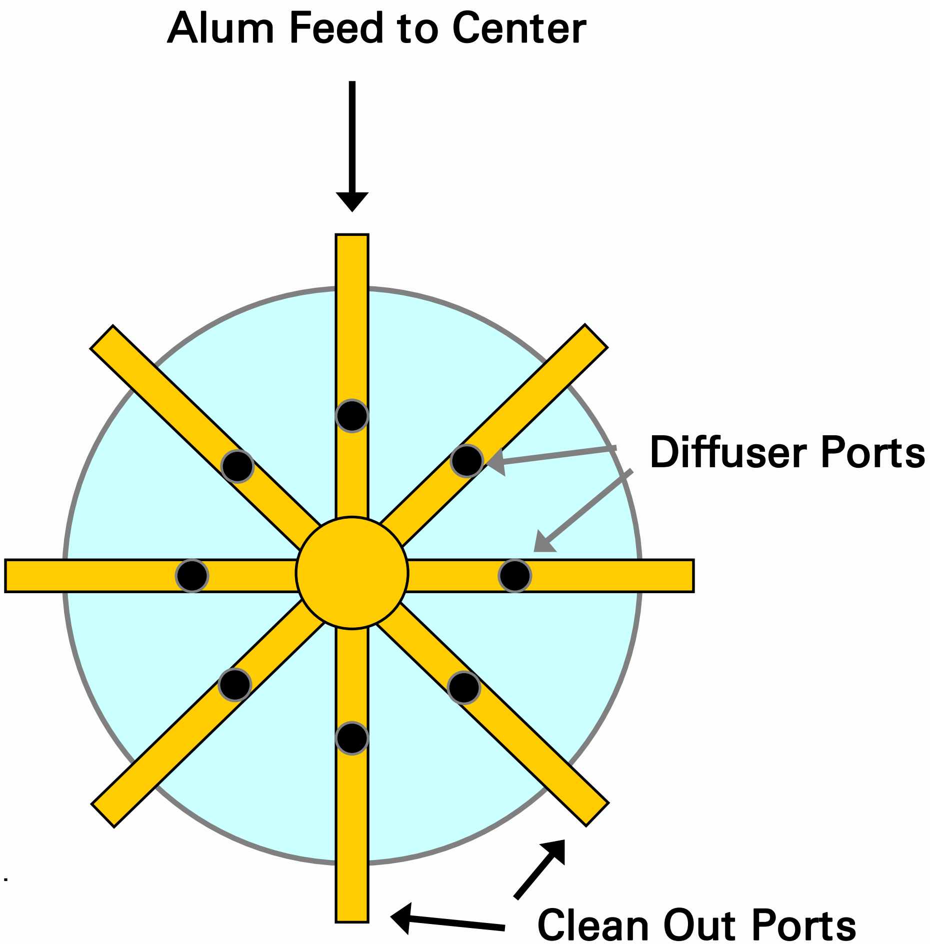
# Special Study Example – Coagulation

Coagulant Injection Schematic – 45 inch raw water line



# Special Study Example – Coagulation

Coagulant Injection Diffuser




- Conclusions and Implementation:
  - The design was causing plugging in the rapid mix unit.
  - When the diffuser ports were cleaned, the alum feed and pH values in the floc basins were similar.
  - Plugging reoccurred in about a week after cleaning.
  - Diffuser was modified to feed from the center rather than ports.
  - Carrier water for the alum feed was initiated rather than feeding alum in neat form.

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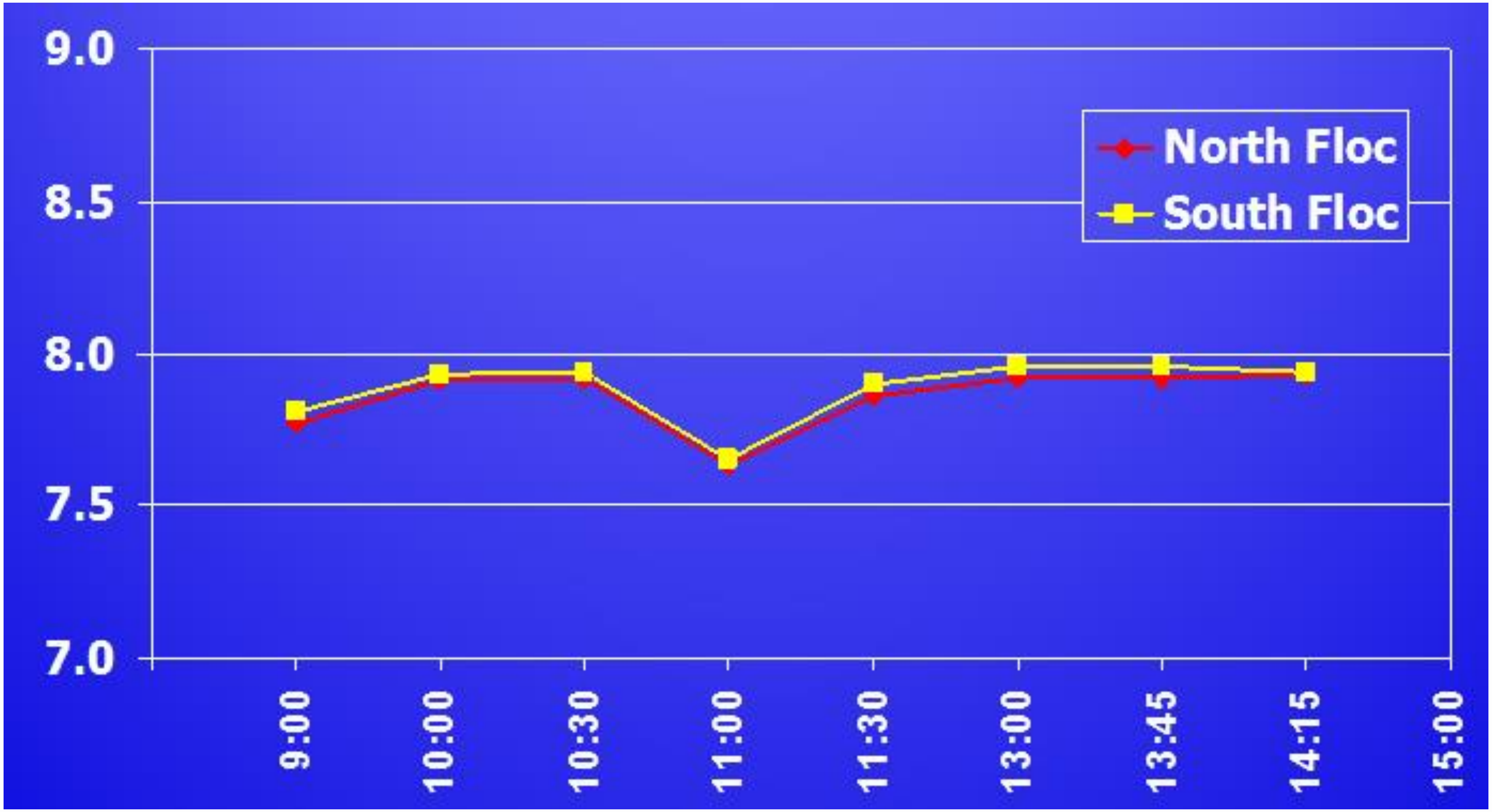
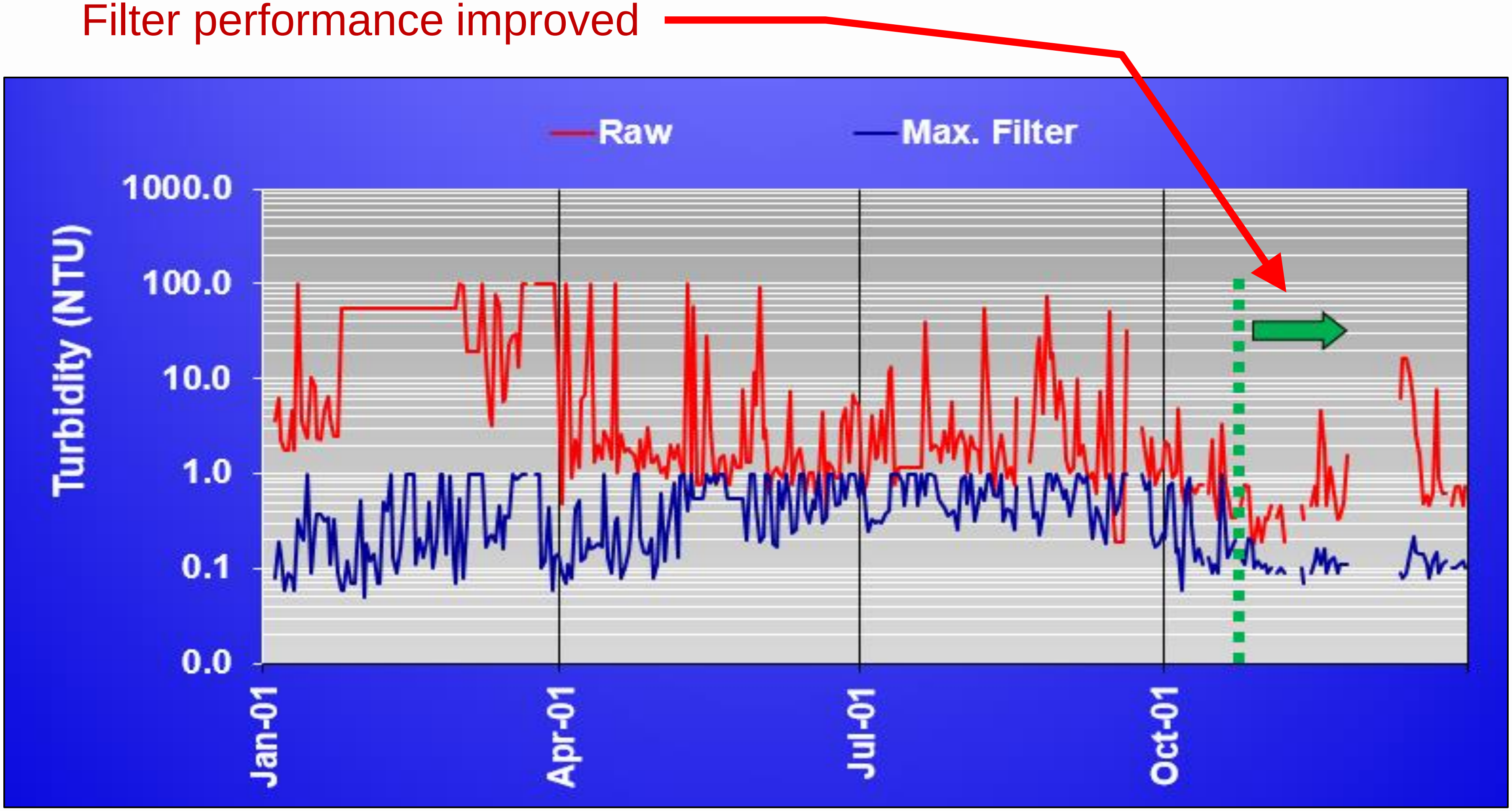
# Special Study Example – Coagulation

