Optimization Stories From the Field

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OTCO Class 3&4 Workshop

August 3, 2017

Agenda

- Optimization practices used in the field
  - Short synopsis
- Optimization stories
  - Evaluations made
  - Technical solutions developed
  - Implementation and verification
  - Results achieved
- Questions

Optimization Practices Used in Field

- Define objectives/goals
  - Why should this project be initiated
- Develop baseline characteristics
  - Current operations and metrics
- Benchmark industry standards or best practices
  - Compare where things are to where you believe they should be
- Conduct gap analysis
  - How do I get to the goals?
  - Tools, capital, training, operating adjustments that might be needed to achieve the goals

Optimization Practices Used in Field

- Establish Implementation strategy
  - Capital needs
  - Tools, modeling, etc.
  - Operational changes
  - Adjustment protocols
  - Verification procedures
- Track progress against objectives/goals
  - Did you meet the objectives and goals?
  - Did you exceed the objectives and goals?
  - Did you improve water quality?
  - Did you improve performance?

Atlanta-Fulton County, Georgia

Atlanta-Fulton County

- 90 mgd surface water plant
  - Average daily production 44.5 mgd
- Reservoir storage from Chattahoochee River
- Coagulation/filtration plant
  - Chemical treatment
  - Solids handling
  - Disinfection and storage
- Finished water pumping to two wholesale distribution systems
  - 400,00 people

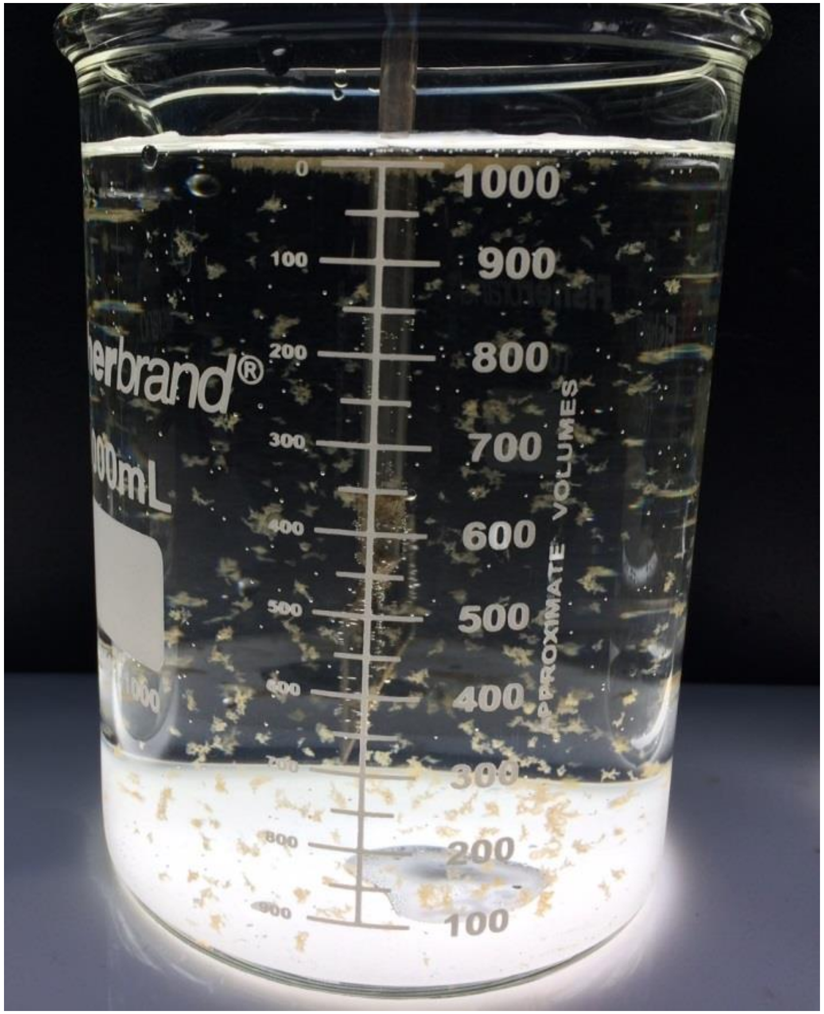
Atlanta-Fulton County

Atlanta-Fulton County

Atlanta-Fulton County

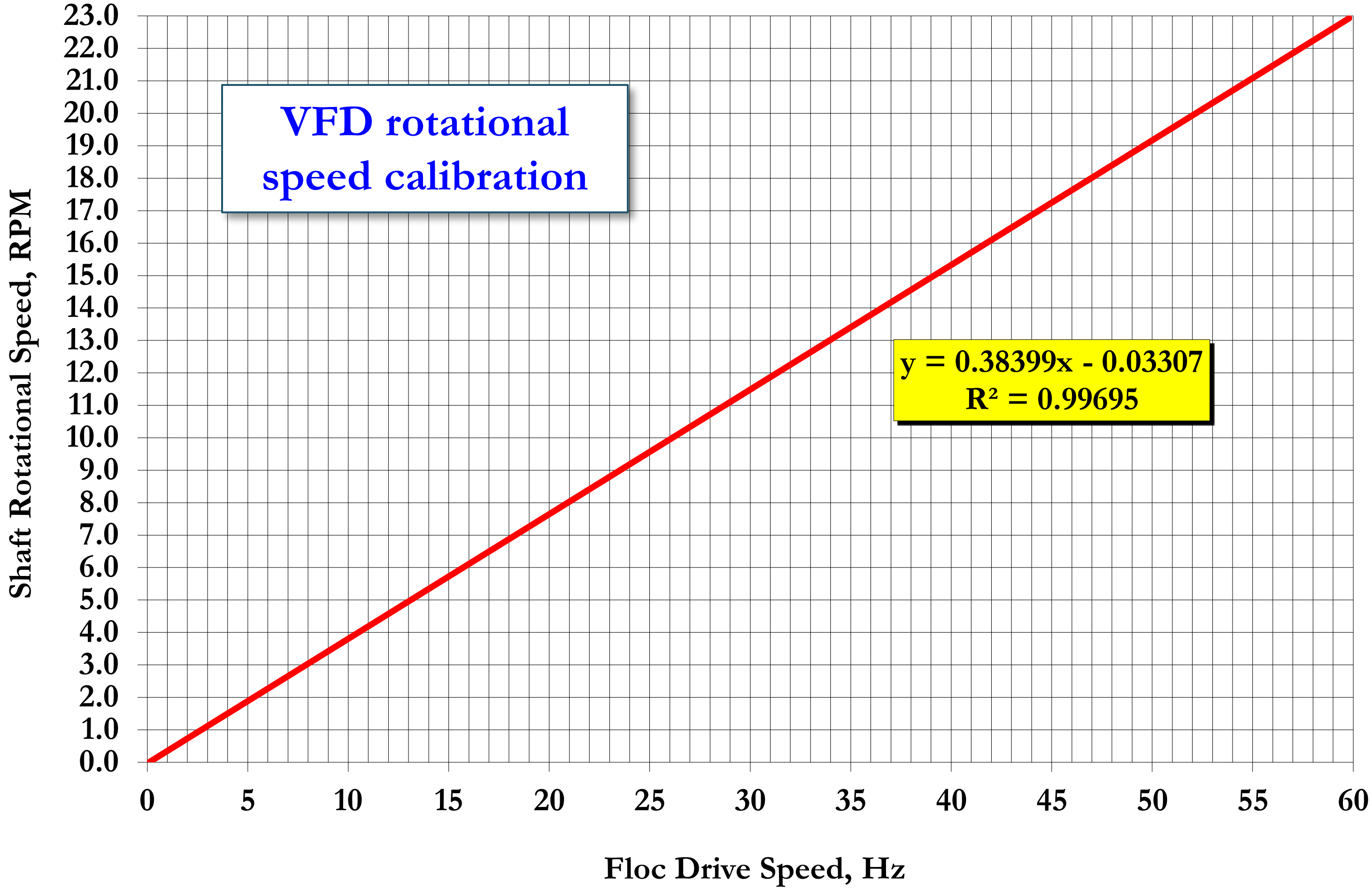
- Floc Speed Adjustments Initiative
  - Jagged, feathery floc observed entering the sedimentation process
  - Measured drive output speeds at different VFD settings
    - Established rotational output at any VFD setting
  - Defined current G values for each of four stages
    - 4 sec^{-1}, 4 sec^{-1}, 3 sec^{-1}, 2 sec^{-1}
    - Operators afraid of floc shear
  - Conducted jar testing to establish optimum G values for floc development and settleability
  - Graphed floc settleability versus G value to find optimum mixing characteristics