pH Variations in Floc Basins matched



# Special Study Example – Coagulation

Filter performance improved



# Exercise –

# 1 MGD Plant in Berry, Alabama

- Develop a special study to evaluate post backwash spikes.

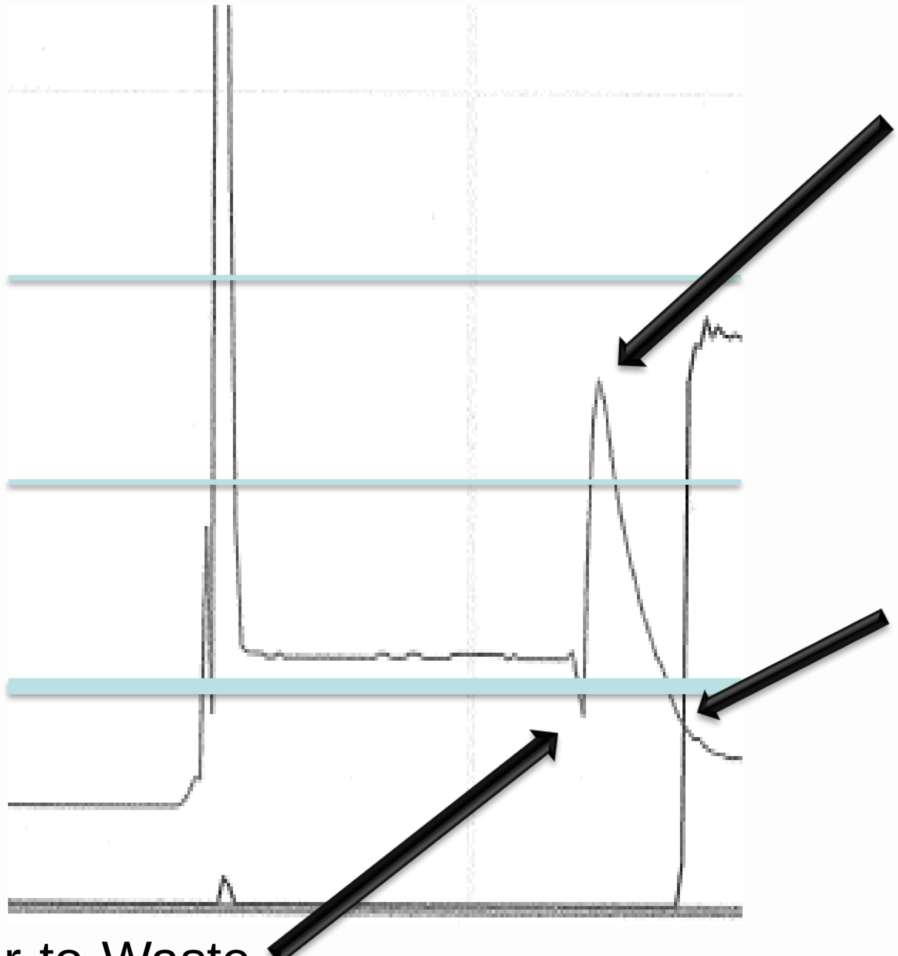
# Exercise – Berry, AL

Original backwash sequence:

1. Air Only (2 minutes)
2. Air / low-rate backwash at 5 gpm/sq ft (45 seconds)
3. High-rate backwash at 18.5 gpm/sq ft (160 seconds)
4. Second low-rate wash to fill filter (165 seconds)

# Exercise – Berry, AL

## Original backwash profile




**Total FTW Time of 60 Minutes**

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# Exercise – ETSW at 1 MGD Plant in Berry, Alabama

- Post backwash spikes lead operators to want to try an extended terminal subfluidization wash (ETSW)
- Develop a special study to evaluate the impact of ETSW.

# ETSW Background & Concepts

- ETSW is a filter backwash technique that involves extending the normal backwash duration at <u>a subfluidization flow rate</u> for an amount of time sufficient to move <u>one theoretical filter-volume</u> of water through the filter box.

  *(reported by Amburgey, 12/03 AWWA Journal)*

- The intent of ETSW is to remove the backwash remnant particles normally left within and above the media following backwash, preventing their passage into the finished water supply.

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# ETSW Mechanisms

- Incremental decrease in backwash allows the bed to settle more slowly (dislodges fewer remnant particles).
- Media restratification moves more small grains to top of the bed, creating a lower porosity layer.
- Most of the dislodged remnant particles are removed from filter box at low flow rate.