Atlanta-Fulton County

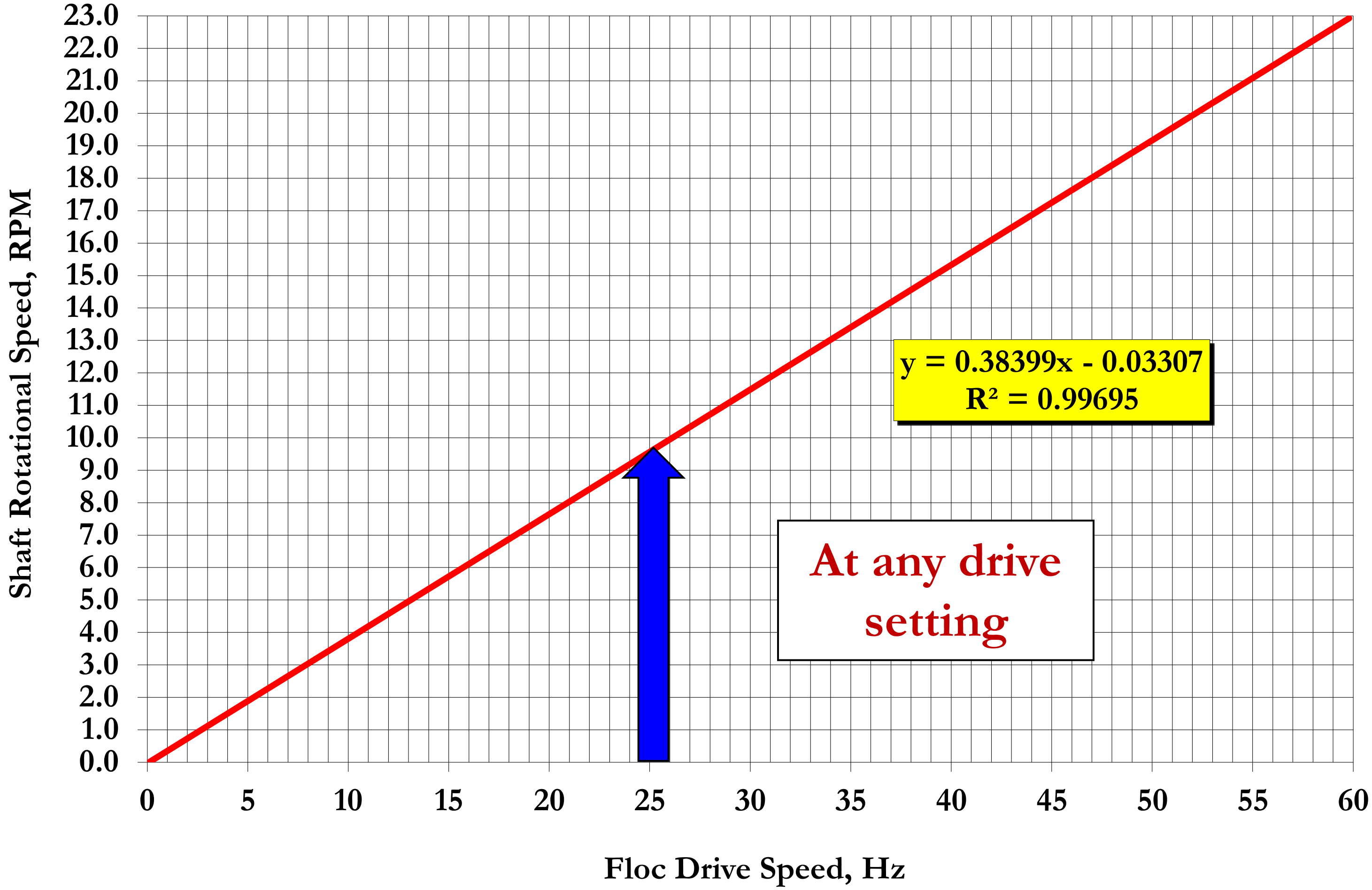


Low density floc particles observed in full-scale operations

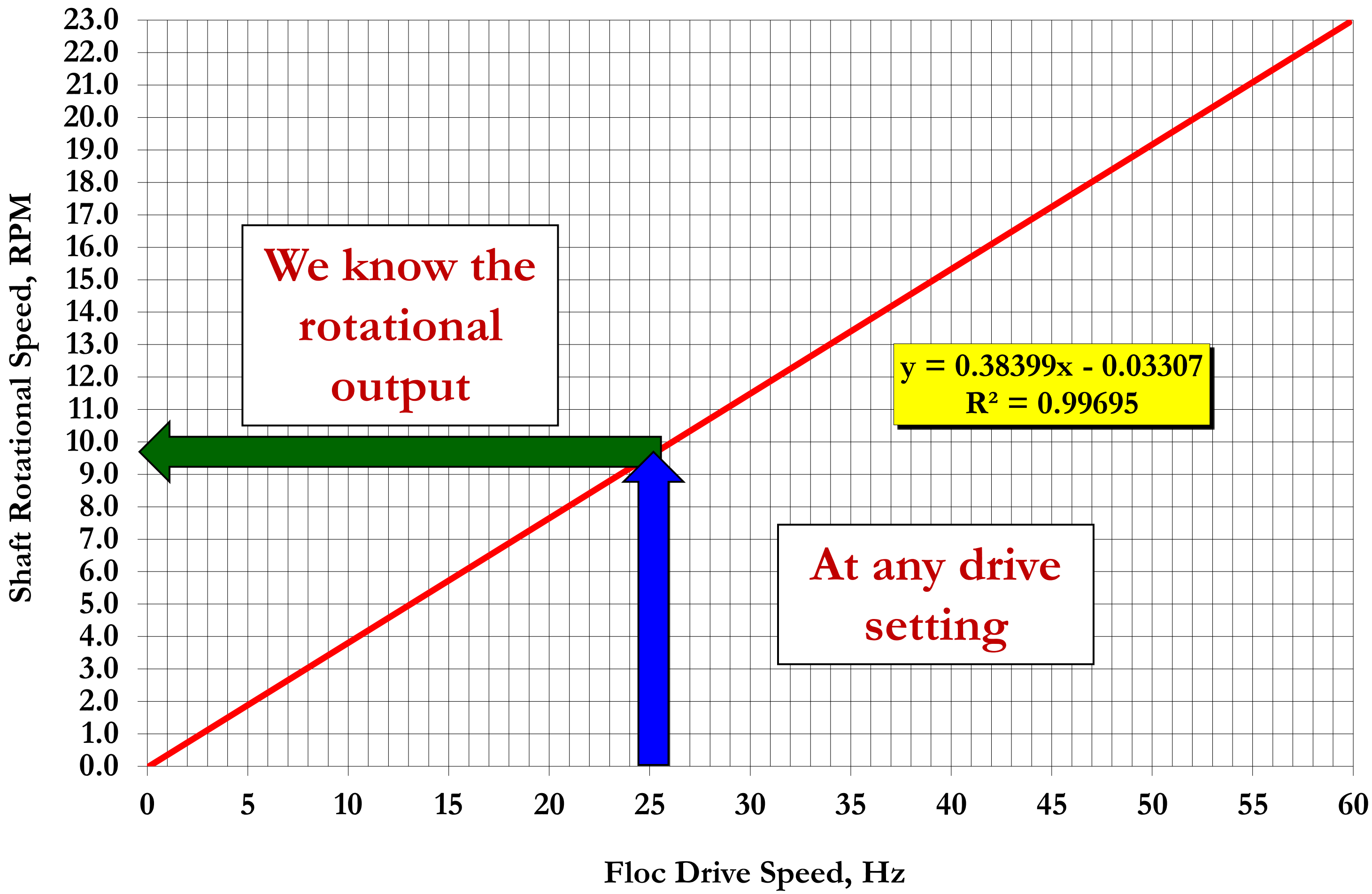
Atlanta-Fulton County



Atlanta-Fulton County



Atlanta-Fulton County



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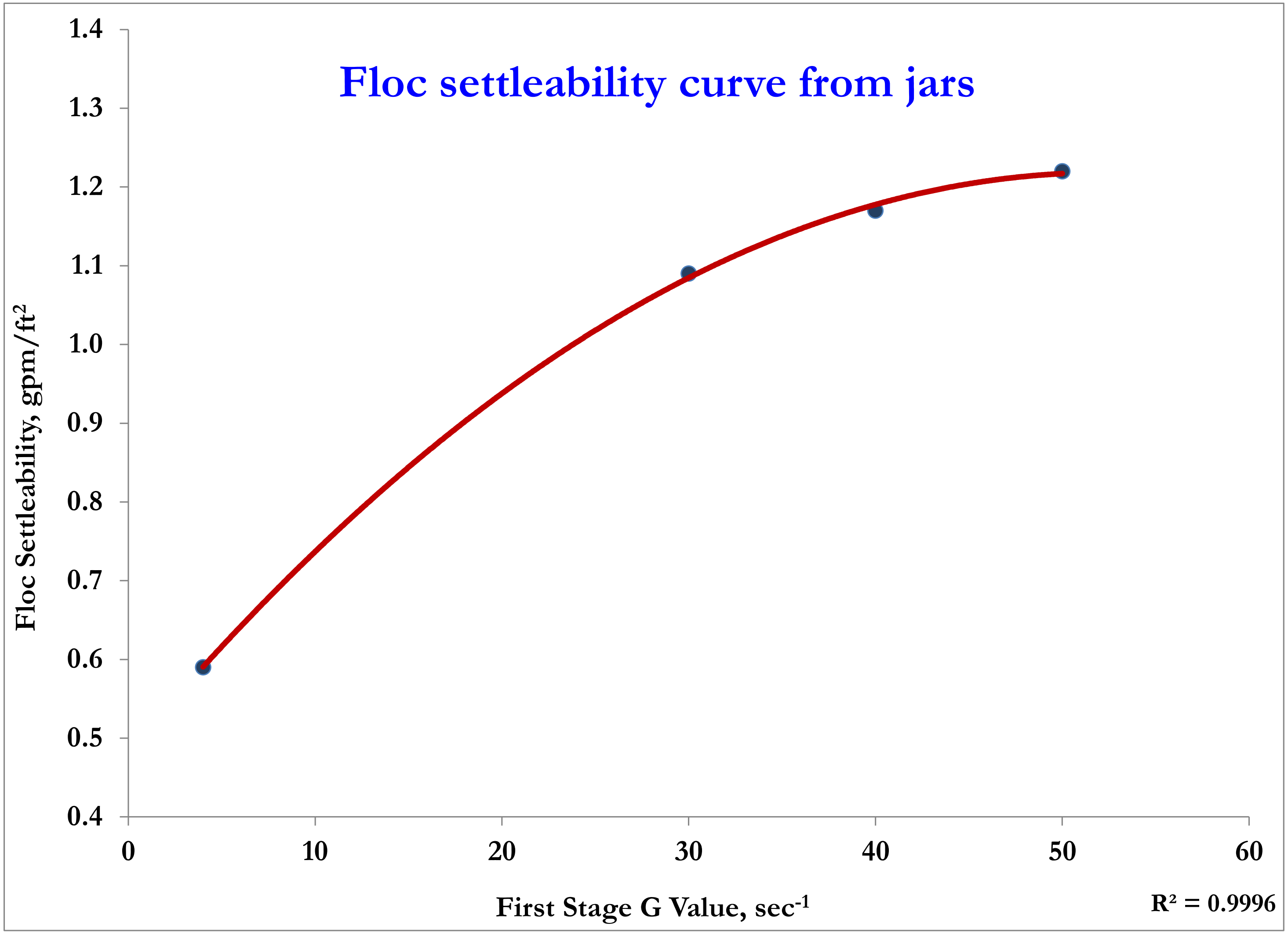
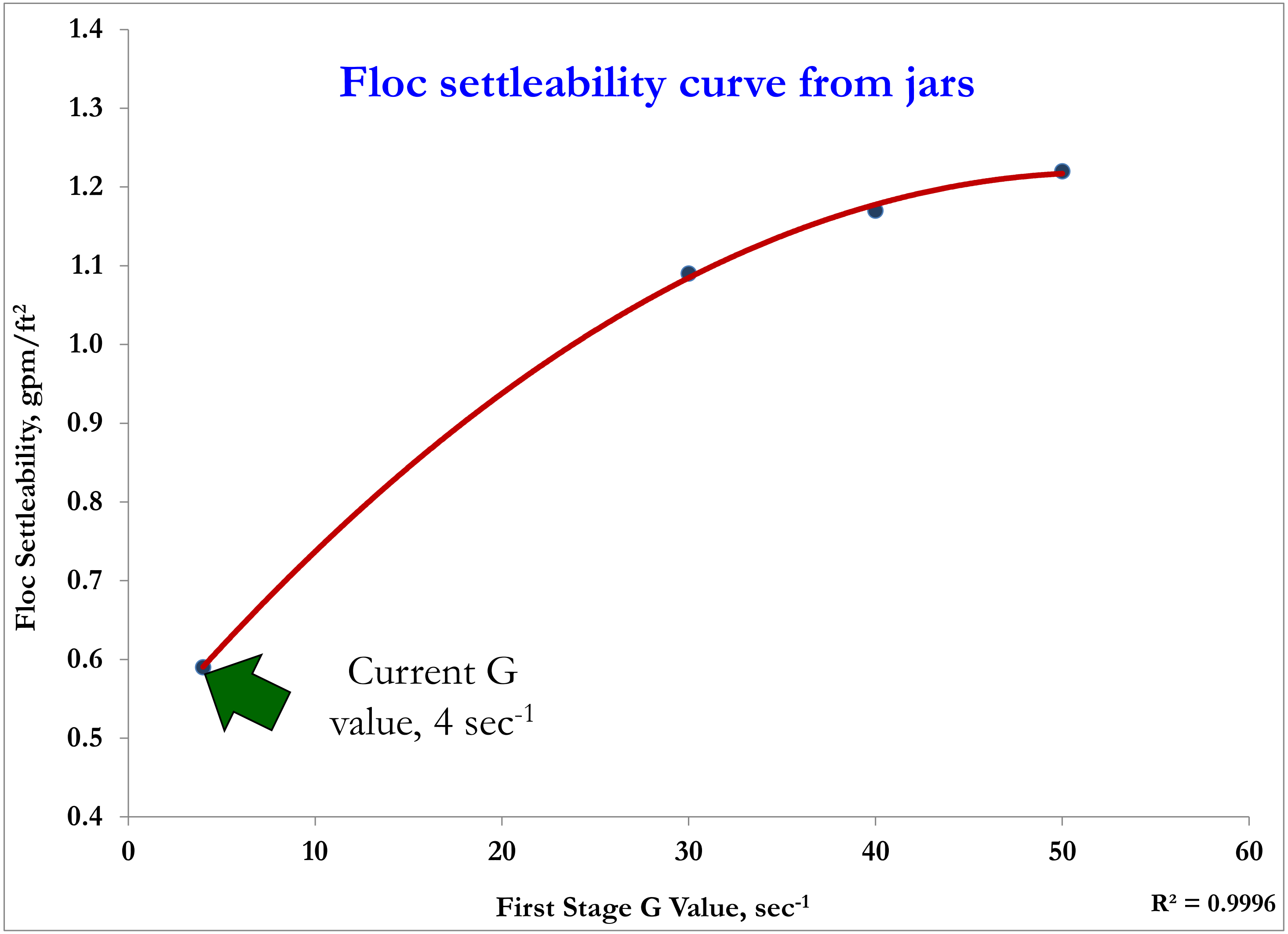
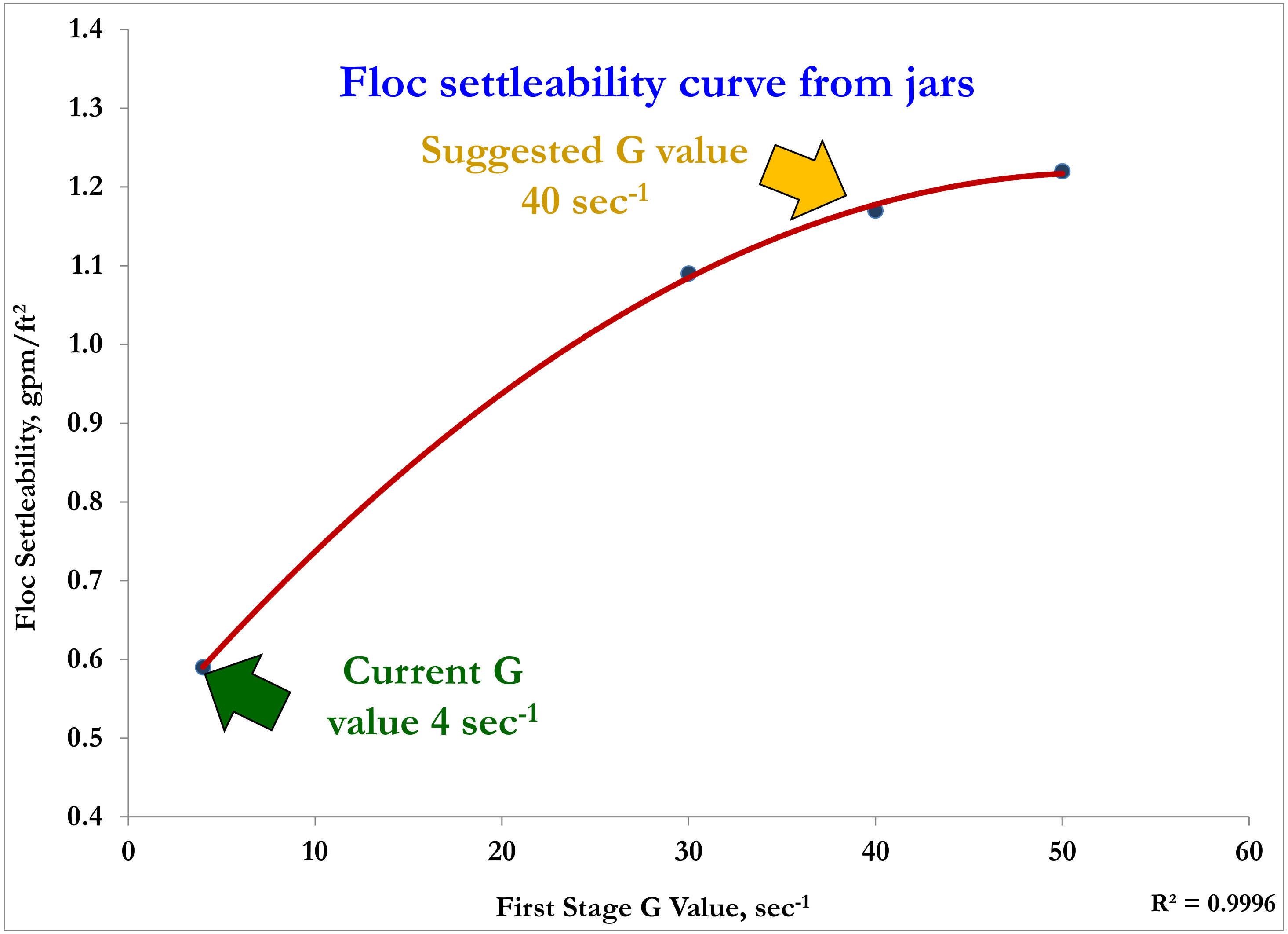


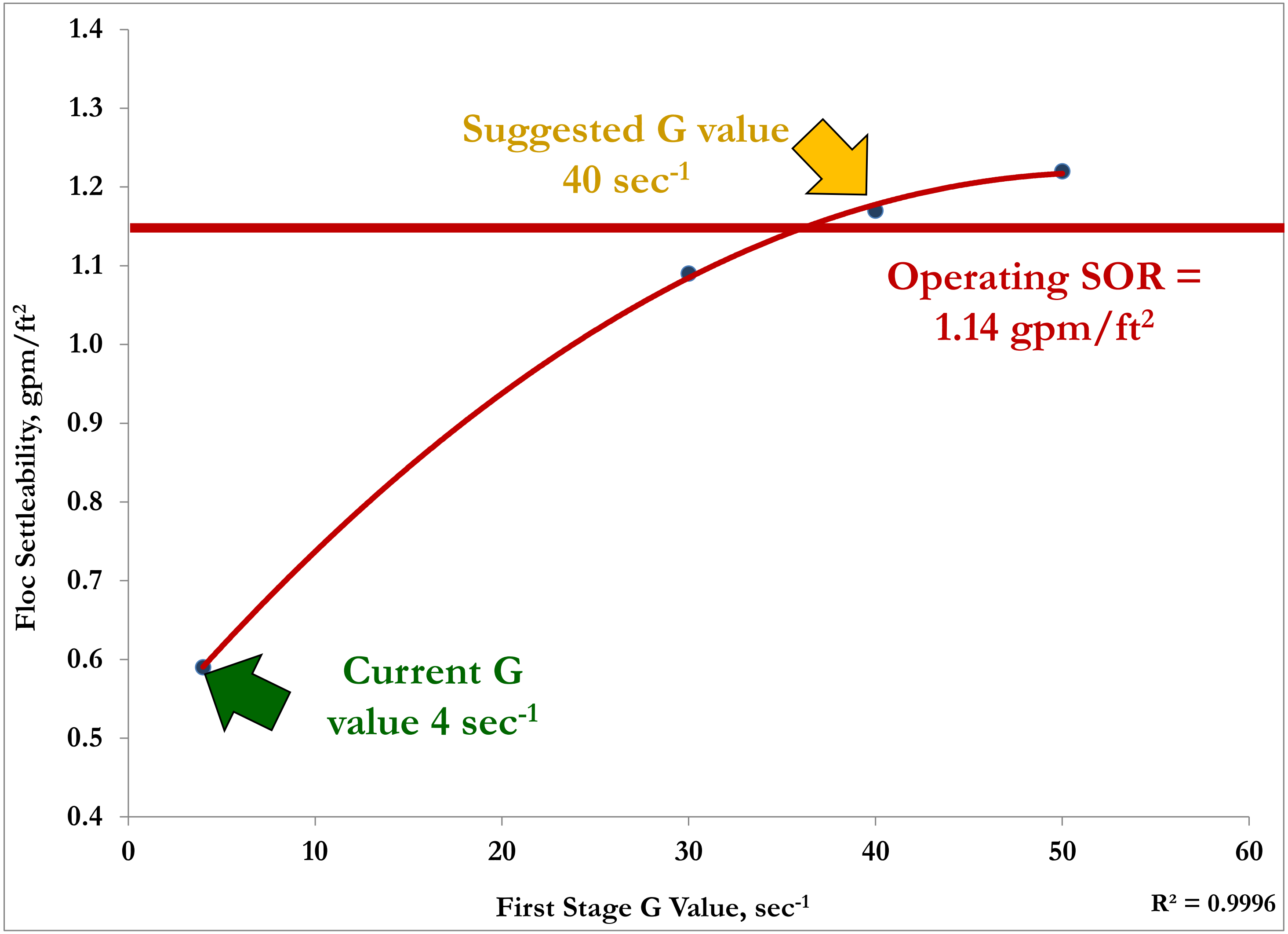
Atlanta-Fulton County



Atlanta-Fulton County



Atlanta-Fulton County

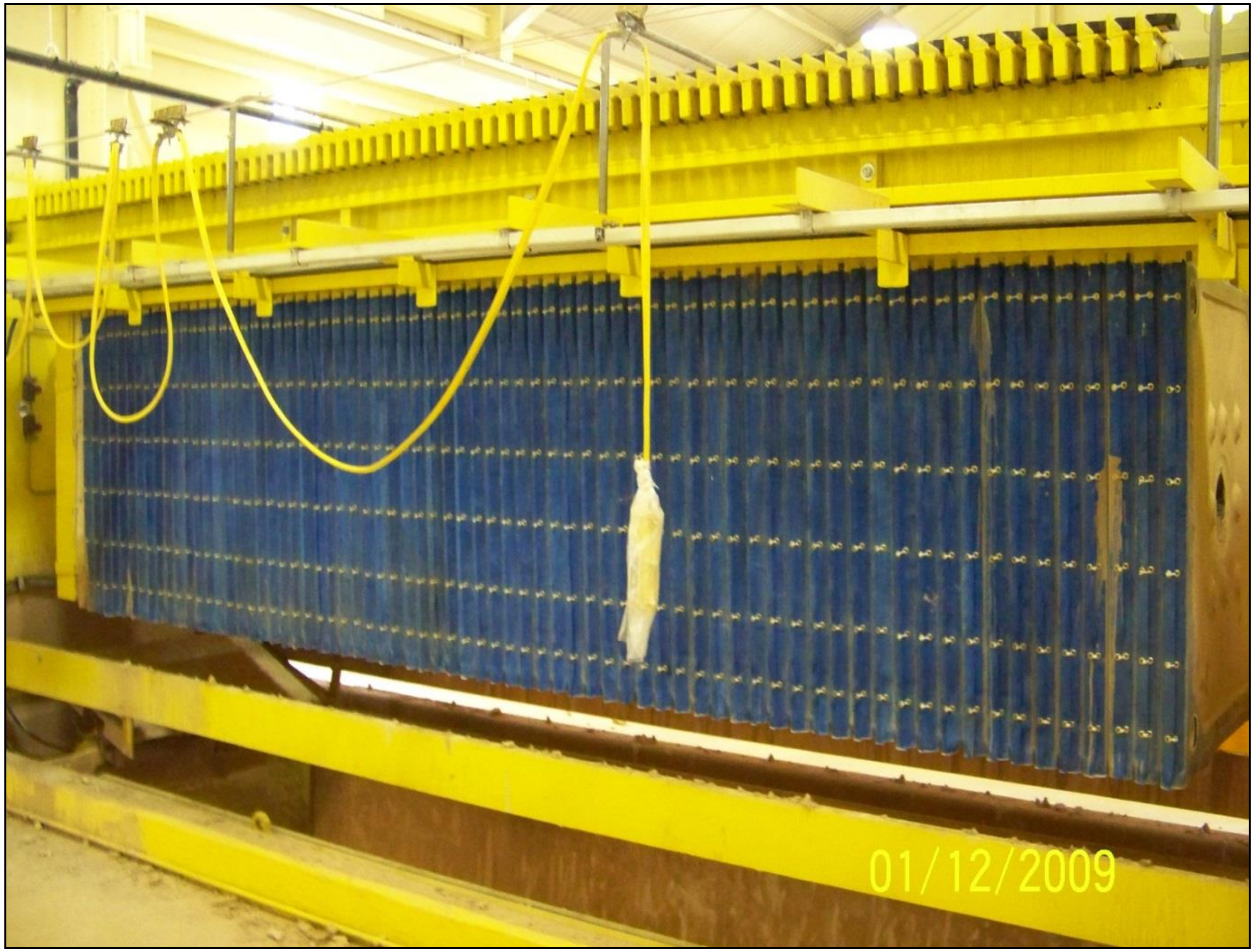


Atlanta-Fulton County

- Adjusted floc drive speeds to produce suggested G values
- Tracked settled water turbidity online monitoring
- Reduced from 0.5 NTU average to **0.1 NTU average** within 4 days
- Possible to reduce coagulant dosage to obtain similar settled turbidity
- **Implemented without capital costs**

Atlanta-Fulton County

- Dewatering accomplished in gravity thickeners, lime amendment to **pH 12**, sludge conditioning and pumping, plate and frame filter press
- Cake disposal in local landfill
- Cake typically 23% solids (another story)

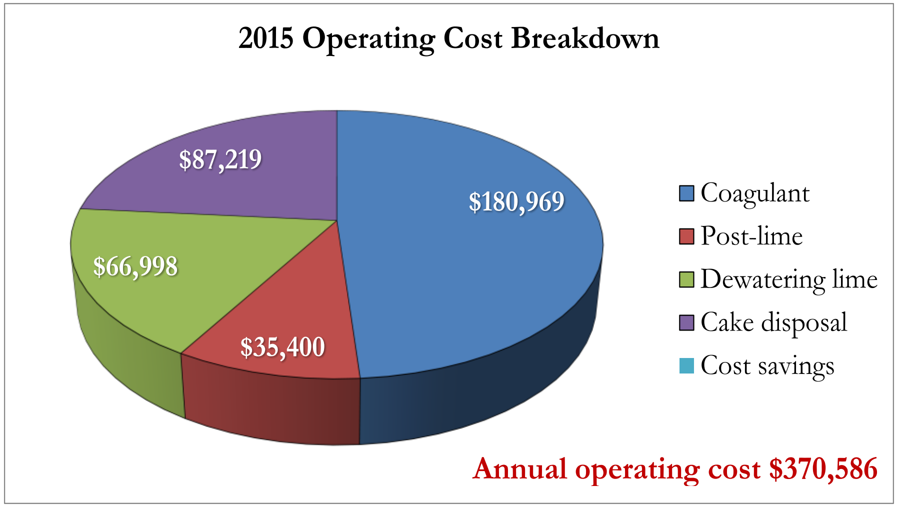


Atlanta-Fulton County

- Coagulant reduction could impact other processes and costs
  - Reduced solids production
  - Reduced lime for dewatering
  - Reduced post-lime for pH adjustment/corrosion control
  - Cake disposal
- Phase 2 optimization
  - Define current operating costs
  - Develop potential costs under optimized coagulant dosing
  - Establish new settled water target values
  - Verify operating costs from annual operations

Atlanta-Fulton County

Initial Operating Metrics	
Alum, mg/L	15.6
Post-lime, mg/L	3.92
Dewatering lime, lbs/mo.	76,798
Filter cake, dry tons per year	941
Alum, lbs/MG	**132.2**
Post-lime, lbs/MG	**33.3**
Dewatering lime, tons per dry ton cake	**1.832**



Atlanta-Fulton County

Initial Operating Metrics		Projected Operating Metrics	
Alum, mg/L	15.6	Alum, mg/L	12.5
Post-lime, mg/L	3.92	Post-lime, mg/L	3.2
Dewatering lime, lbs/mo.	76,798	Dewatering lime, lbs/mo.	57,599
Filter cake, dry tons per year	941	Filter cake, dry tons per year	752
Alum, lbs/MG	**132.2**	Alum, lbs/MG	**105.9**
Post-lime, lbs/MG	**33.3**	Post-lime, lbs/MG	**27.2**
Dewatering lime, tons per dry ton cake	**1.832**	Dewatering lime, tons per dry ton cake	**1.832**

Expected 20% overall reduction in operating costs

Atlanta-Fulton County

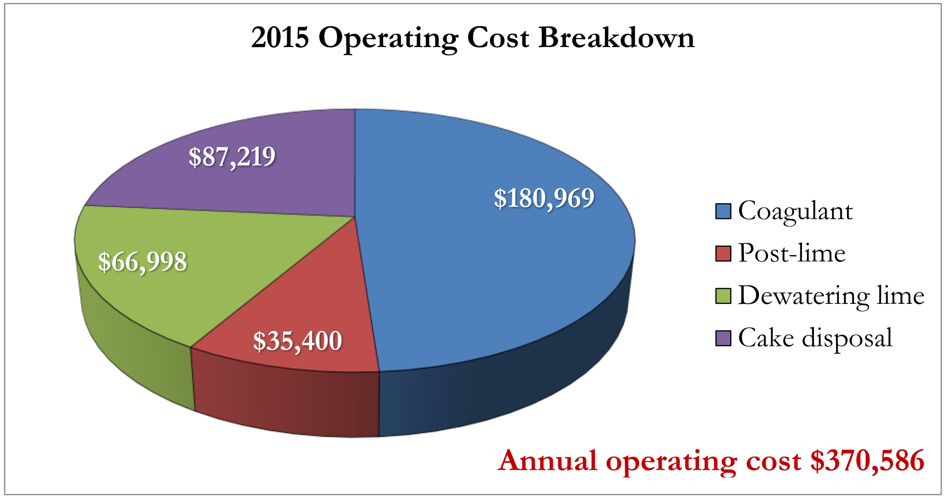
- Implementation and verification of annual operations
  - Month-to-month tracking and comparisons first year
  - Calculation of operating costs and actual savings
  - Adjustment of operating metrics
  - Summation of first-year operations

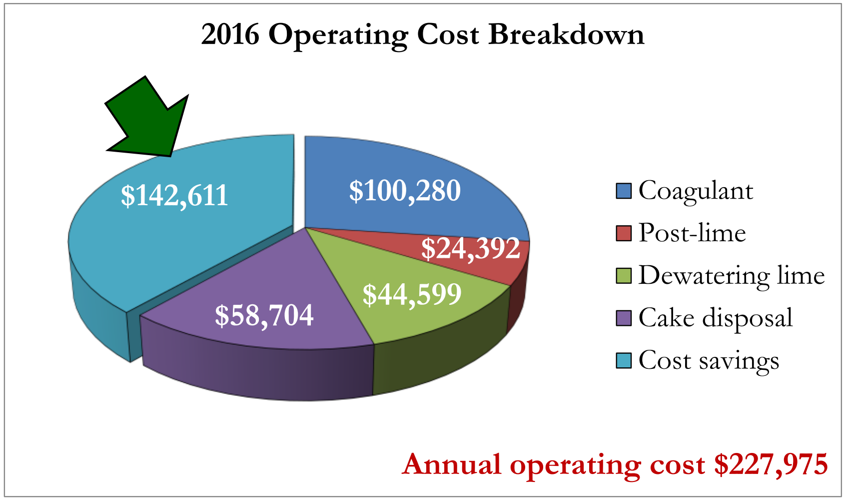
Dewatering lime feed

Atlanta-Fulton County

Initial Operating Metrics		Actual Operating Metrics	
Alum, mg/L	15.6	Alum, mg/L	9.6
Post-lime, mg/L	3.92	Post-lime, mg/L	2.9
Dewatering lime, lbs/mo.	76,798	Dewatering lime, lbs/mo.	51,123
Filter cake, dry tons per year	941	Filter cake, dry tons per year	650
Alum, lbs/MG	**132.2**	Alum, lbs/MG	**79.8**
Post-lime, lbs/MG	**33.3**	Post-lime, lbs/MG	**23.7**
Dewatering lime, tons per dry ton cake	**1.832**	Dewatering lime, tons per dry ton cake	**1.832**

Atlanta-Fulton County

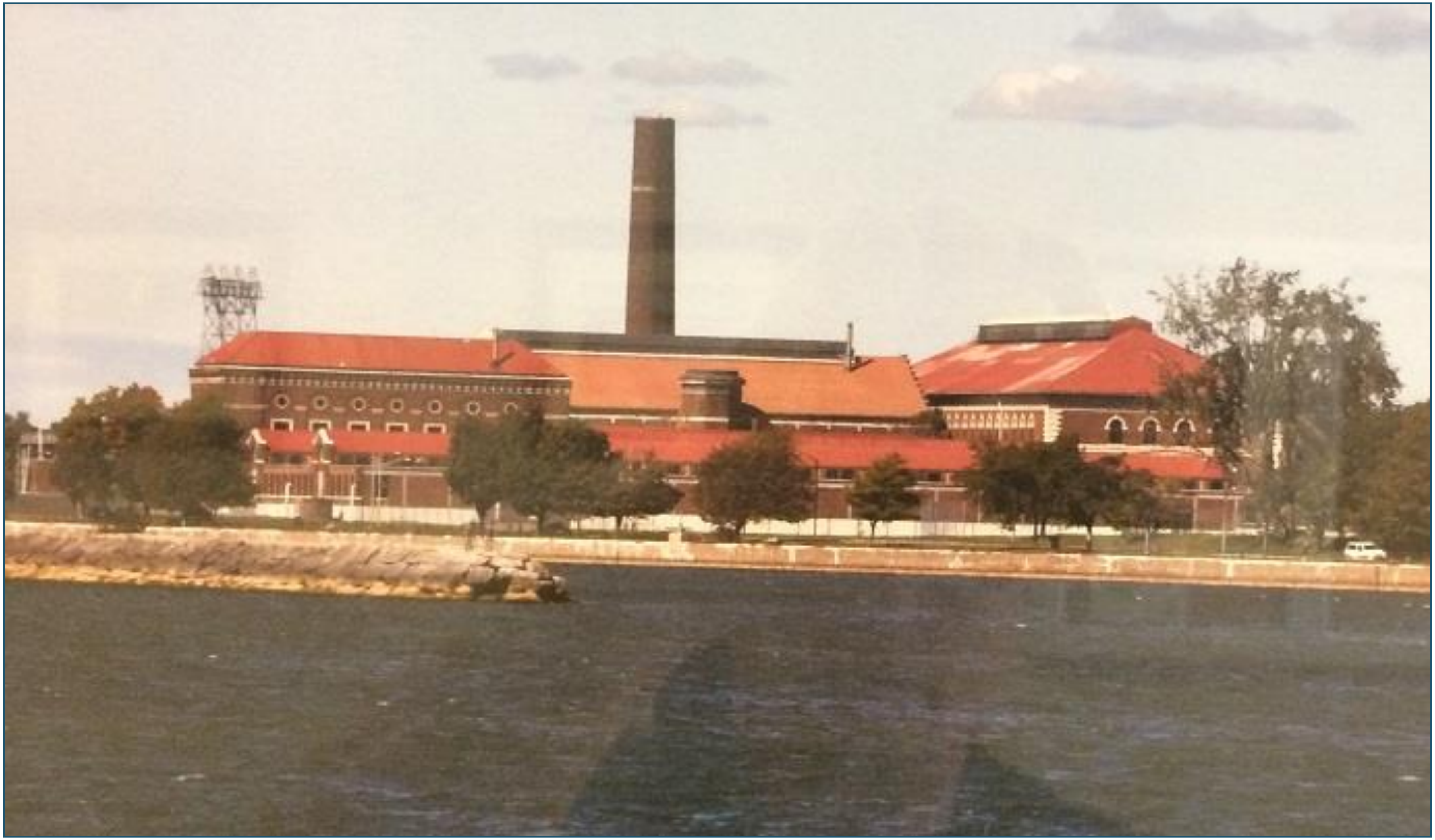




Actual 38% reduction in annual costs obtained

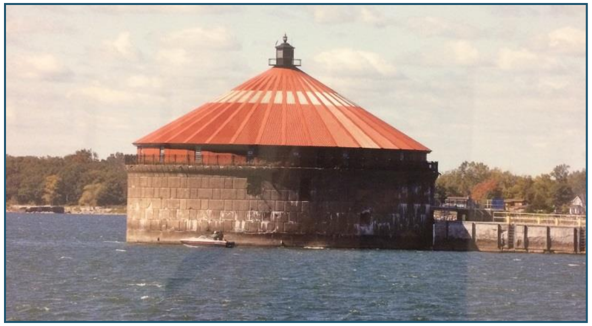
Excellent coordination between operations and engineering toward a common goal

Buffalo Water, New York



Buffalo Water

- 120 mgd surface water plant, originally 1922
  - Average daily production 71 mgd
- Direct draw from eastern basin Lake Erie
  - Just upstream of Niagara River
- Coagulation/filtration plant
  - Chemical treatment
  - Solids handling
  - Disinfection and storage
- Finished water pumping to distribution system
  - 257,00 people