# Exercise - ETSW

## How would you complete the table below?

| ETSW Special Study | October 2015 |
|---:|---|
| Hypothesis: | |
| Approach and resources: | |
| Duration of study: | |
| Expected results: | |
| Summary and conclusions: | |
| Implementation: | |

# Exercise - ETSW

## How would you complete the table below?

| ETSW Special Study | October 2015 |
| --- | --- |
| Hypothesis: | Remnant particles left within and above the media following backwash are reaching their way into the finished water.<br><br>Implementing ETSW should solve this problem. |

# Exercise - ETSW

## How would you complete the table below?

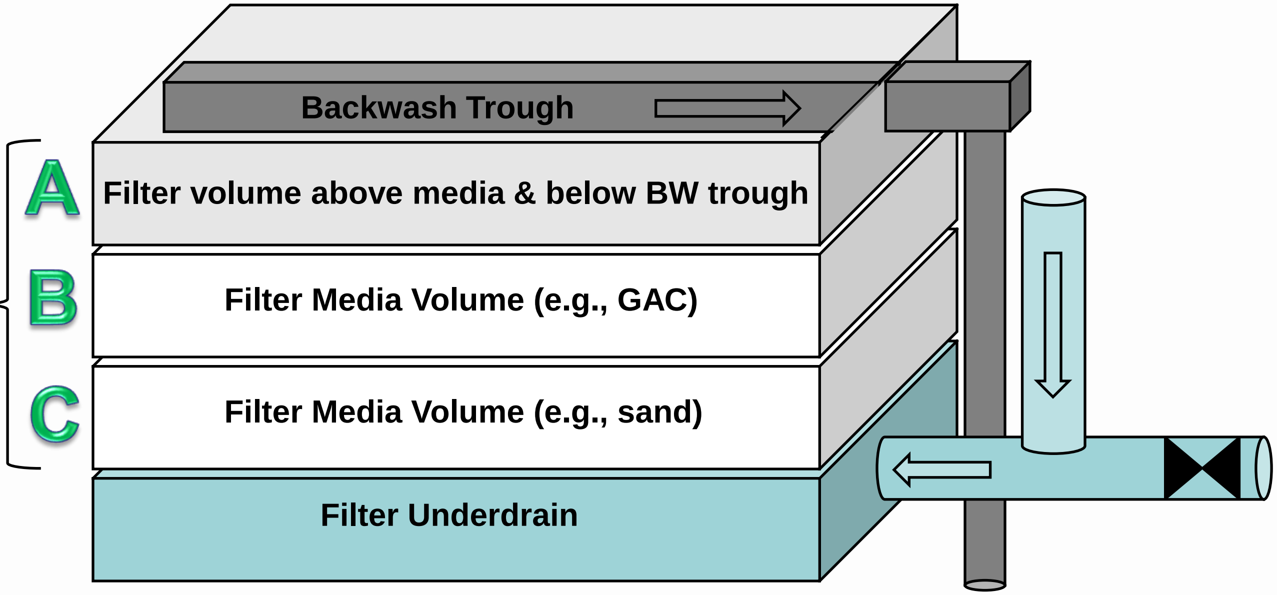
| ETSW Special Study | October 2015 |
|---|---|
| Approach and resources: | 1. Determine if low rate backwash rate of 3 to 6 gpm/$ft^2$ can be achieved (be cautious of throttling pumps)<br>2. Can the flow rate be controlled and measured? If not flow measurement can be a challenge, but it’s not a deal killer.<br>3. If 1. and 2. are feasible, estimate low-rate wash duration:<br>• Determine bed volume to be displaced<br>• Based on low-rate wash rate, calculate duration<br>4. Filter 1 was selected to be the test filter while maintaining Filters 2 and 3 the same (control filters). |

# ETSW Technique Measurements and Calculations

**At what flow rate?**

**~ 3 to 6 gpm/ft$^2$ – minimal media expansion**

**Volume to Remove Remnant Particles**




**How long?**

**Time to replace ~ 1 bed volume**

**= A + B + C (assume 100% of volume in A+B+C)**

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# Example ETSW Calculations

- Calculate Bed Volume:
  - Surface area of filter = 320 $ft^2$
  - Media depth = 30 inches (sand & anthracite)
  - Water depth between media and top of BW trough = 54 inches
  - Total bed depth = 30 + 54 = 84 inches = 7 ft.
  - Total bed volume = 320 $ft^2$ x 7 ft = 2,240 $ft^3$
  - 2,240 ft3 x 7.48 gal/ft3 = <u>16,755 gallons</u>

- ETSW wash rate = 5 gpm/$ft^2$ x 320 $ft^2$ = <u>1,600 gpm</u>
- ETSW time = 16,755 gal. ÷ 1,600 gpm = <u>10.5 minutes</u>

# Exercise - ETSW

## How would you complete the table below?

| ETSW Special Study | October 2015 |
|---|---|
| Hypothesis: | |
| Approach and resources: | |
| Duration of study: | Try ETSW on three backwashes on filter #2 |
| Expected results: | ETSW will reduce post backwash turbidity spikes |
| Summary and conclusions: | |
| Implementation: | |

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# Exercise - ETSW

## How would you complete the table below?

| ETSW Special Study | October 2015 |
|---|---|
| Hypothesis: | |
| Approach and resources: | |
| Duration of study: | |
| Expected results: | |
| Summary and conclusions: | ETSW not only reduced post backwash turbidity spikes, it also decreased the amount of water consumed during the backwash process. |
| Implementation: | |

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# Exercise – Berry, AL

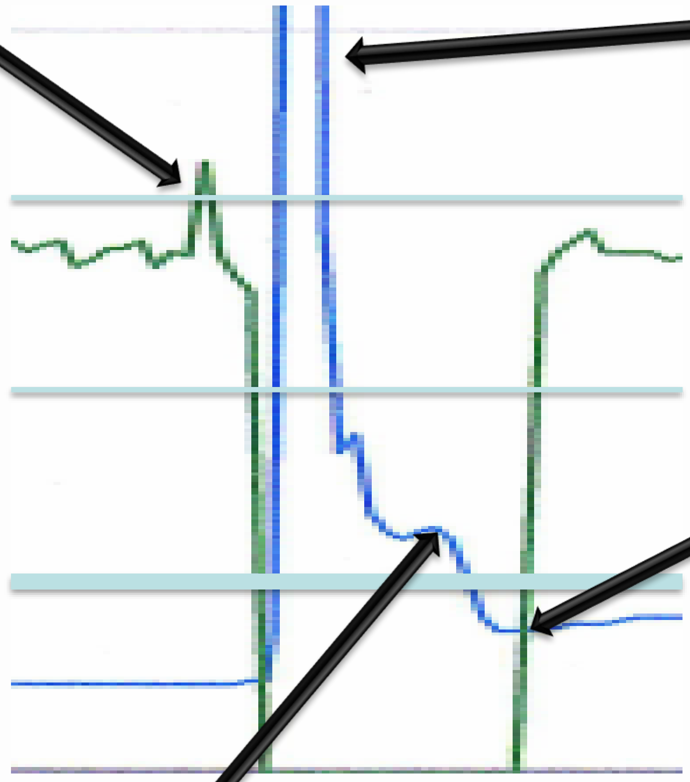
Original backwash sequence:

1. Air Only (2 minutes)
2. Air / Low Wash at 5 gpm/sq ft (45 seconds)
3. High wash at 18.5 gpm/sq ft (160 seconds)
4. Second low wash to fill filter (~~165 seconds~~) – extended to 465 seconds

# Exercise – Berry, AL – results with second low wash extended to 465 s

**Flow to clear well**

**Turbidity**



**No Rewash Spike**

Filter Returned To Service

Start of Rewash

**Total Rewash Time of ~~20~~ 60 Minutes**

# Example – Berry, AL

Before ETSW

- Backwash:
  - 10,800 Gallons Used
  - 9 Minutes
- Rewash:
  - 22,680 Gallons Used
  - 60 Minutes
- Turbidity Spike:
  - 0.25 NTU
- Total:
  - 33,500 Gallons Used
  - 75 Minutes

After ETSW for 465 seconds

- Backwash:
  - 15,750 Gallons Used
  - 18 Minutes
- Rewash:
  - 11,340 Gallons Used
  - 30 Minutes
- Turbidity Spike:
  - Spike was reduced to a few minutes, all during rewash. No post rewash spike.
- Total:
  - 27,000 Gallons Used
  - 60 Minutes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# Exercise – Berry, AL

Modified original backwash sequence:

1. Air Only (2 minutes)
2. Air / Low Wash at 5 gpm/sq ft (45 seconds)
3. High wash at 18.5 gpm/sq ft (160 seconds)
4. Second low wash to fill filter (~~165 seconds~~) – extended to 465 seconds

# Example – Berry, AL

- Berry WTP is saving approximately 15,000 gallons per backwash.
- Filters returned to service in less than 15 minutes.