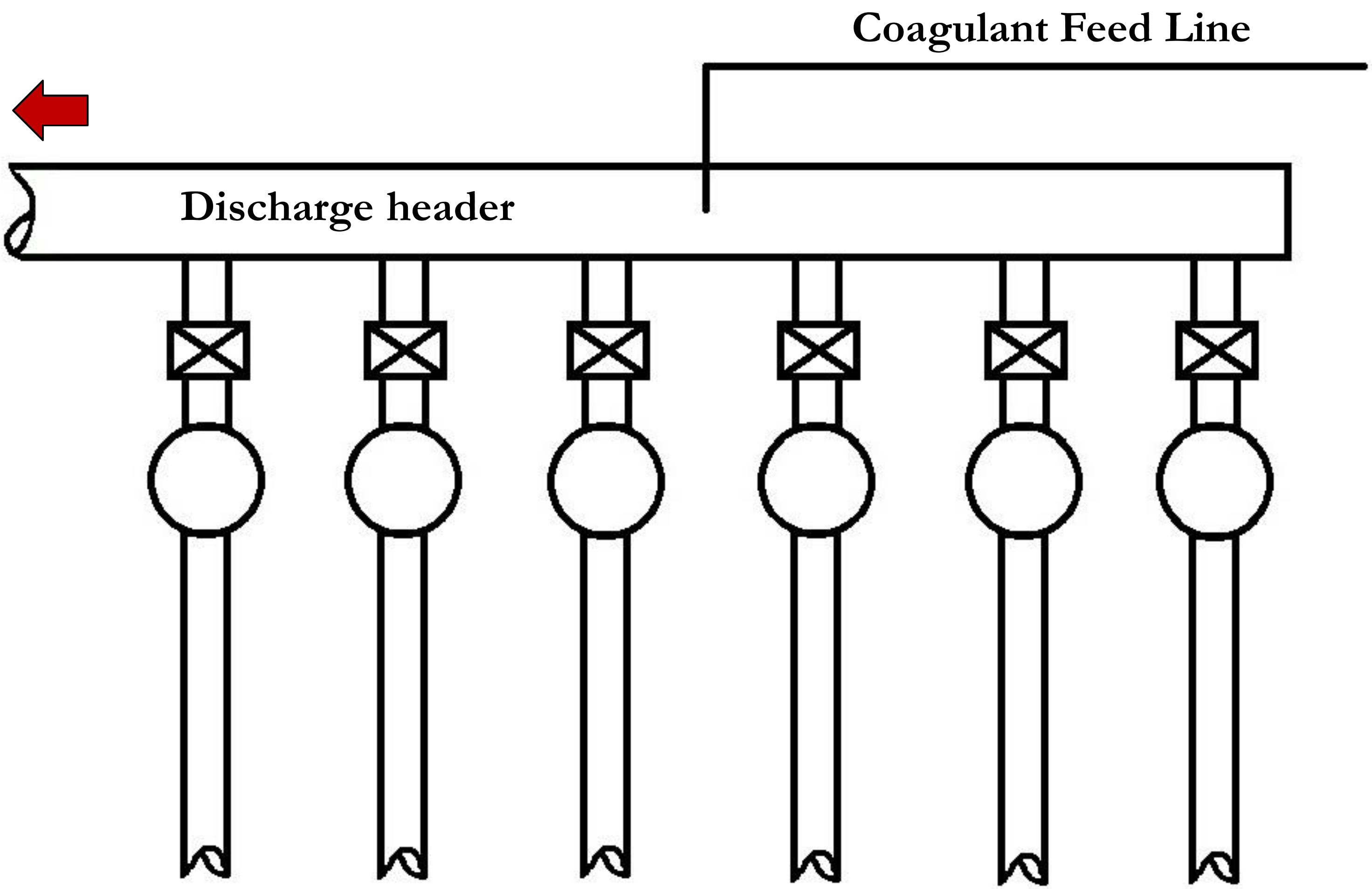
Lake Intake Structure

Buffalo Water

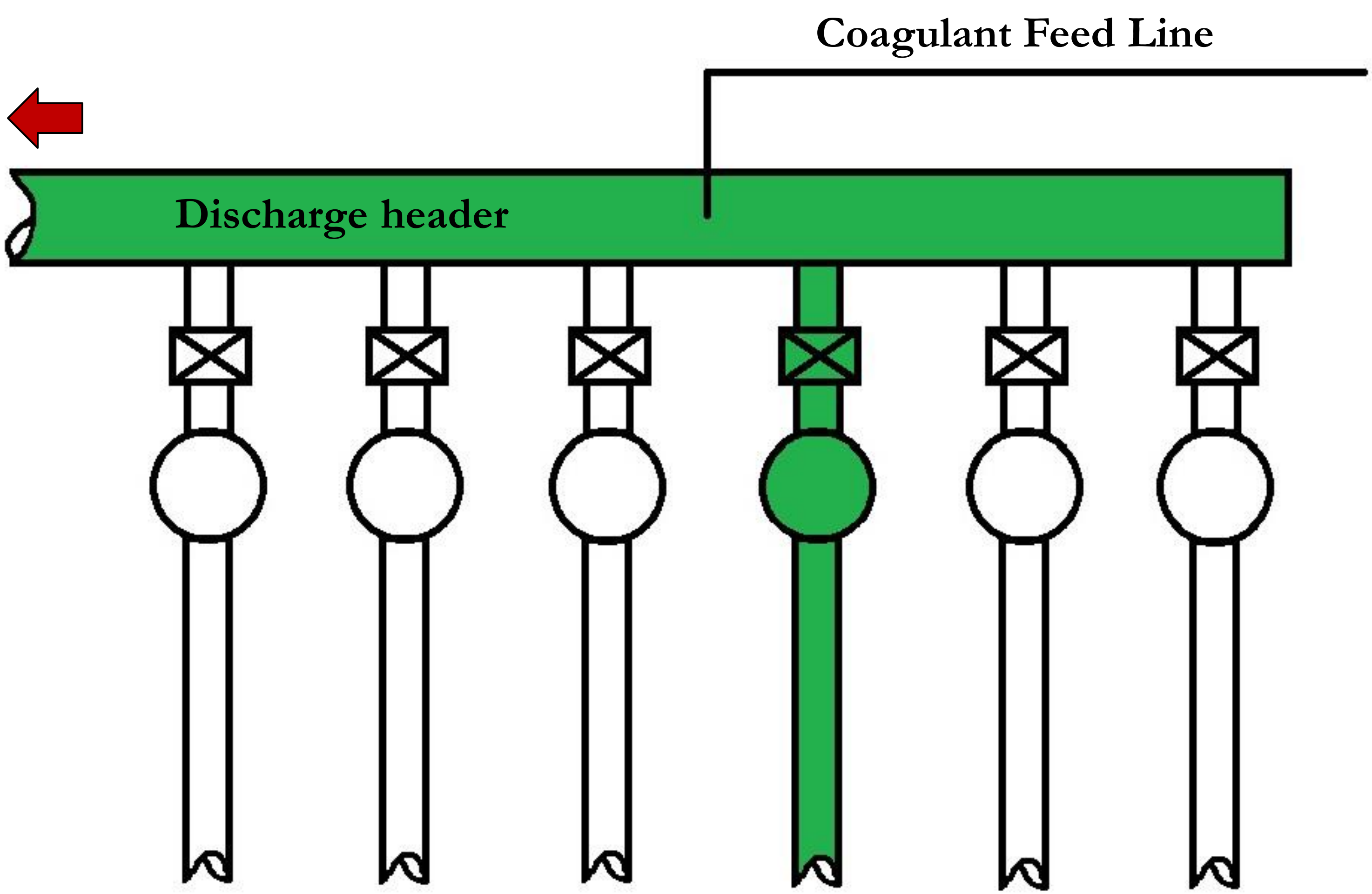
Buffalo Water

- SternPac coagulant used since 1990's
  - Raw water turbidity averages 2 NTU
  - Settled water turbidity averaged 0.85 NTU
  - Filter run times 72 hours
    - Low head loss, possible optimization initiaitive
- One coagulant feed point
  - Low service discharge header
  - Relatively poor mixing
  - Coagulant not contacting within pump flow depending on pump in operation

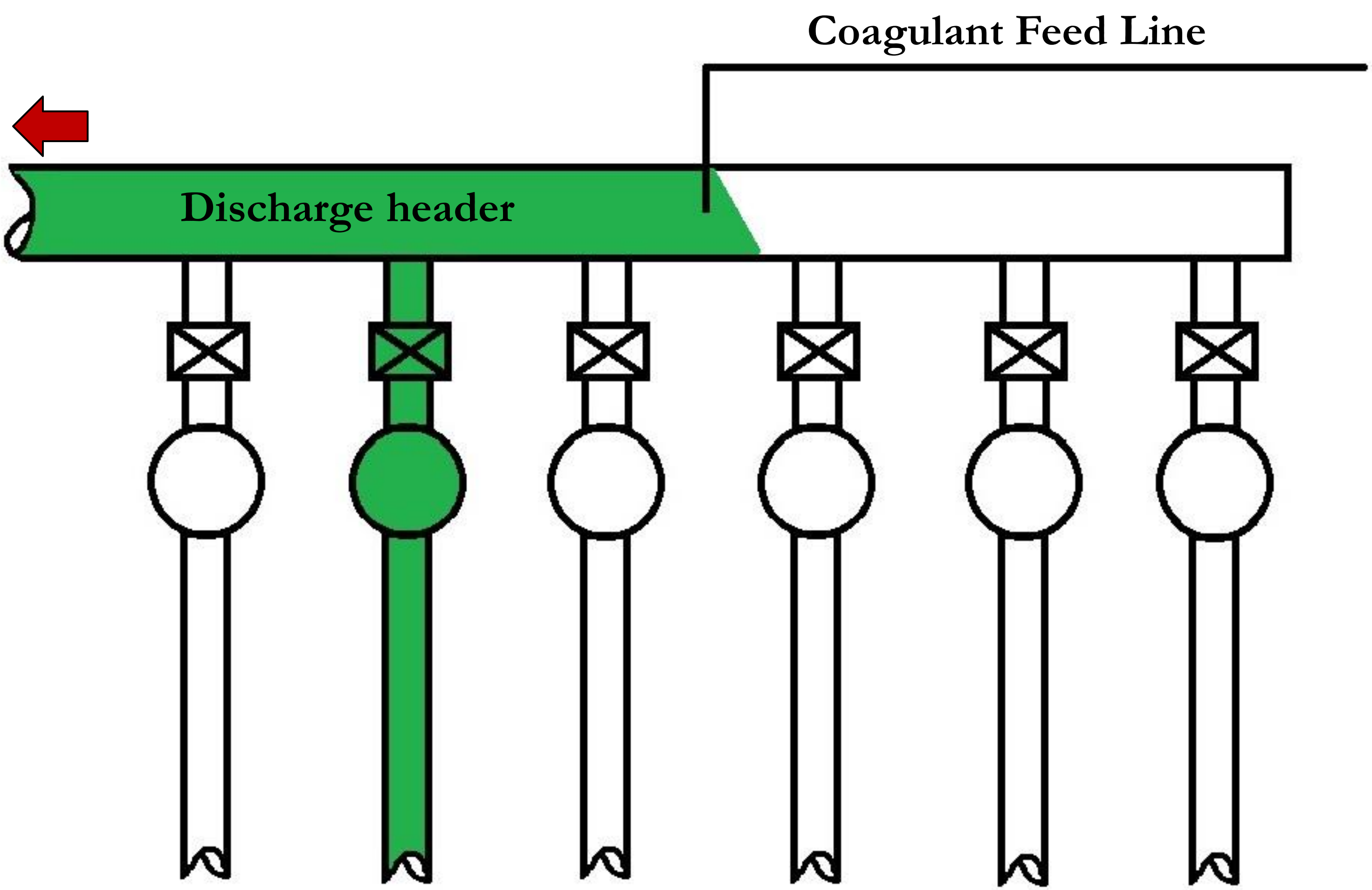
Buffalo Water



Buffalo Water

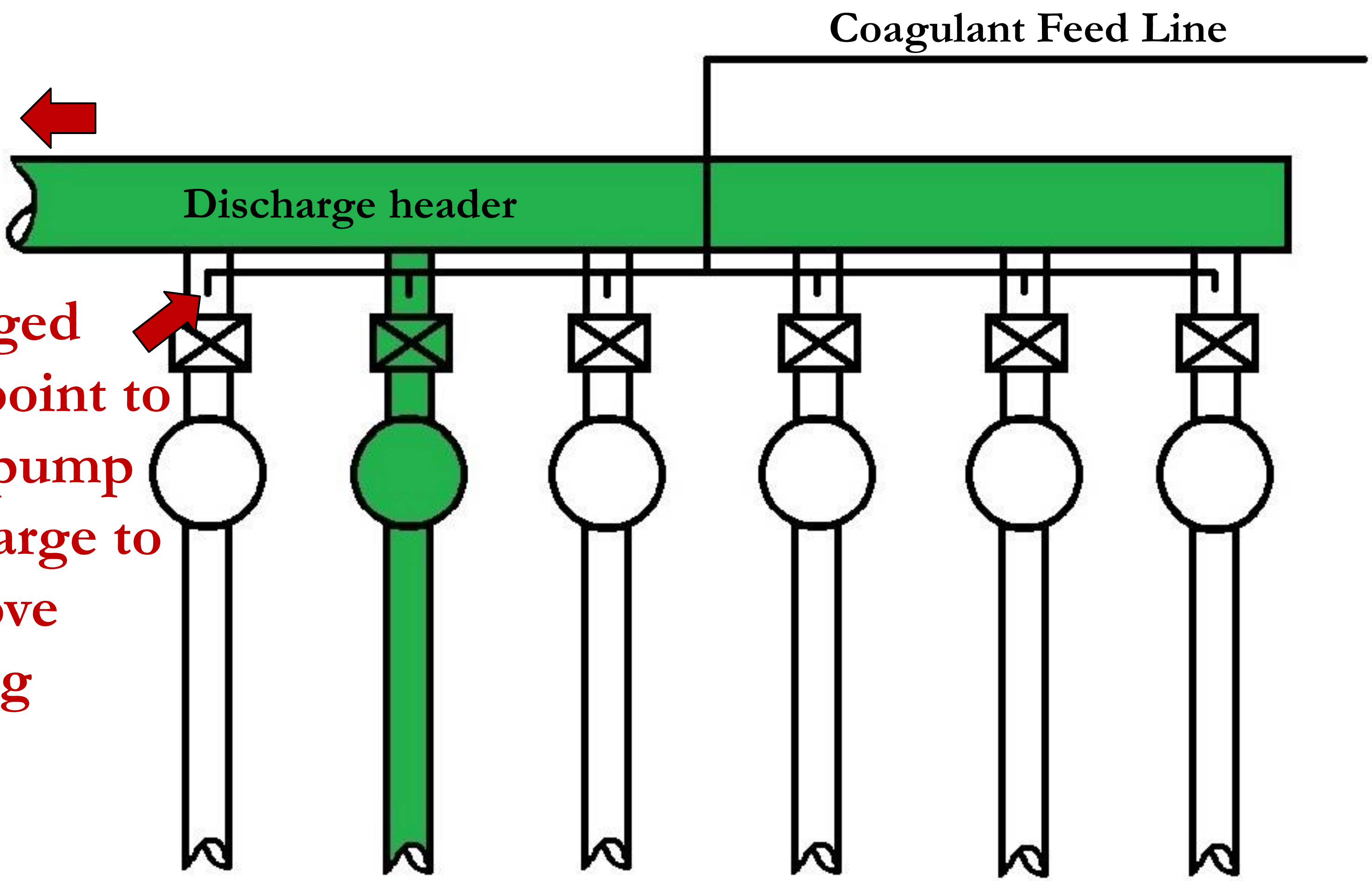


Buffalo Water



Buffalo Water

Changed feed point to each pump discharge to improve mixing

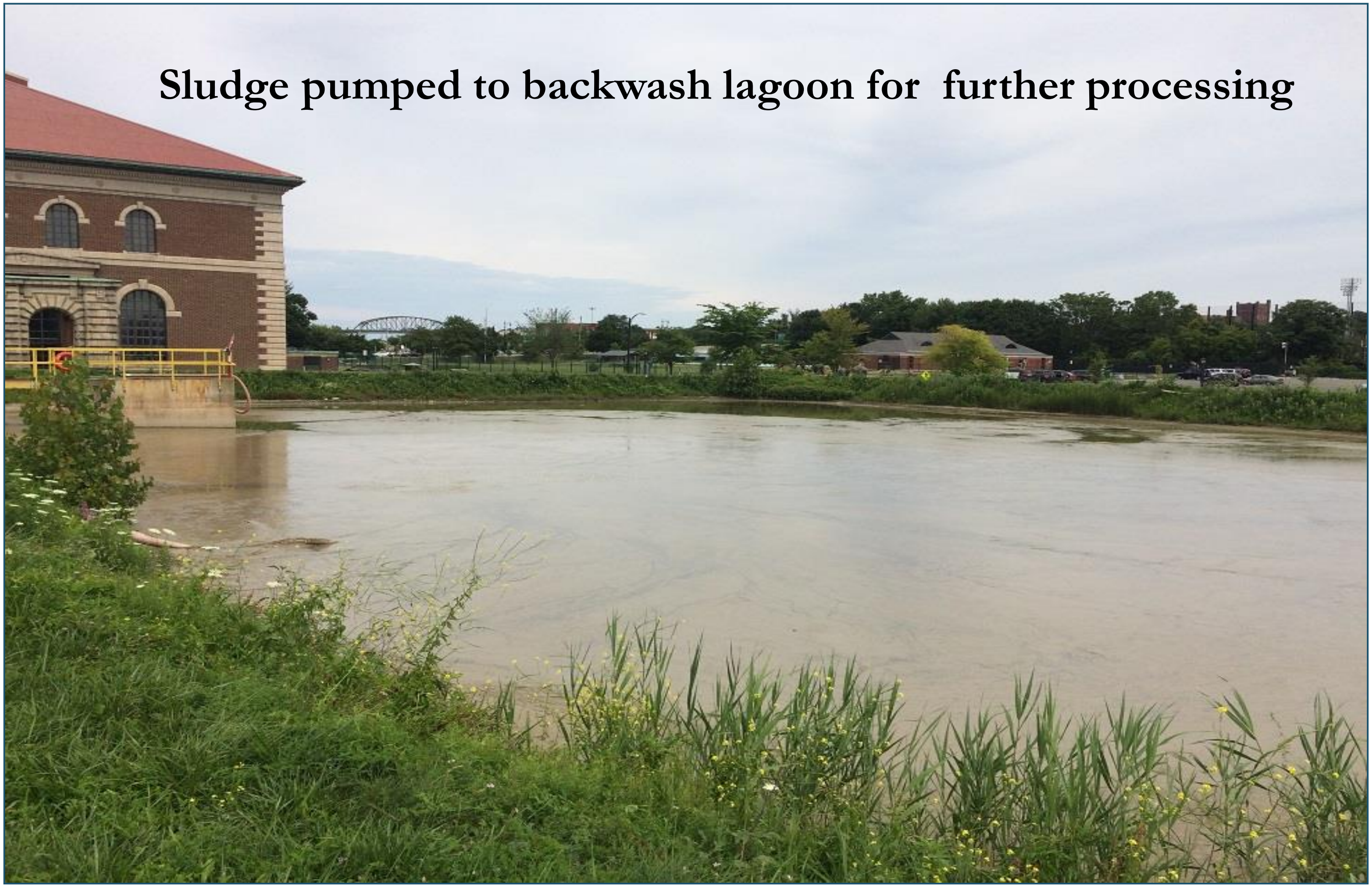


Buffalo Water

- Mixing improvement immediately led to 17% reduction in coagulant dosage
  - 9.7 mg/L to 8 mg/L
- Coagulant reduction also impacted
  - Sludge dewatering
  - Polymer conditioning
  - Cake disposal
  - Operating costs

Buffalo Water

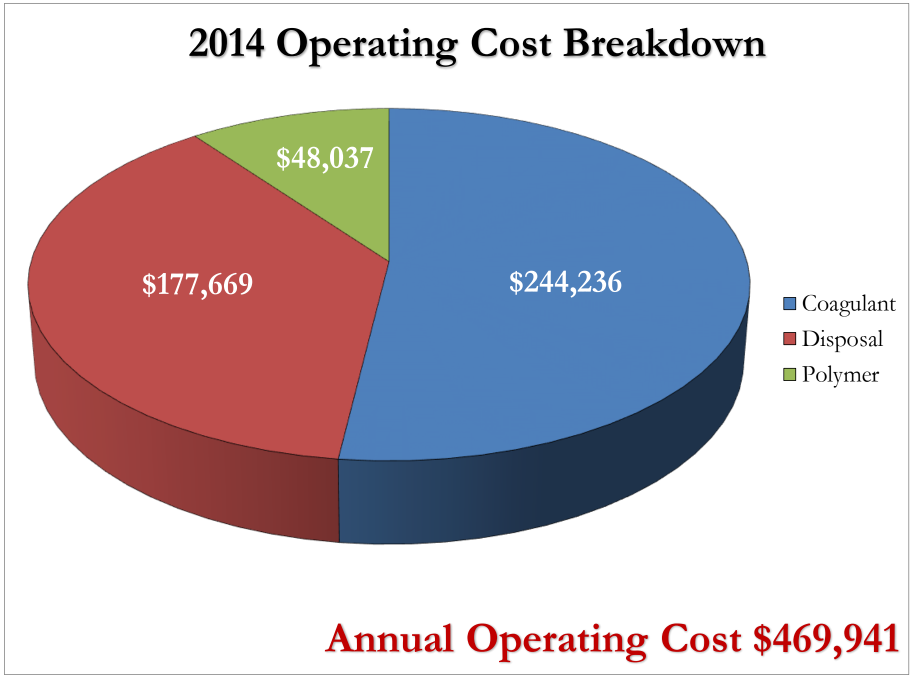
Buffalo Water


Sludge pumped to backwash lagoon for further processing

Buffalo Water

Buffalo Water

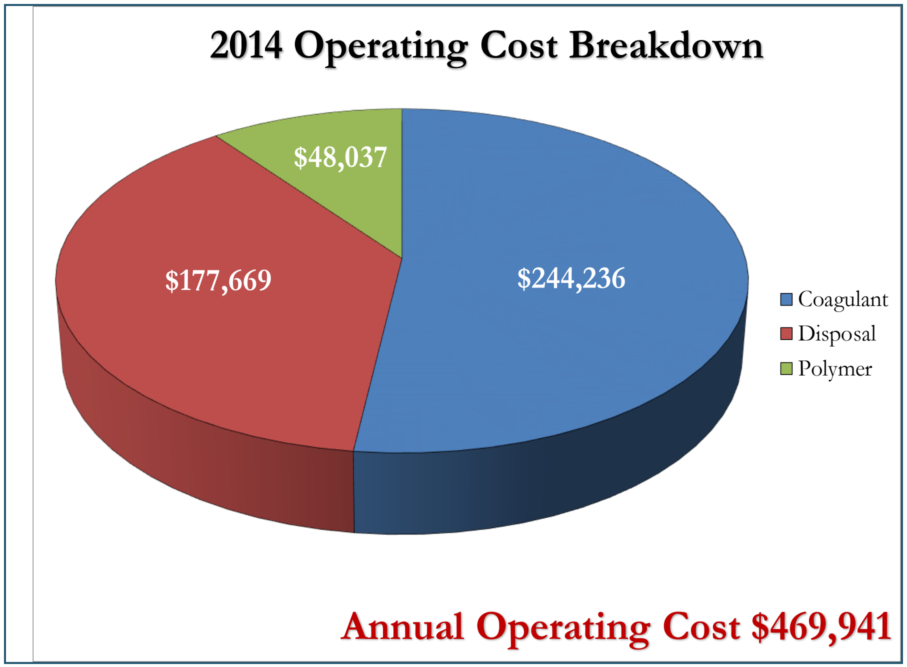
Initial Operating Metrics	
SternPac, mg/L	9.67
Dewatering polymer, lbs/ton	12.95
Cake production, dry tons/yr	931
Cake solids, %	22.6

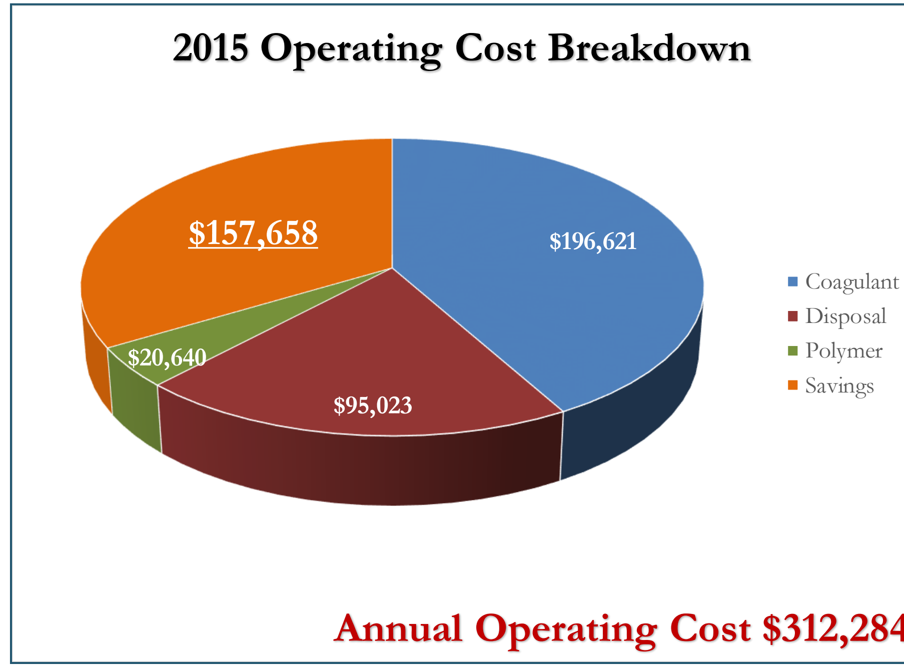


Buffalo Water

Initial Operating Metrics		Actual Operating Metrics	
SternPac, mg/L	9.67	SternPac, mg/L	8.0
Dewatering polymer, lbs/ton	12.95	Dewatering polymer, lbs/ton	10.13
Cake production, dry tons/yr	931	Cake production, dry tons/yr	725
Cake solids, %	22.6	Cake solids, %	32.1

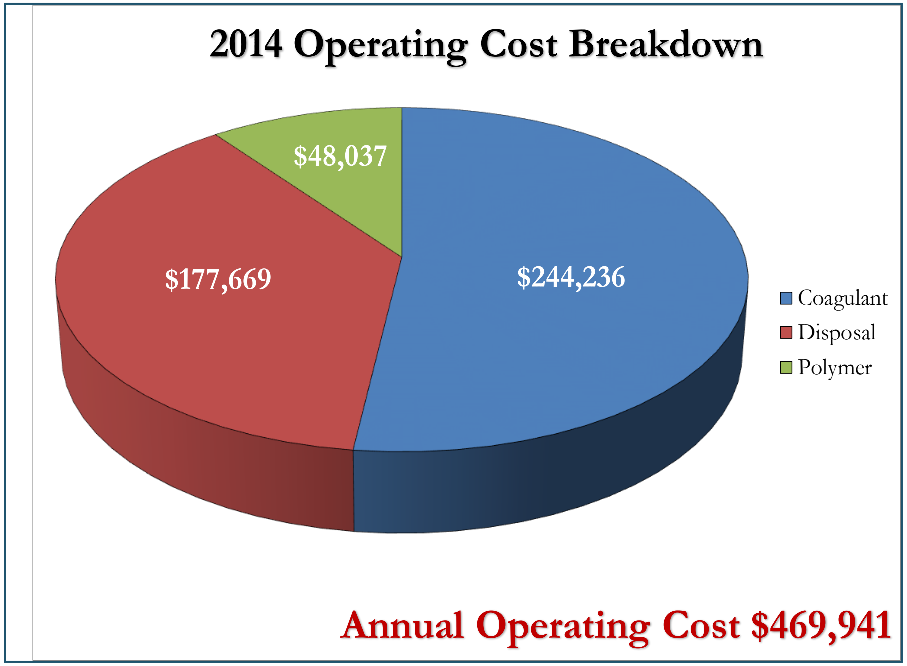
Buffalo Water

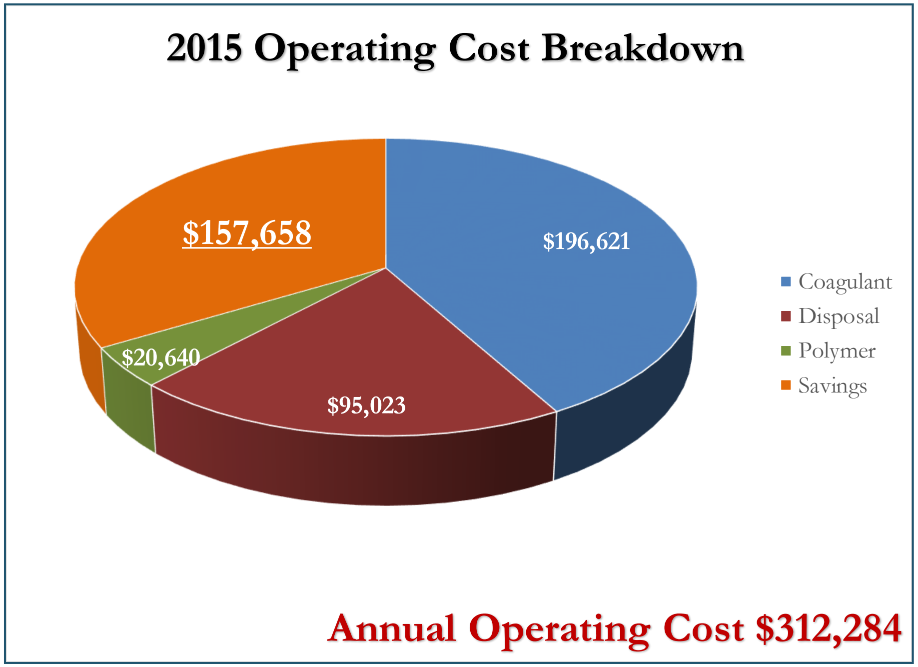




Actual 33.5% reduction realized in annual costs

Buffalo Water





Actual 33.5% reduction realized in annual costs

Annual cost savings $157,657

Buffalo Water

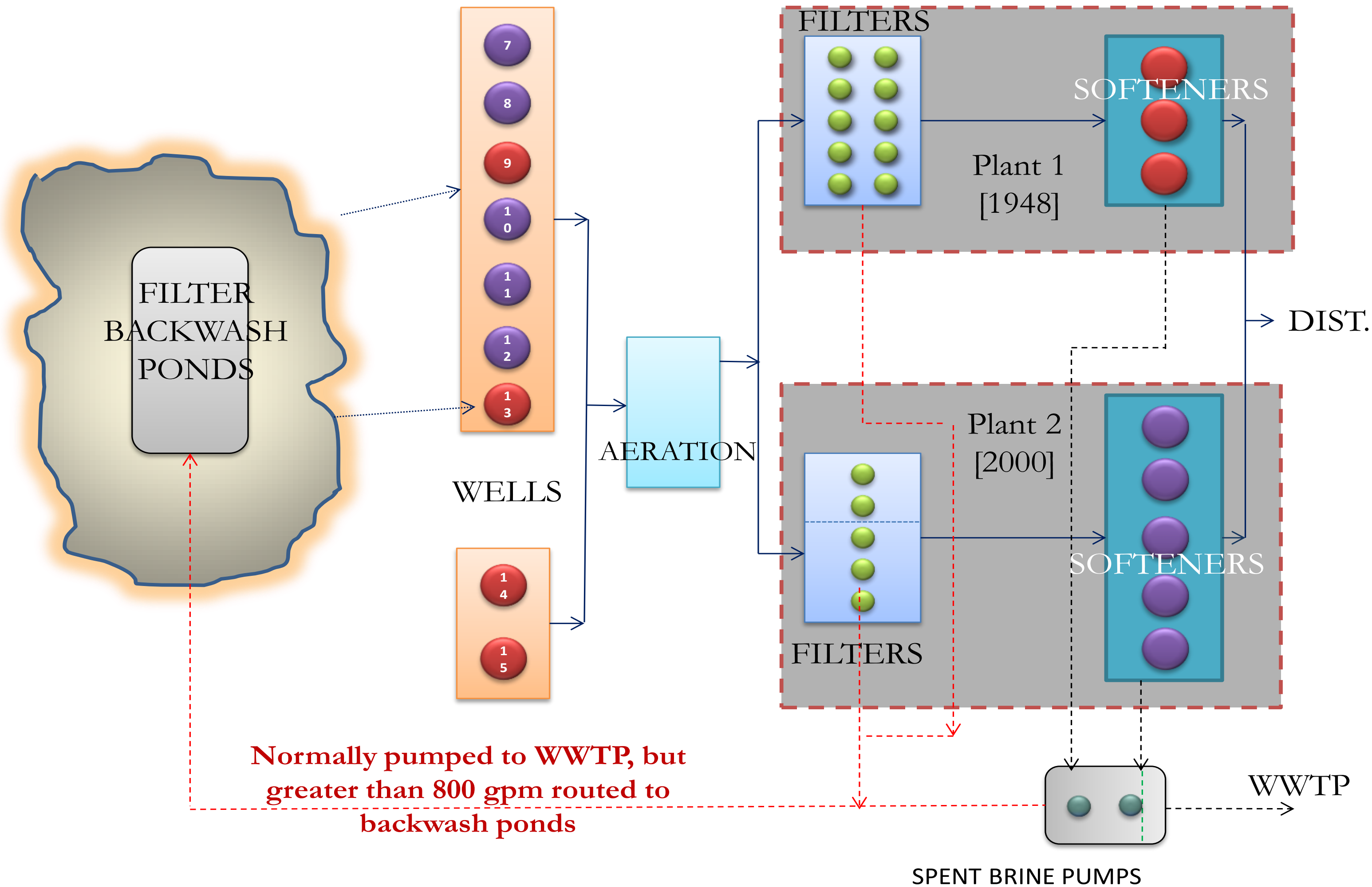
- Future optimization plans
  - Floc speed adjustments (underway with another 12% coagulant reduction)
  - Incorporate activated carbon reactors for T&O/cyanotoxin treatment
  - Install conventional rapid mix to further reduce coagulant feed
  - Add streaming current monitors to automate coagulant feed
  - Optimize filter performance

Edwardsville Water, Illinois

- Two separate ground water treatment plants
  - Plant 1 1948, 3 IX softeners, 12 filters, production capacity 4.2 mgd
  - Plant 2, 2000, 6 IX softeners, 6 filters, production capacity 3.6 mgd
  - Total production capacity 7.8 mgd
- Current production availability 4.7 mgd
  - 40% reduction due to IX softener issues
  - Likely would not meet summer 2016 demands
  - Target 130 mg/L hardness
  - Target manganese <0.05 mg/L
- Manganese breakthrough in Plant 2 filters
  - Causing color problems

Edwardsville Water

High salt usage, manganese breakthrough, low production issues



Edwardsville Water

- Investigations into high salt usage, manganese breakthrough, and poor production capabilities September 2015
  - 25-year old softening resin, Plant 1
  - 65-year old pressure tanks, Plant 1
  - 4 hour softener cycles
  - No softener bypass used
  - Manganese breakthrough Plant 2 only
  - Chlorides at WWTP approaching 1,400 mg/L
  - Operators on mandatory overtime just to wash filters and to regenerate softeners
  - Ongoing contract dispute related to who pays for capital and what is considered capital expense