# Example – Berry, AL

Feedback from a water plant manager:

> *"If my operators gave me a formal study like this with documented results and recommendations, it would provide a strong basis for making a change to my plant. I could not ignore it".*

# ETSW Benefits

- Lowers filter-to-waste time (rewash).
- Reduces or eliminates rewash spike.
- Filters return to service quicker.
- Less water wasted.
- No degradation of filter performance.

# ETSW Benefits

- Successful ETSW results assume that previous backwash steps result in adequately cleaned media.
- Refinements to existing backwash procedure may be part of ETSW evaluation (e.g., changes to initial low wash and high wash duration).

# ETSW Benefits

- ETSW can be fairly simple to implement, but filter backwash controllability needs to be assessed first.
- Potential ETSW benefits include improved filter performance, shorter filter-to-waste time, and water savings.
- ETWS will be one special study conducted during the Day 2 plant training.

# Impacts of Special Study Approach

- Provides data-based reasons for change.
- Powerful site-specific training tool:
  - Teaches problem-solving skills
  - Addresses limitations
- Convincing to management and outside technical resources.
- Basis for future special studies (i.e., special studies *“breed”* more special studies).

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# Optimization Summary

- Develop onsite priority-setting capability:
  - Set priorities based on impact to water quality.
  - Routinely assess optimization status through formal communication and training.
- Develop onsite problem-solving capability:
  - Develop and utilize operational guidelines.
  - Develop and utilize special studies.
- Key to success:
  - systematic and ongoing pursuit of optimization goals.

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# Homework!

- Study 1 – Chemical feed pump evaluation
- Study 2 – Filter bed expansion and backwash duration
- Study 3 – Post backwash performance assessment
- Study 4 – Performance of adjacent filters during backwash and turbidimeter signal verification
- Study 5 – Comparison of sedimentation basin performance
- Study 6 – Turbidimeter calibration check

# Don’t ignore tanks/reservoirs/clearwells!

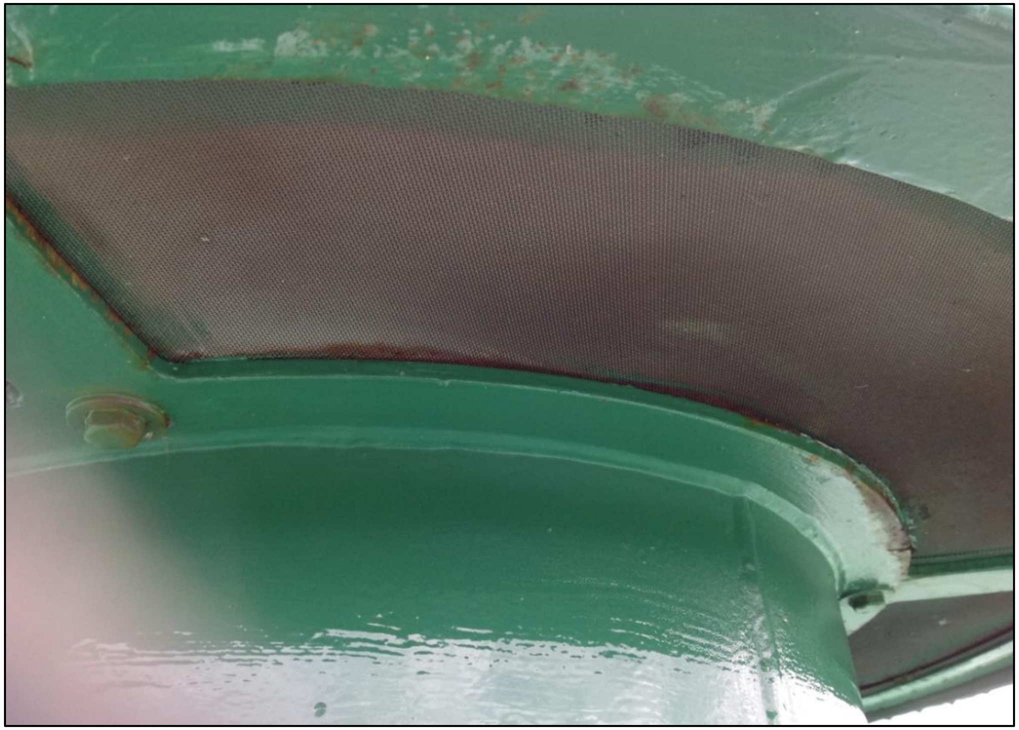

City of Sheridan, 2008

# Ensure vents have adequate screens

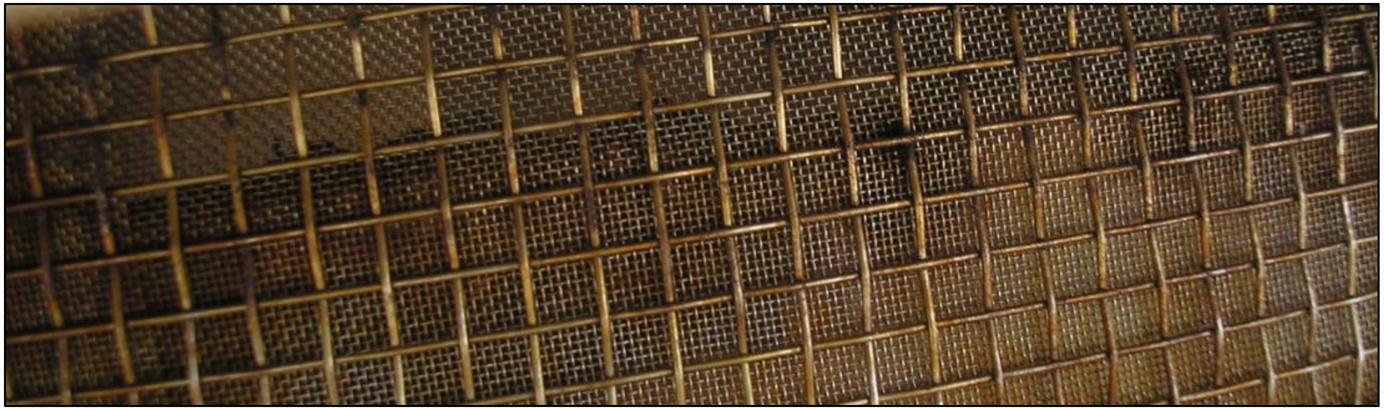
**Clatskanie, 2014**

# Screened Vents

Clatskanie, 2014



Sheridan, 2011



# Screened Vent - #24 mesh (stainless)


Slide courtesy of Bob Clement – USEPA Region 8

# Inadequate Screened Vent

# Vent allows aspiration…

## Tanks can aspirate contaminants through vent if too close to a surface


Slide courtesy of Bob Clement – USEPA Region 8

# Allow adequate offset of vent…

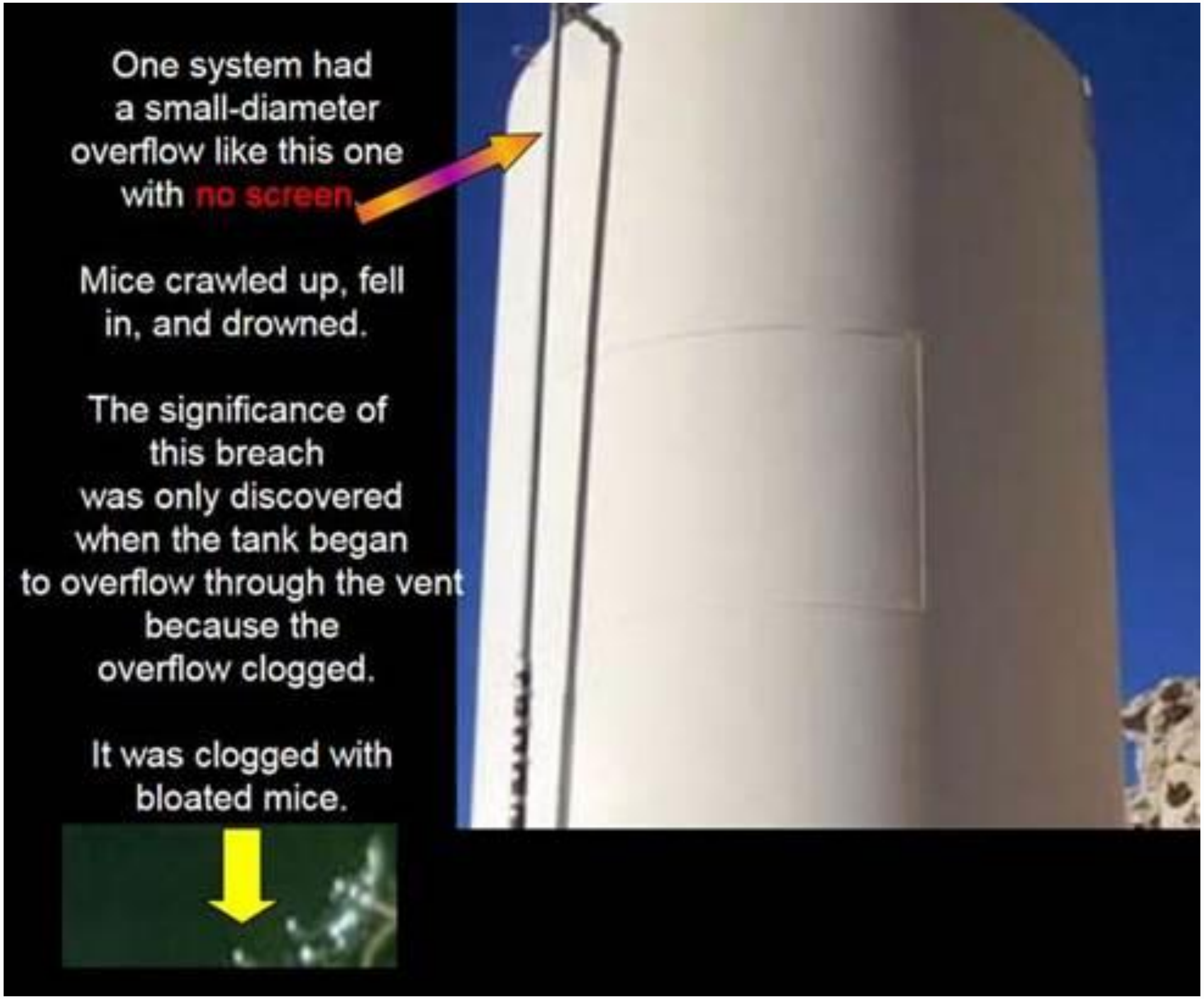
# Hopefully this vent isn't close enough to aspirate debris from this pile of dead flies…

# Protected Overflow

"Duck Bill"
Sheridan, 2011

Flap valve
Warrenton, 2014

# Unprotected overflow clogged with dead mice…




Slide courtesy of Bob Clement – USEPA Region 8

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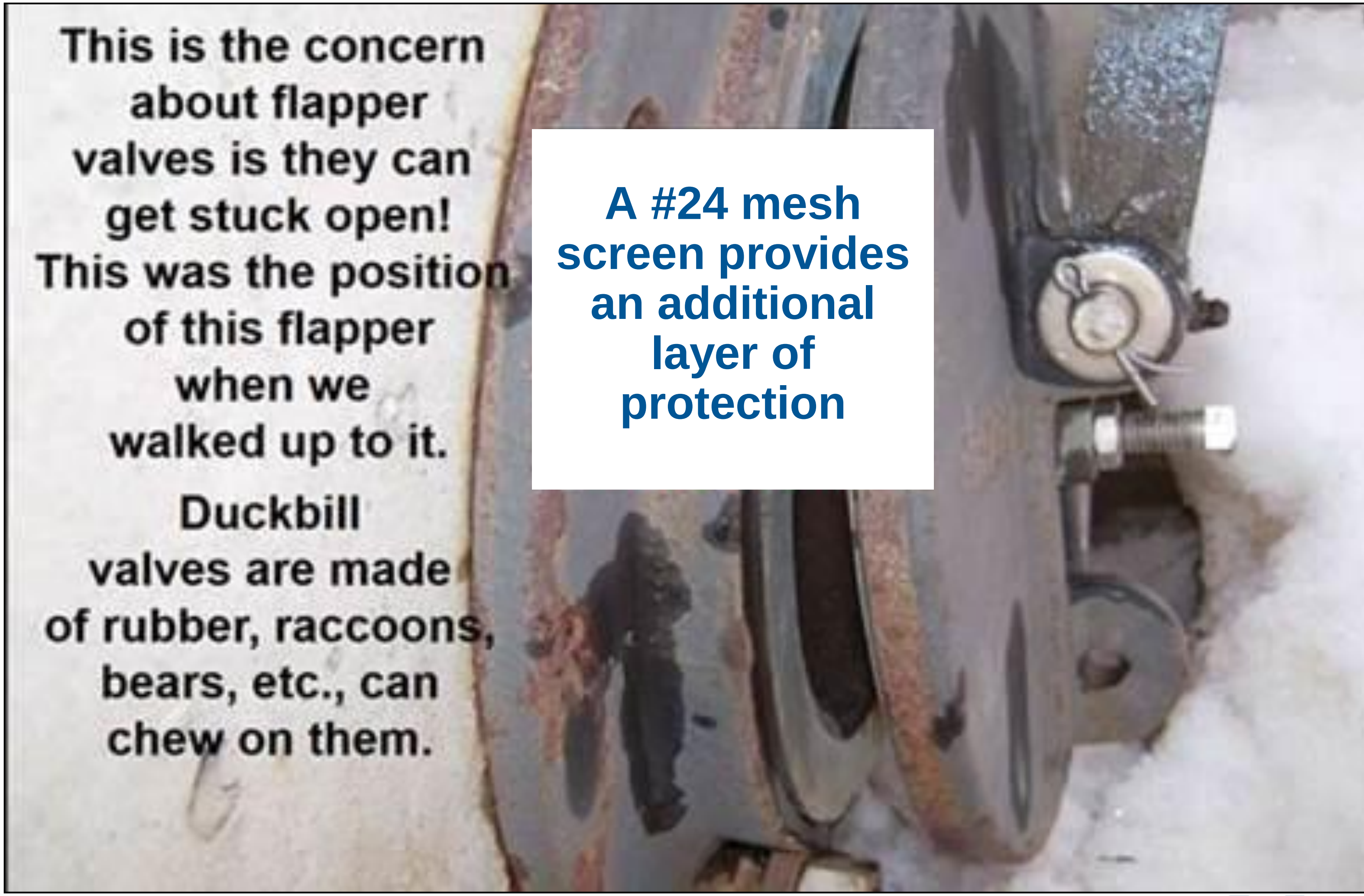
# Protected Overflow