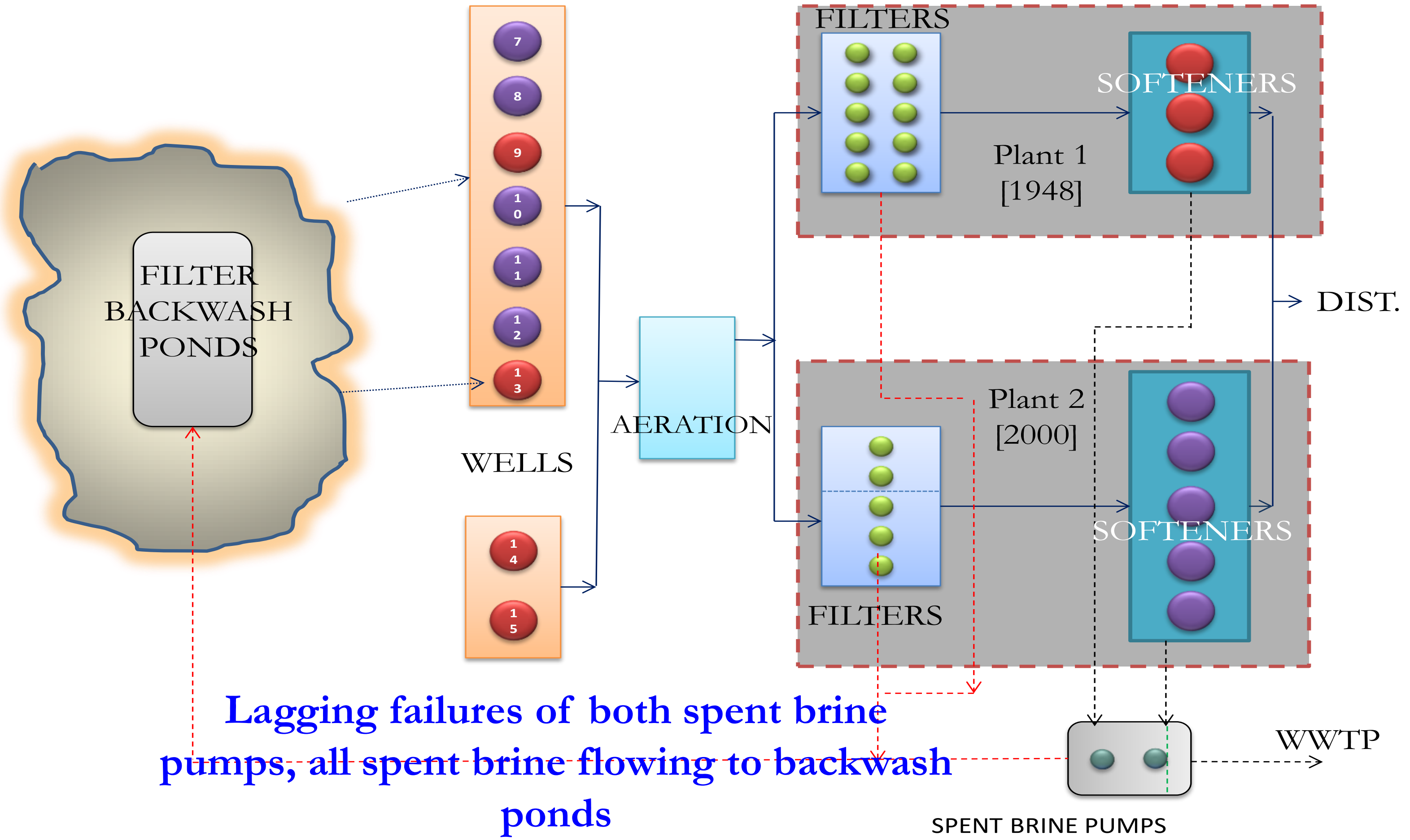
Edwardsville Water

- Manganese breakthrough
  - $KMnO_4$ used for greensand recharge at 0.3 mg/L
  - Manganese levels in Plant 2 greater than 0.1 mg/L
- Reviewed greensand dosing requirements
  - $KMnO_4$ dosing requirement 0.4 ounces per cubic foot filter media
    - New $KMnO_4$ dosing set at 0.7 mg/L
  - Manganese quickly reduced to 0.03 mg/L in filter effluent
  - Color issues eliminated

Edwardsville Water

- Well hardness increased from 380 mg/L to greater than 700 mg/L
  - Identify source of hardness increase
- Significant increase in salt demand
  - Likely due to raw hardness increase
- Resin capacity in question
  - No current capacity evaluations
  - Original capacity Plant 1 - 20,000 grains/cf
  - Original capacity Plant 2 - 43,700 grains/cf

Edwardsville Water



Lagging failures of both spent brine pumps, all spent brine flowing to backwash ponds

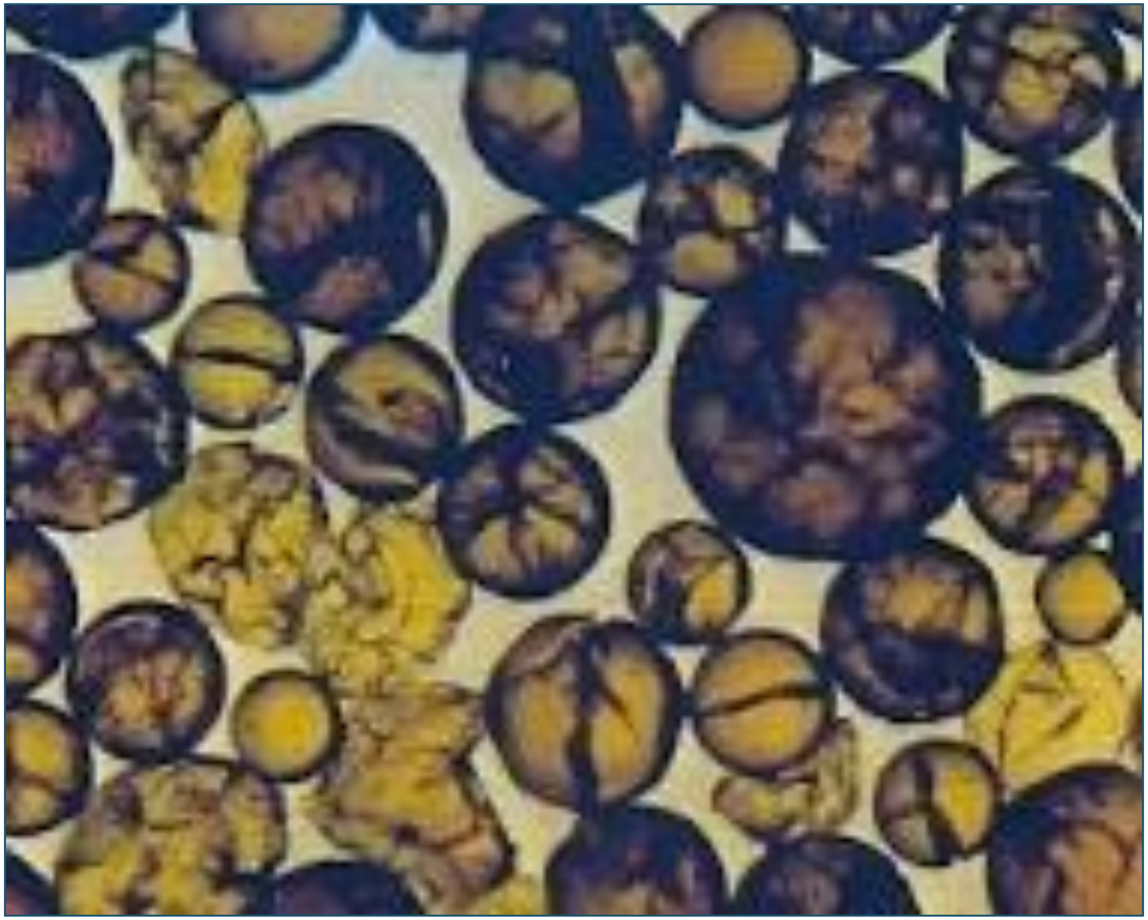
Edwardsville Water

- Spent brine analysis
  - 45,000 mg/L chlorides
  - 36,000 mg/L calcium
  - 9,000 mg/L magnesium
- Backwash ponds recharge wells near the ponds
  - Spent brine responsible for hardness increase in wells
  - Once spent brine pumps replaced, well hardness returned to normal within 12 days

Edwardsville Water

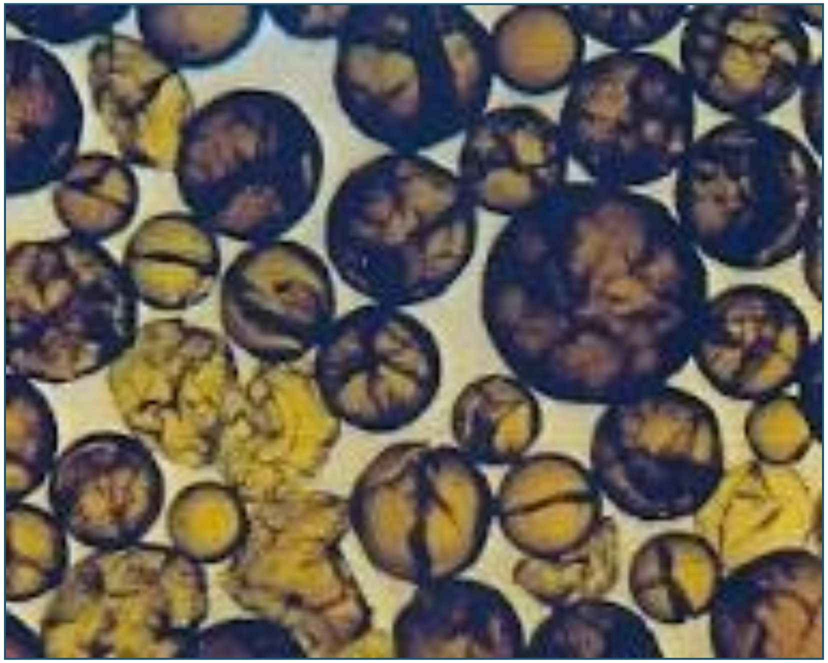
- Softener resin investigations Plant 2
  - 30,000 gallons softened between regeneration cycles
  - Salt dosing 1,100 pounds per softener (5.5 lbs/cf)
  - Run cycles about 4 hours
  - Regeneration cycle about 75 minutes
  - No current capacity evaluations
    - 2009 last capacity check showing 33% lost capacity
    - 20,000 grains/cf original capacity (low capacity resin)
    - Resin placed in softeners in 1990 (25 years old)