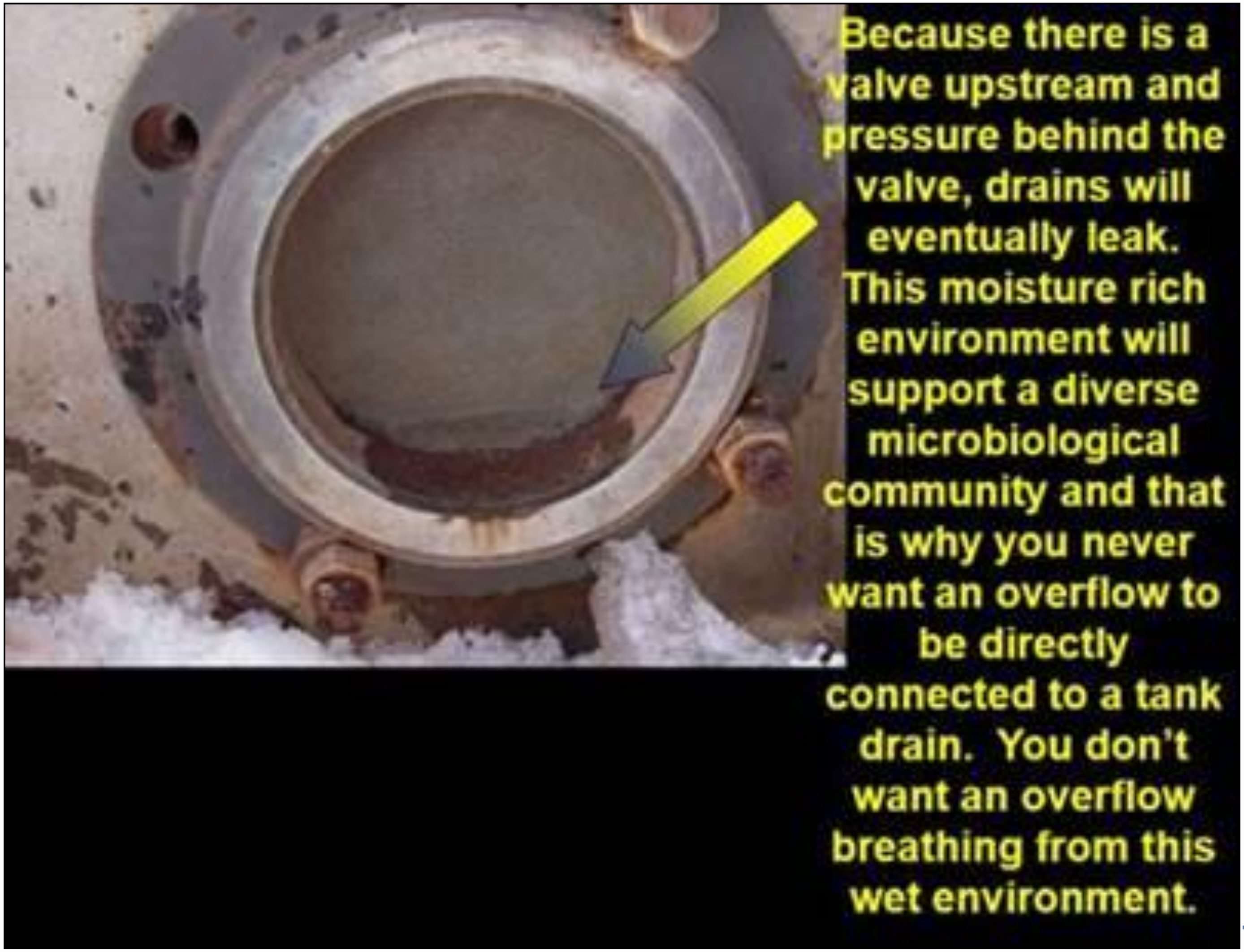



Slide courtesy of Bob Clement – USEPA Region 8

# Physical separation from ground surface prevents animals from gaining access and contaminants from being aspirated…


Slide courtesy of Bob Clement – USEPA Region 8

# Separate drain from overflow piping

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# Separate drain from overflow piping




Slide courtesy of Bob Clement – USEPA Region 8

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# Recommendations for Tanks/Reservoirs/Clearwells

**For vents:**

1. #24 SS screen
2. Additional vacuum/pressure release valve on steel tanks
3. Vents discharge 24” above nearest grade

**For overflows:**

1. #24 SS screen between pipe and removable flange on all overflows and protected by flap valve, or duck bill
2. Overflows separate from drains
3. Overflow drains to daylight 12-24” above grade into a splash block, riprap, or other energy dissipating structure to minimize erosion without the possibility to be submerged or obstructed.
4. No direct discharge to sewers
5. 36” vertical separation from storm drains
6. Diameter of overflow be no less than inlet diameter
7. Overflow is readily visible from the tank or a road and within 5-ft of the ground surface.

# Watertight Hatch
# (keep gutter drains clear of debris)

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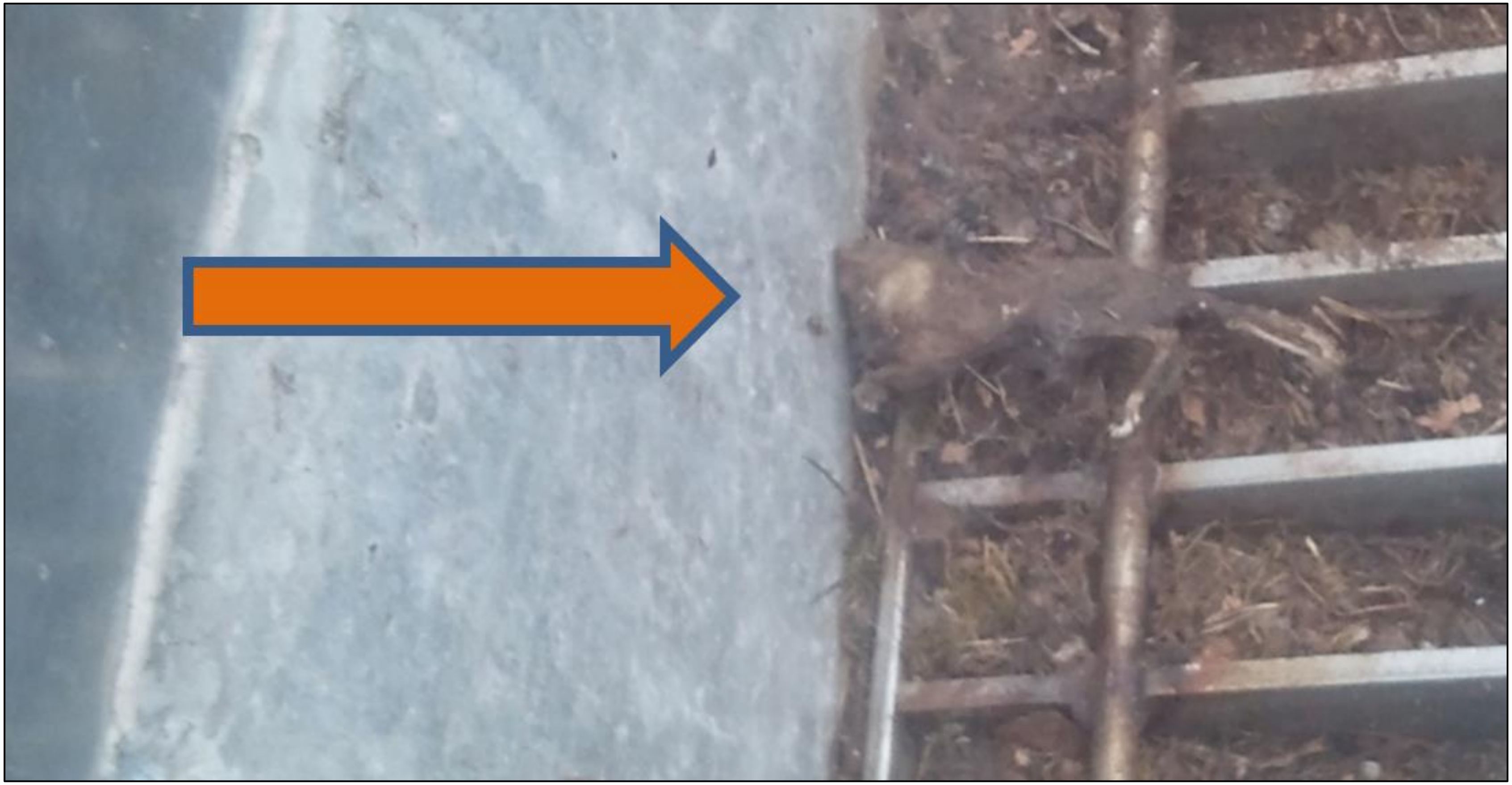
# What happens when gutter drains clog?

# Hatch should be rodent proof

## (keep gutter drains screened)



# Hatch should be locked…

## unlike these!

Rock lock =>

<= Tire lock

# Curbing, lock, and "shoebox" style overlapping lid work best and are required for new tanks

# Don’t forget about security

How many think this tank was secure?

# Don’t forget about security

How many think this tank was secure?

Animal trail found under the fence

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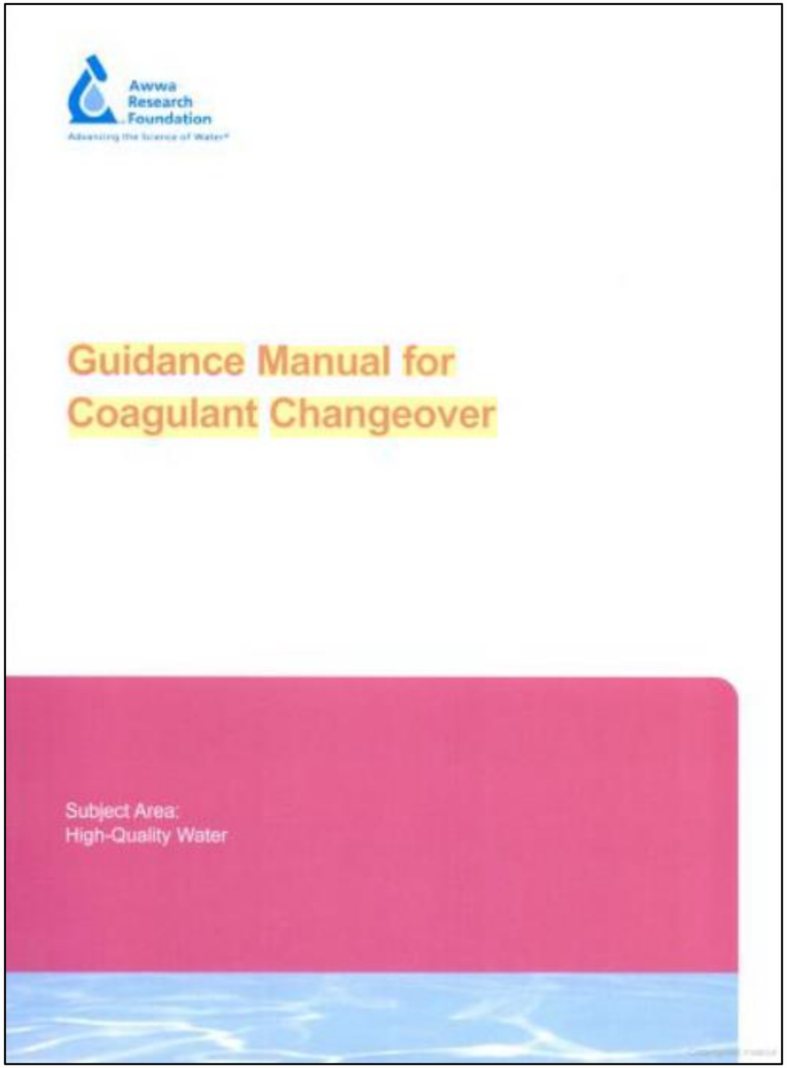
# Don’t forget about safety

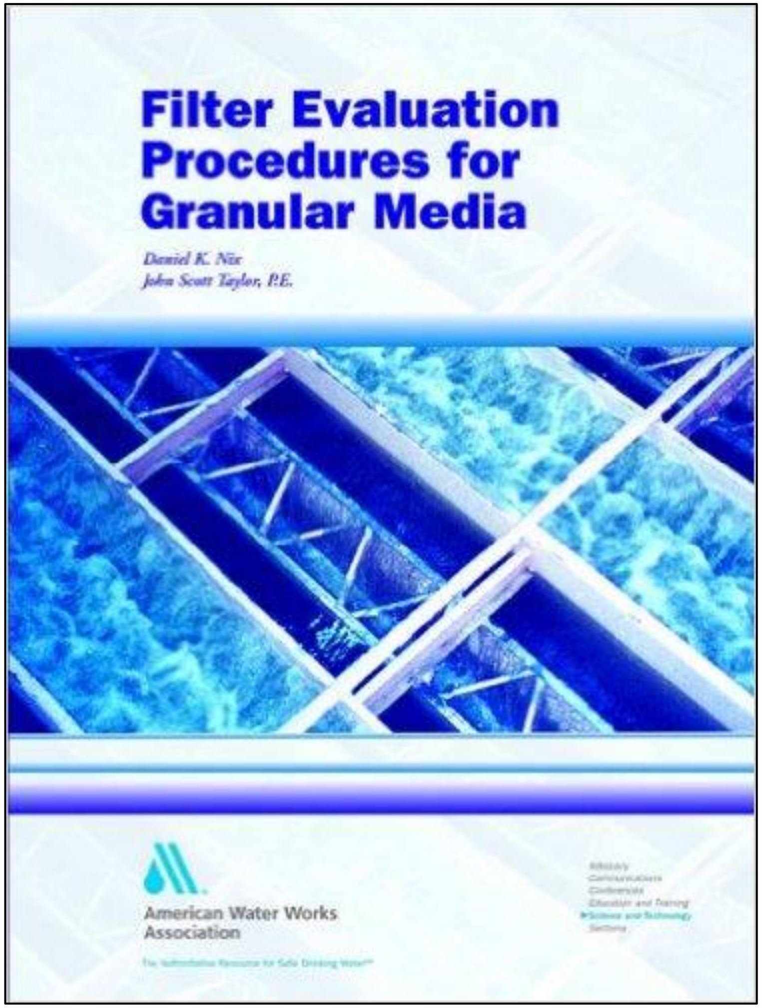
Great for safety – not sure how secure though??

# For more information…



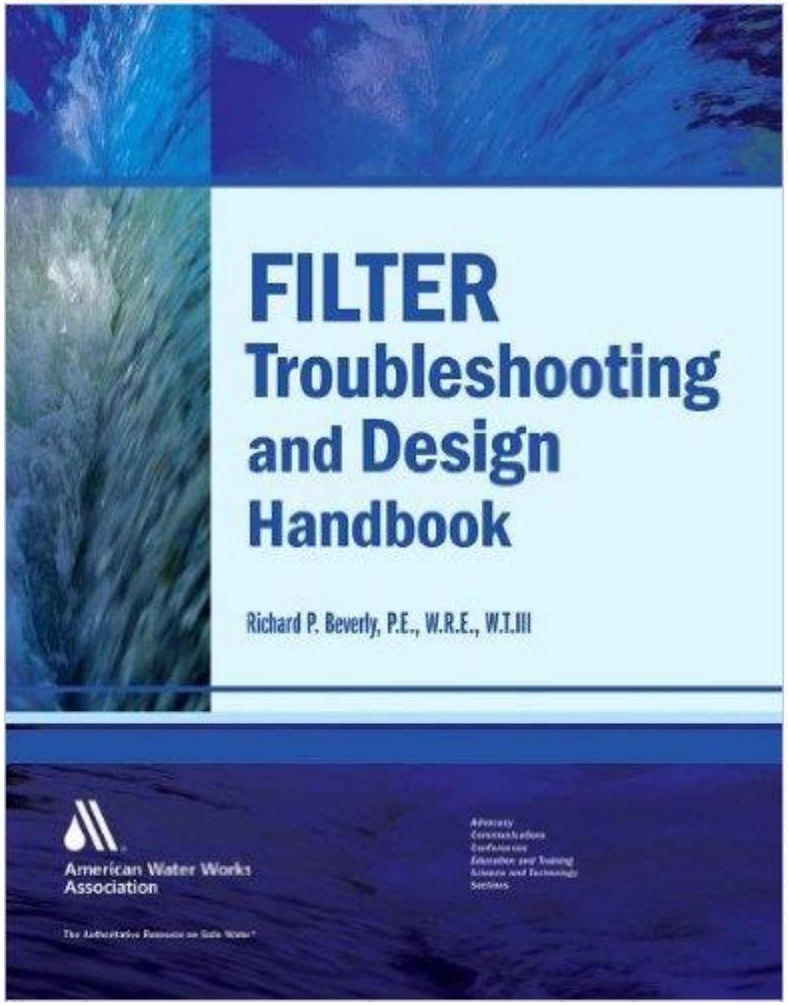

Guidance Manual for Coagulant Changeover (AWWARF, 2003)