Edwardsville Water

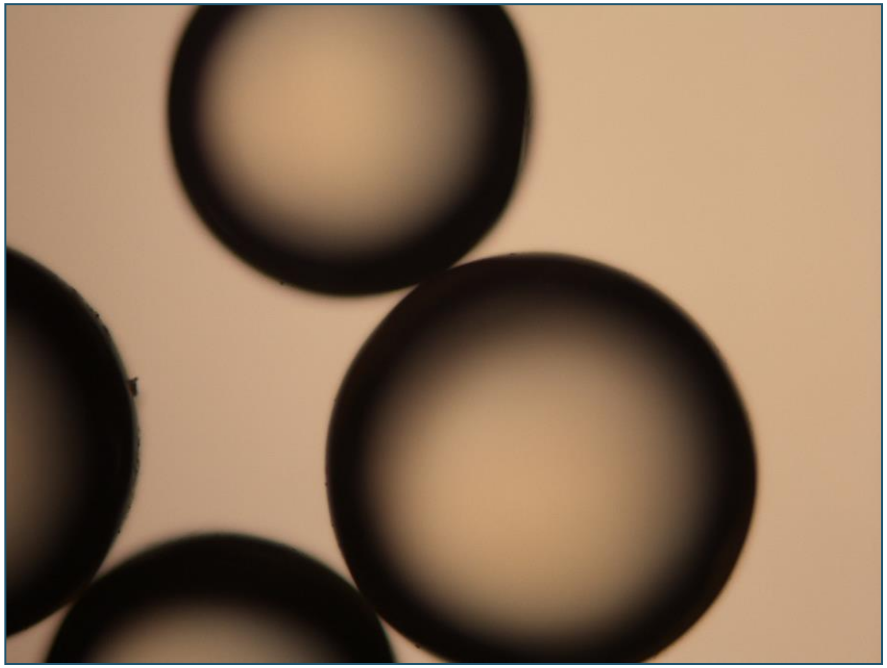


Resin condition - significant broken, cracked, and collapsed beads

Edwardsville Water



Resin condition, significant broken, cracked, and collapsed beads

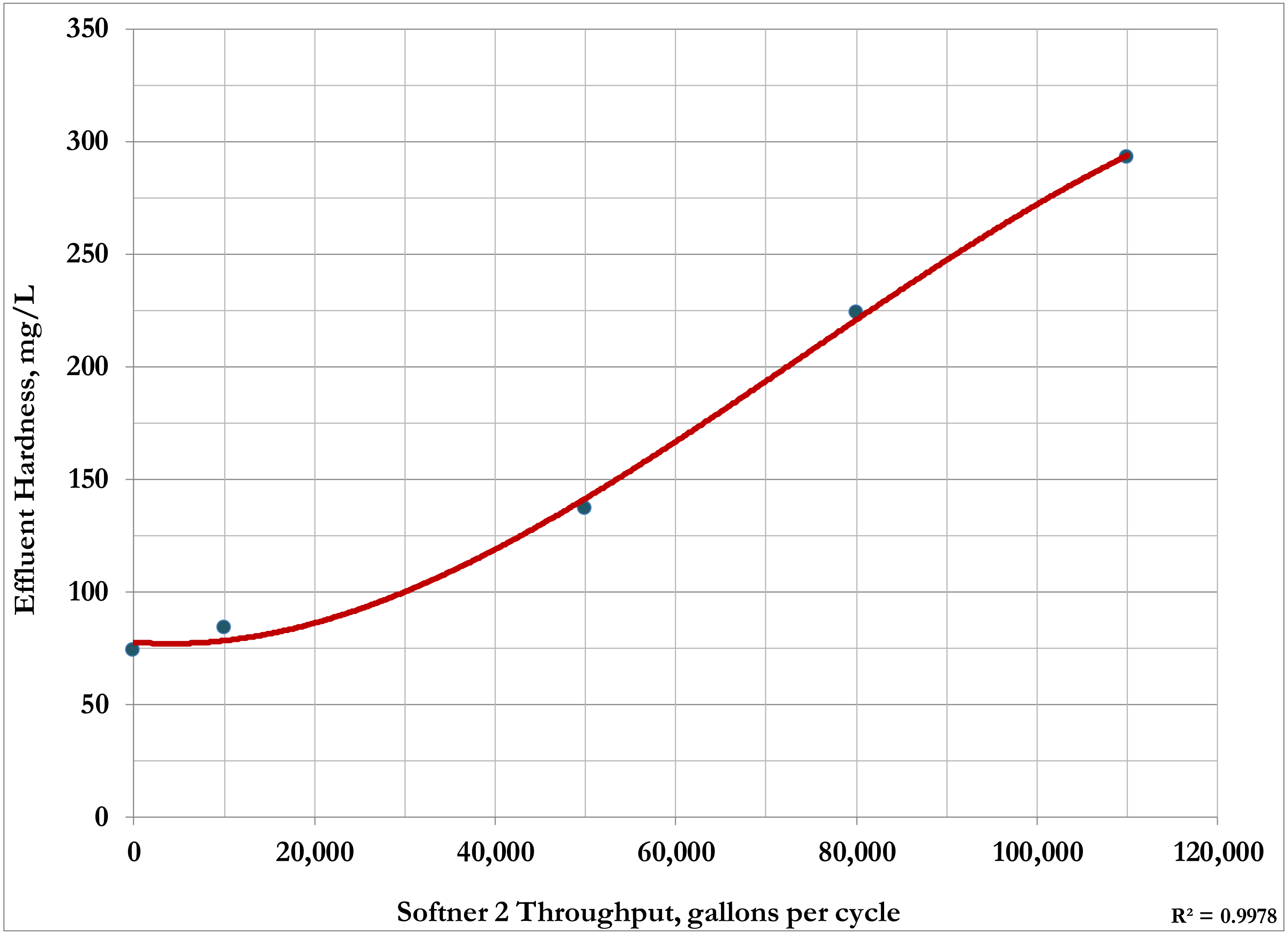


New resin illustrating smooth spherical beads

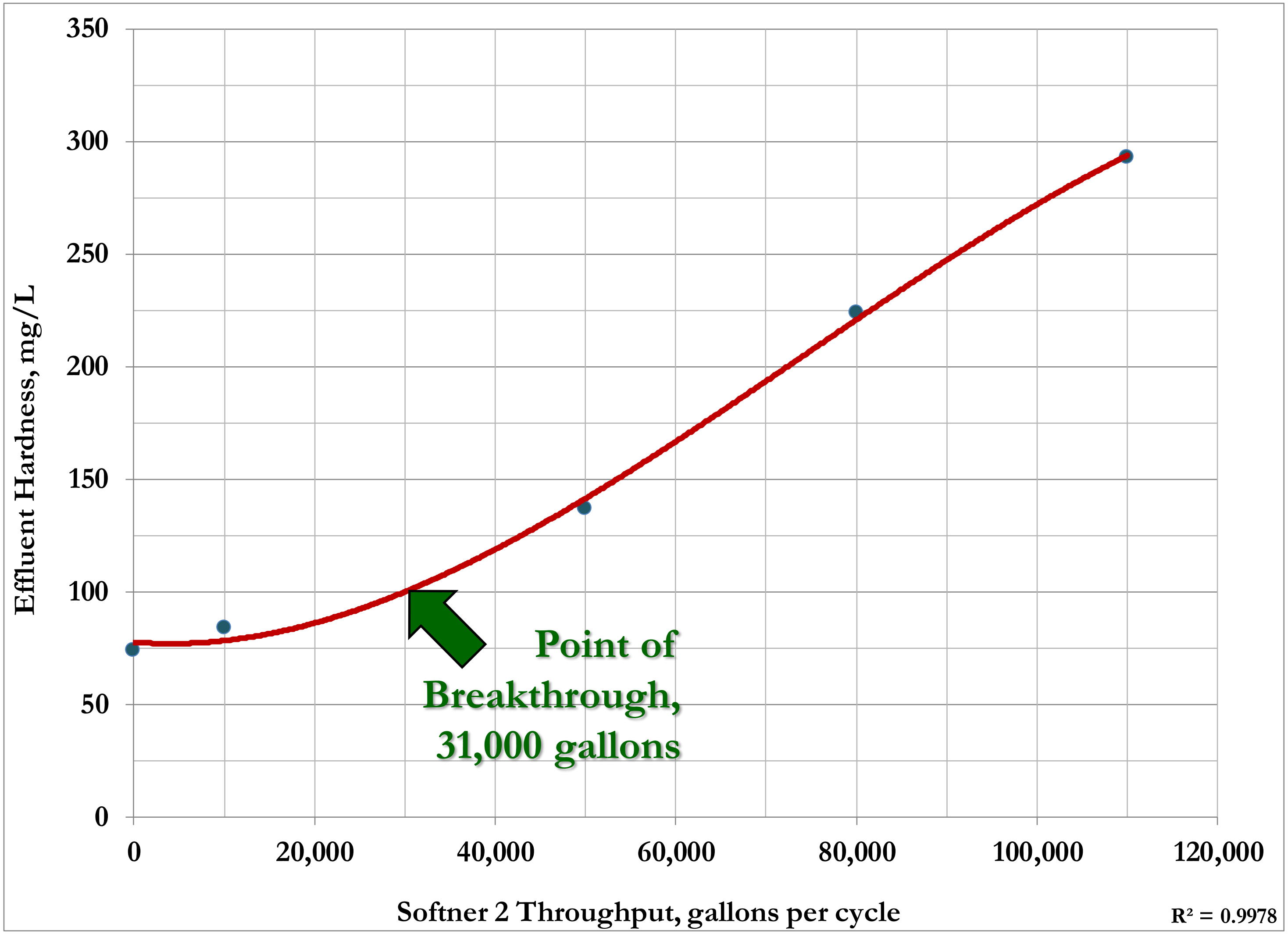
Edwardsville Water

- Resin capacity evaluations
  - Collected softener effluent hardness data every hour
    - Ran softeners beyond hardness breakthrough
  - Graphed data
  - Estimated current operating capacity from graphs
  - Estimated salt dosing based on current capacity

Edwardsville Water



Edwardsville Water



Edwardsville Water

- Current resin capacity estimated at about 11.2% (2,200 grains/cf)
- Salt dose estimated at 420 pounds rather than 1,100 pounds
  - Resin capacity related to hardness capture and salt retention
  - Developed softener operating and regeneration model
  - Further evaluations of operating costs

Softener Regeneration Model

Edwardsville
Plant 1 Softening

Plant operating hours	16.7	ave.	
Plant production	1.938	mgd	
Actual flow	1,934	gpm	645 gpm per softener
Average hardness	390	mg/L	22.8 gpg
Target hardness	130	mg/L	

Plant 1 Softeners

Percent bypass	30%		193 gpm
Flow per softener	451	gpm	
Total capacity	20.0	kgr/cf	
Capacity efficiency	11.2%		
Exchange Capacity	0.9	kgr/cf	
Salt requirement	1.429	lbs/kgr	
	1.2	lbs/cf	

Volume softened per cycle	31,000	gallons
Estimated softener run time	4.2	hours
Salt required for regeneration	**420**	pounds
Saturated brine required	164	gallons

Edwardsville Water

Operating Costs Plant 1		
	2014	2015
Salt usage, pounds	4,680,000	6,063,011
Salt dose, lbs/cf	5.5	5.5
Run times	9.2	4.6
Bypass	0%	0%
Salt cost	$242,424	$314,064

Increased costs from 2014 $71,640

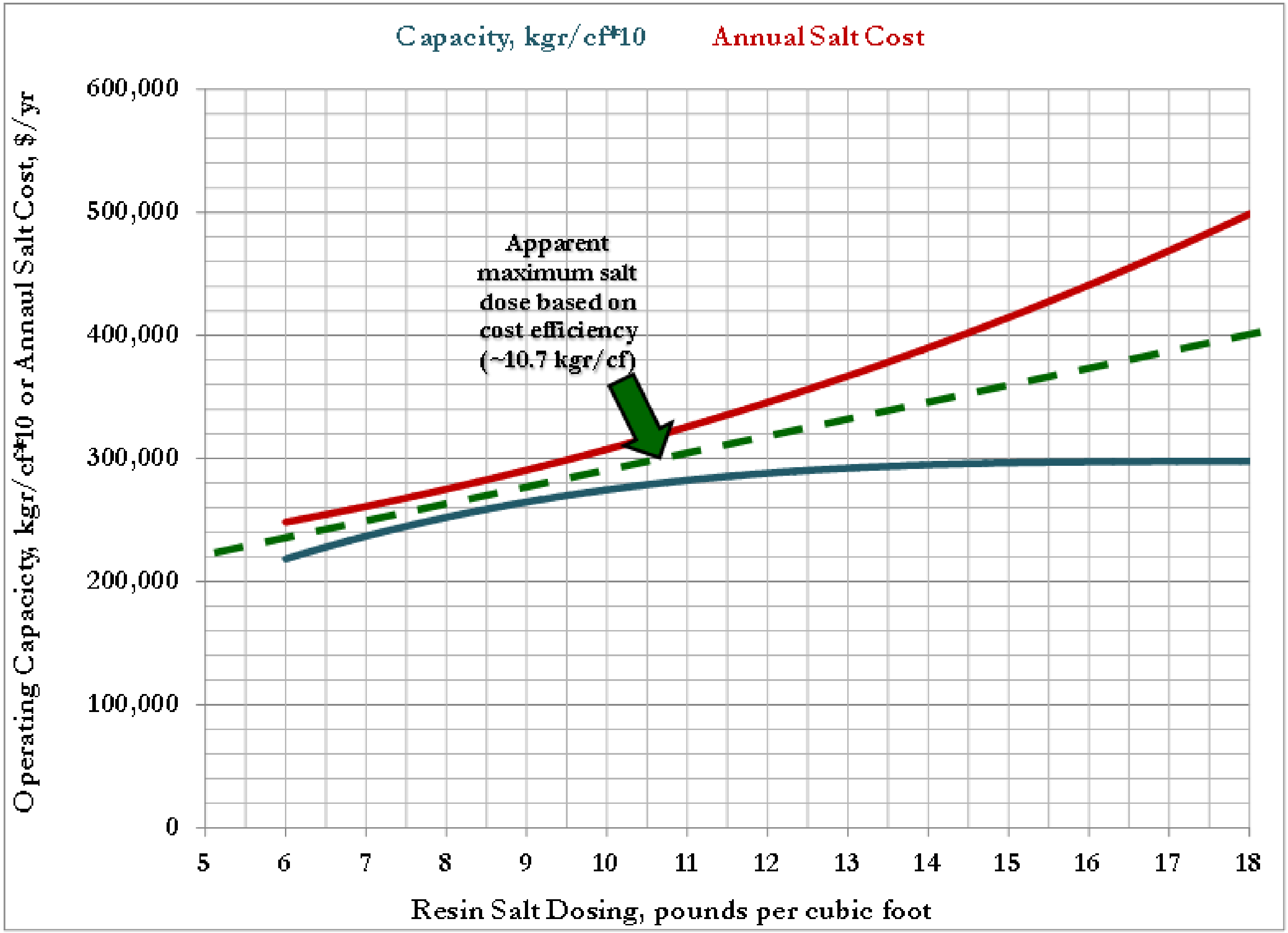
New high capacity resin cost $53,000

Disposal of resin $14,800

Edwardsville Water

Edwardsville Water

Edwardsville Water



Edwardsville Water

- Salt dosing set at 10.7 lbs/cf after resin replacement
  - 30% bypass initiated
  - Effluent target hardness 130 mg/L
  - Softener throughput 360,000 gallons
  - Run cycles 15.3 hours
  - Regained Plant 1 production capacity of 4.2 mgd
    - Met summer demands in 2016
  - 2016 salt usage - 4, 115,446 pounds ($213,180)
  - Cost savings over 2015 **$100,884 (ROI 8 months)**

Elyria Water Pumping Plant, Ohio

Elyria Water Pumping Plant

- 22 mgd surface water plant drawing from Lake Erie
  - Average daily production 12 mgd (2009)
- Coagulation/filtration plant
  - Chemical treatment
  - Solids handling
  - Disinfection and storage
- Finished water pumping to Elyria and one wholesale distribution system
  - ≈54,000 people

Elyria Water Pumping Plant

Elyria Water Pumping Plant

- 2008 chemical treatment
  - Potassium permanganate
  - Alum coagulation
  - Activated carbon (seasonally)
  - Lime
  - Fluoride
  - Chlorine, zinc orthophosphate
- Wet weather turbidity can reach more than 200 NTU
  - Significant increases in alum dose
  - Excess solids carryover to filters
  - Excess sludge stored in sedimentation basins until it can be processed

Elyria Water Pumping Plant

- Optimization needs
  - Reduce coagulant dosing overall and during wet weather events
    - Dosages often reached more than 60 mg/L
  - Reduce solids carryover to filters
    - Settled turbidities climbed as high as 10 NTU during wet weather
  - Extend filter run times
  - Reduce solids handling
    - 2,500 gallon tanker shipments to WWTP for processing
  - Reduce chemical operating costs
    - Some chemicals increased 100% in 2009 bids

Elyria Water Pumping Plant

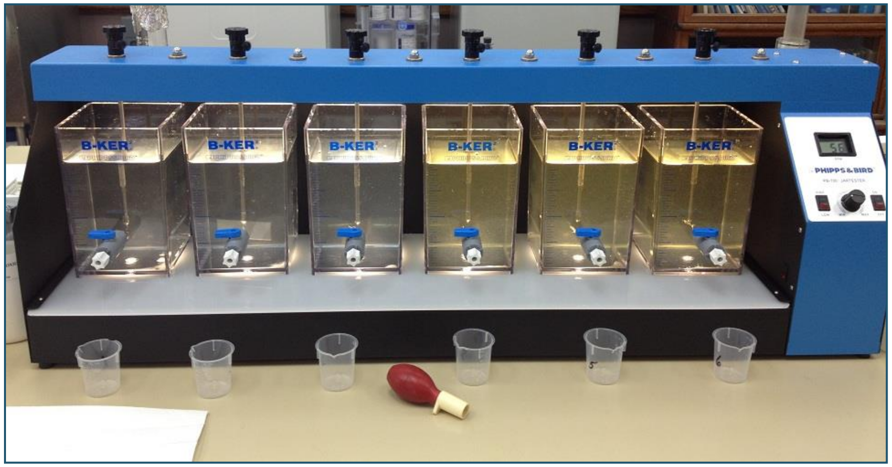
Alum rotodipper

Lime slurry in basement

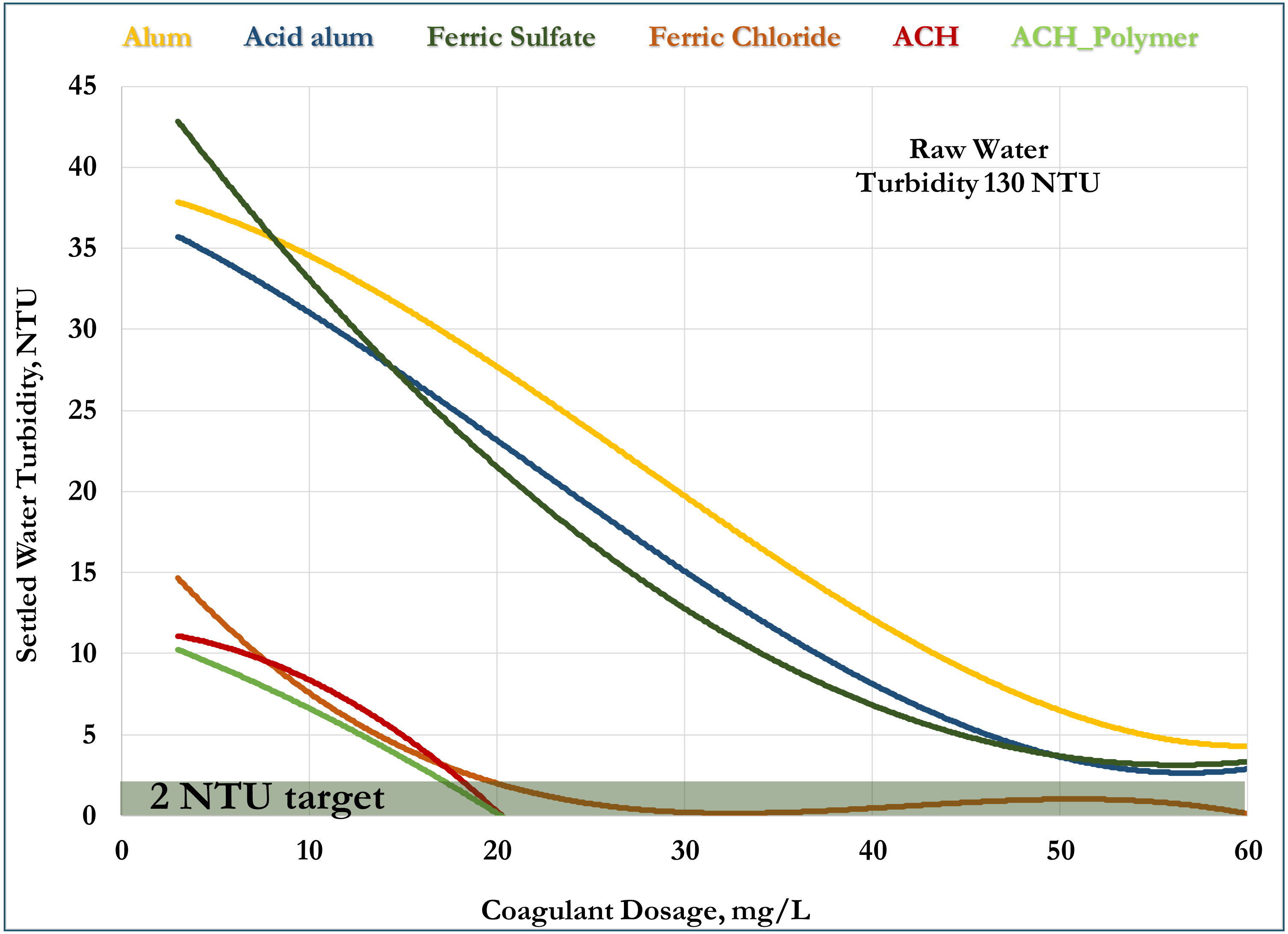
Alum, carbon fluoride, lime fed to raw water channel upstream of rapid mix