# For more information…



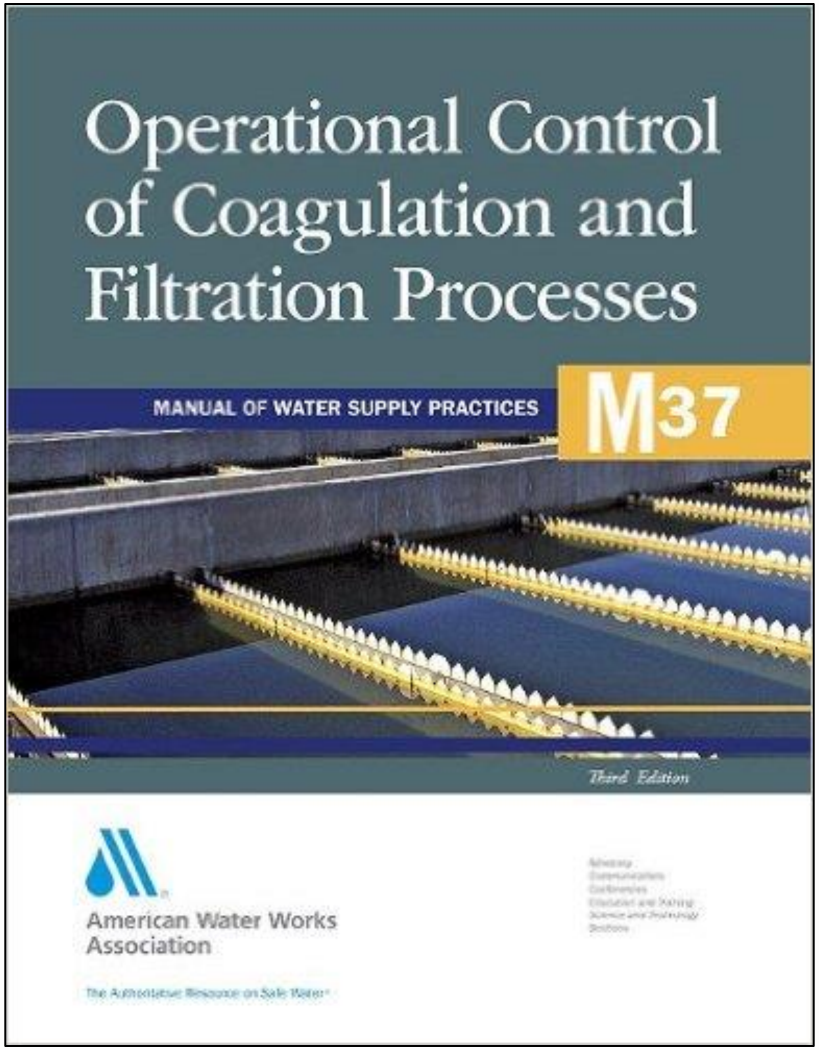

Filter Evaluation Procedures for Granular Media (AWWA 2003)

# For more information…




Filter Troubleshooting and Design Handbook (AWWA 2005)

# For more information…




M37 Operational Control of Coagulation and Filtration Prcoesses (AWWA, 2011)

Chapter 1: Particle and NOM Removal
Chapter 2: Jar Testing
Chapter 3: Online Sensors
Chapter 4: Flocculation and Clarification
Chapter 5: Filtration
Chapter 6: Pilot Testing and Pilot Filters
Chapter 7: Case Studies

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# Conclusion

## Practice should embrace the multiple barrier approach

Develop Drinking Water Protection Plan to protect source water

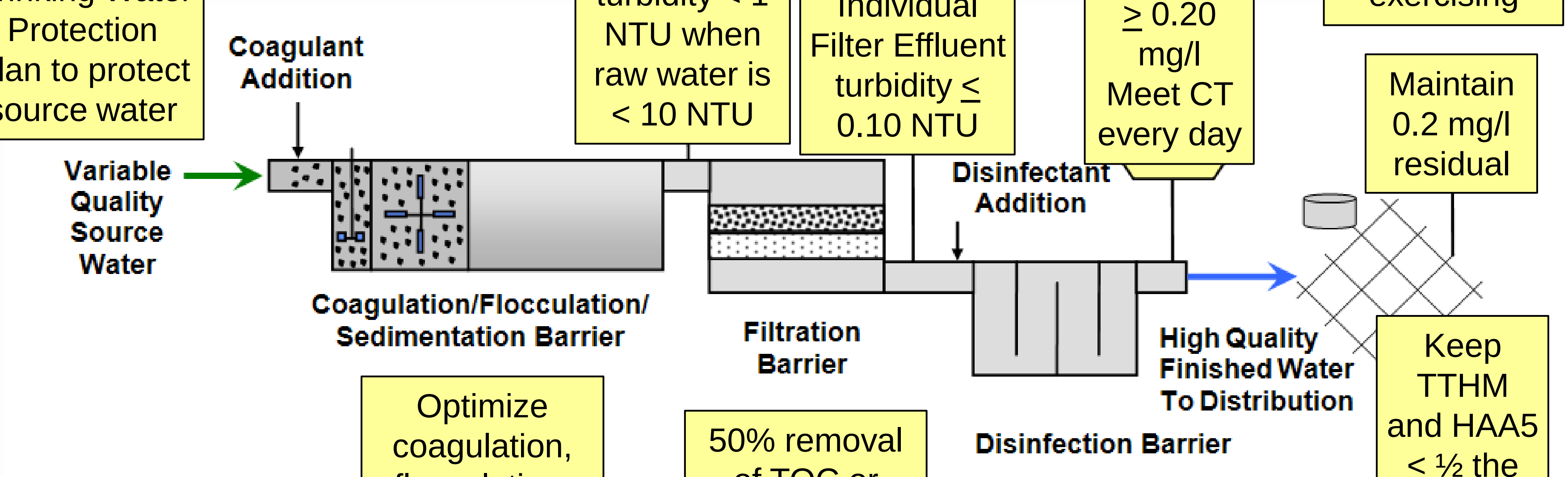
settled water turbidity < 1 NTU when raw water is < 10 NTU

Individual Filter Effluent turbidity ≤ 0.10 NTU

Free Chlorine ≥ 0.20 mg/l Meet CT every day

Keep Corrosion in check and implement routine flushing/valve exercising

Maintain 0.2 mg/l residual




Optimize coagulation, flocculation, and sedimentation

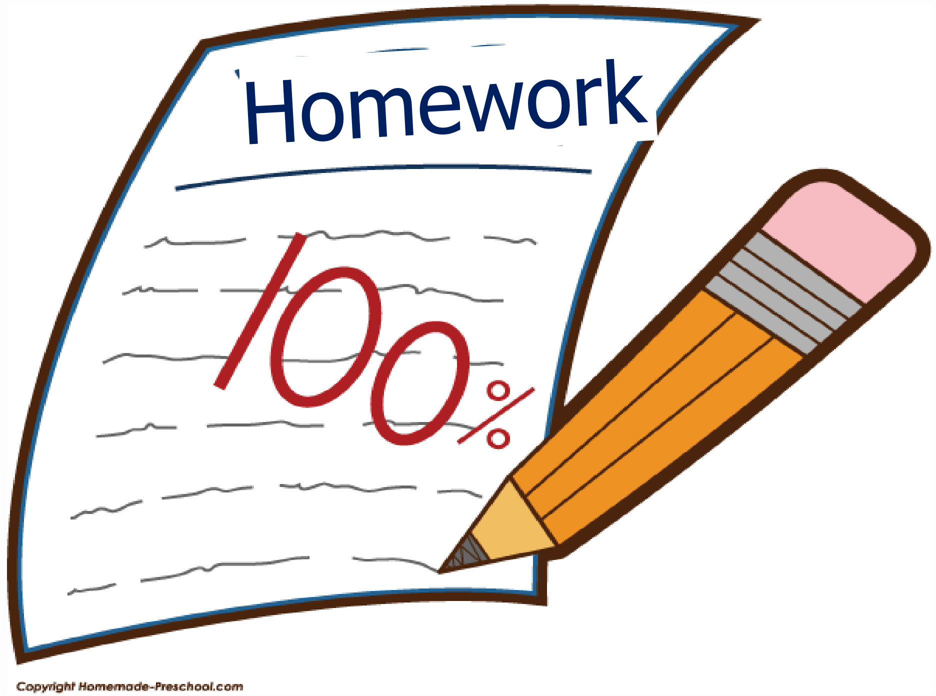
50% removal of TOC or TOC ≤ 2 mg/l

Keep TTHM and HAA5 ≤ ½ the MCL

# Homework Reminder

Create Standard Operating Procedures (SOPs) for…

1) Determining chemical dosages
2) Verifying flow rates
3) Calculating CT
4) Calibrating turbidimeters
5) Conducting a backwash
6) Data collection and analysis
7) Regulatory reporting



# Thank You!!