Elyria Water Pumping Plant

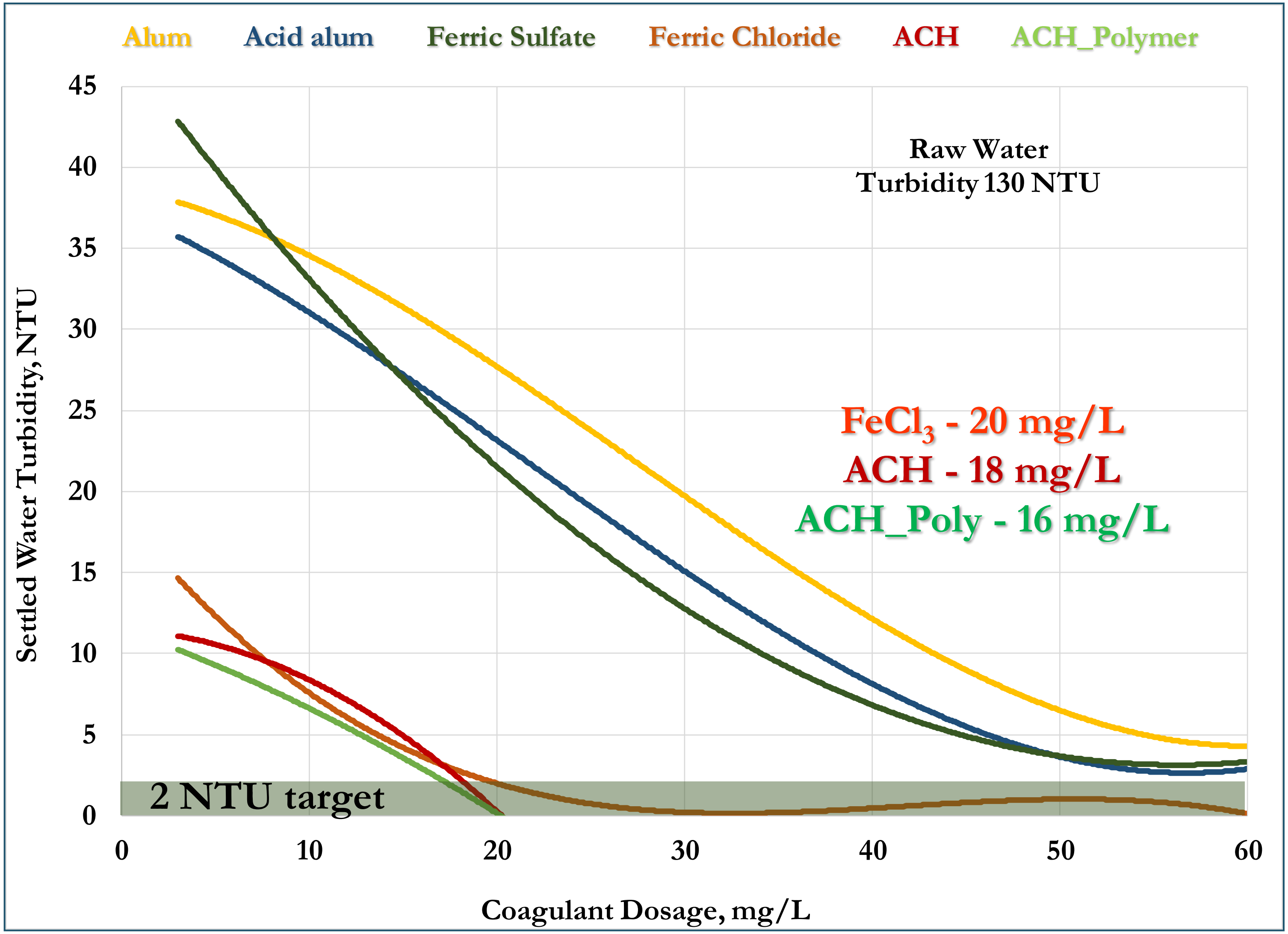
- Jar test screening
  - Raw turbidity 130 NTU
  - Alum
  - Acidified alum
  - Ferric chloride
  - Ferric sulfate
  - Aluminum chlorohydrate (ACH)
  - Aluminum chlorohydrate with cationic polymer
- Identify coagulant dosing to achieve settled water turbidity 2 NTU or less
- Prepare dosing curve based on raw turbidity



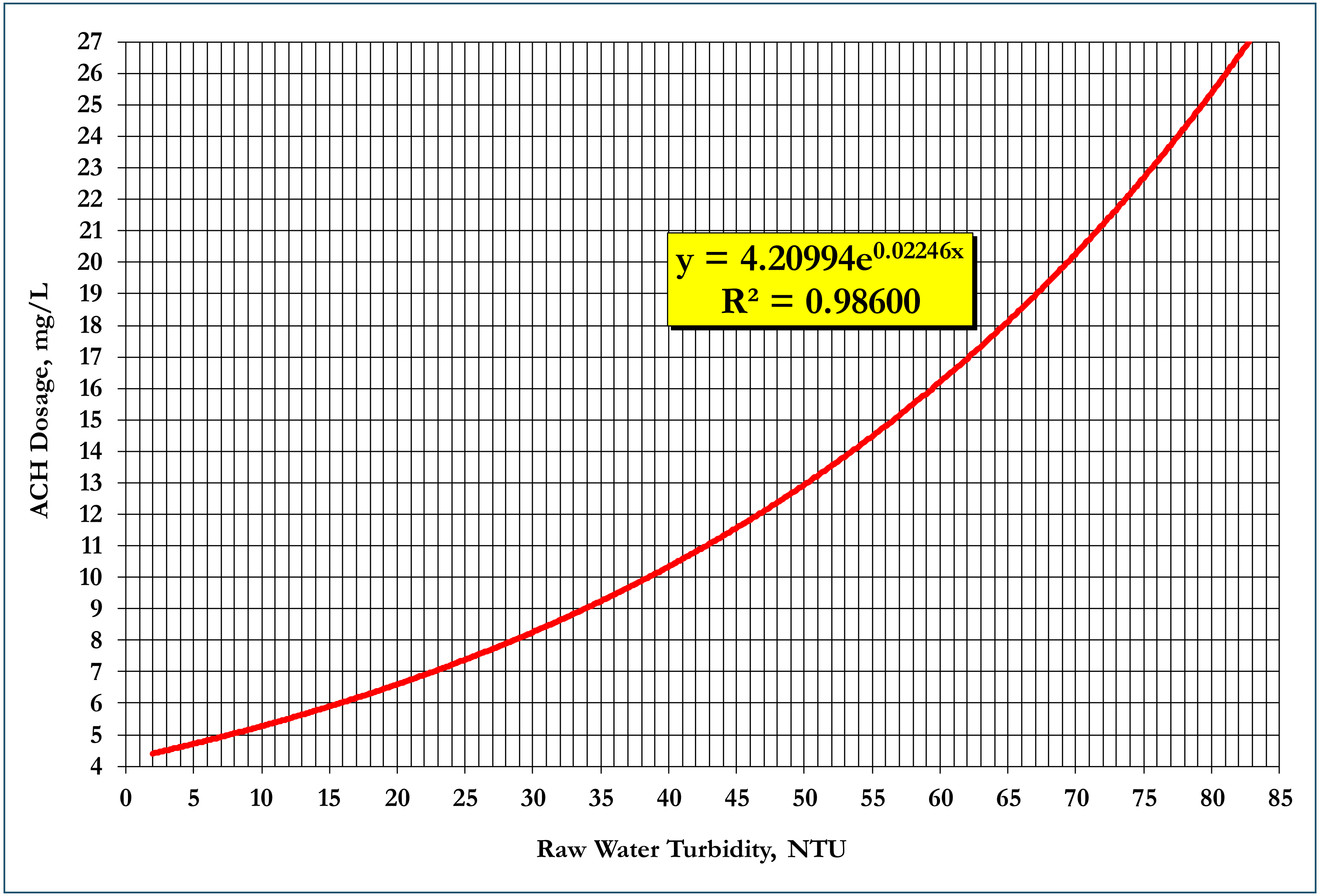
Elyria Water Pumping Plant



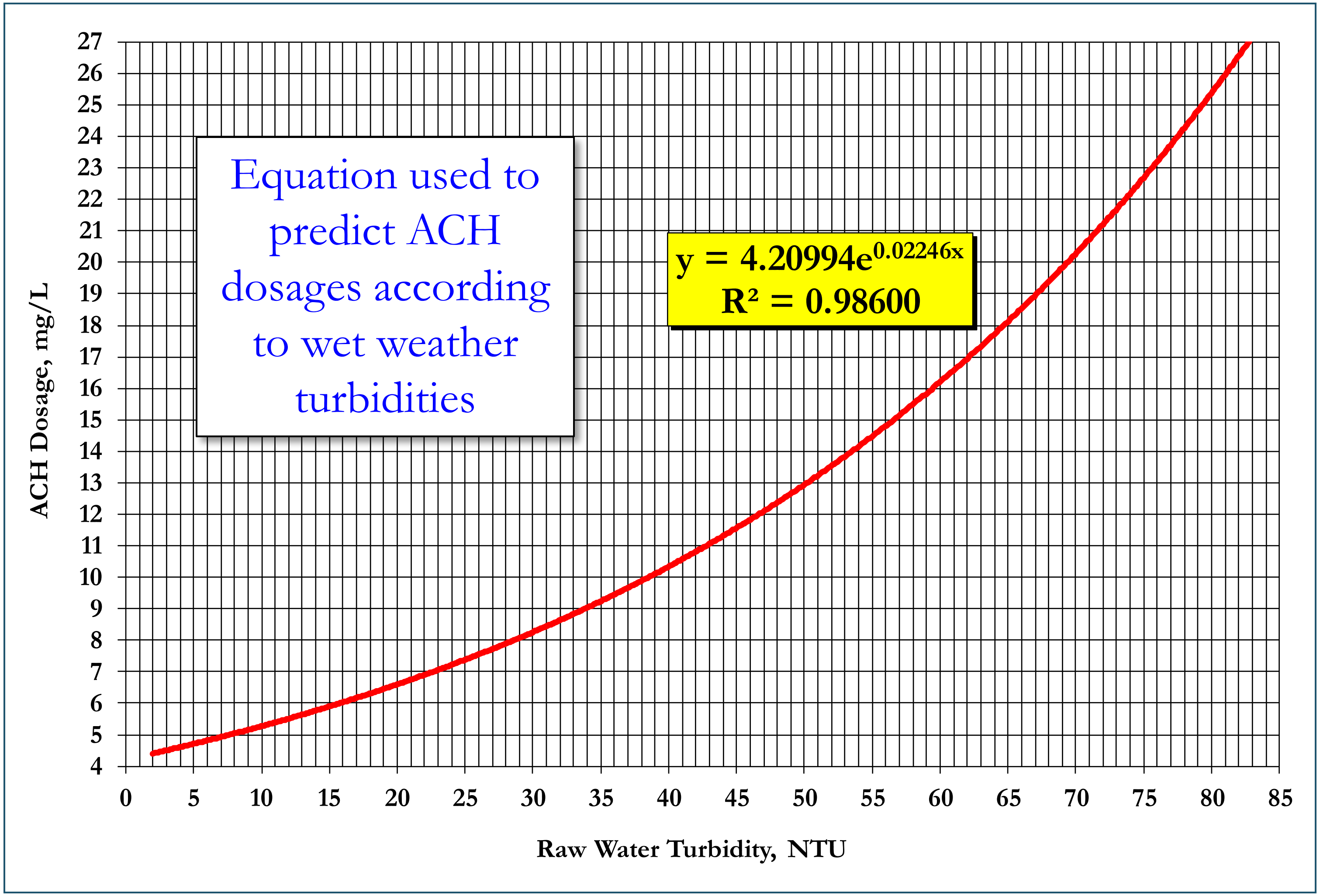
Elyria Water Pumping Plant



Elyria Water Pumping Plant



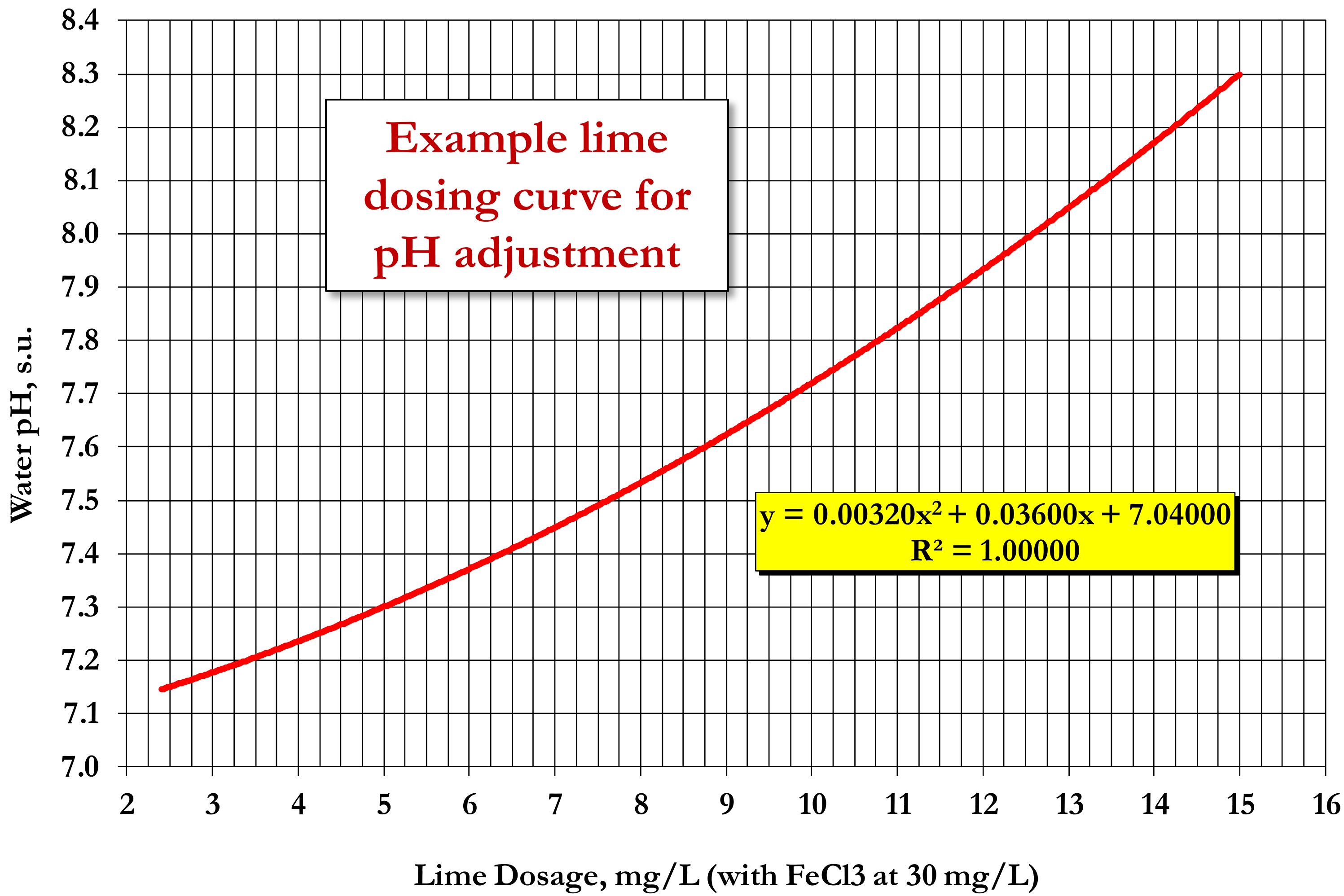
Elyria Water Pumping Plant



Elyria Water Pumping Plant

- Jars evaluated under average raw water conditions
  - Determine average dosing
  - Define likely pH adjustment using lime
  - Estimate solids production and operating costs
  - Compare coagulants for optimum treatment and costs
  - Select alternate coagulant for plant trial

Elyria Water Pumping Plant



Elyria Water Pumping Plant

Item	Alum	Acid alum	$FeCl_3$	$Fe_2(SO_4)_3$	ACH
Coagulant, mg/L	26	16.3	11.2	23	4
Lime, mg/L	6	8.5	8	10	0
Solids, gal/yr (2.6%)	6,744,000	5,771,000	4,498,000	4,938,000	2,827,000
Coagulant, $/yr	$184,681	$114,912	$107,399	$138,866	$49,722
Lime, $/yr	$15,982	$22,641	$21,309	$26,637	$0
Disposal, $/yr	$155,116	$132,743	$103,454	$113,576	$65,020
Combined, $/yr	$355,799	$270,296	$232,162	$279,079	$114,742

Elyria Water Pumping Plant

- ACH selected for full-scale plant trial
  - Feb-Mar 2009 trial period
- Data collection
  - Turbidities - raw, applied, filtered
  - Water pH - raw, applied, finished
  - Alkalinities - raw, applied, finished
  - Dosages (ACH and customary alum)
  - TOC - raw, tap
  - CCPP - raw, tap
  - Langelier Index - raw, tap
  - TTHM and Pb/Cu evaluations

Elyria Water Pumping Plant

$$Al_2(SO_4)_3 + 3Ca(HCO_3)_2 \Rightarrow 2Al(OH)_3 + 3CaSO_4 + 6CO_2$$

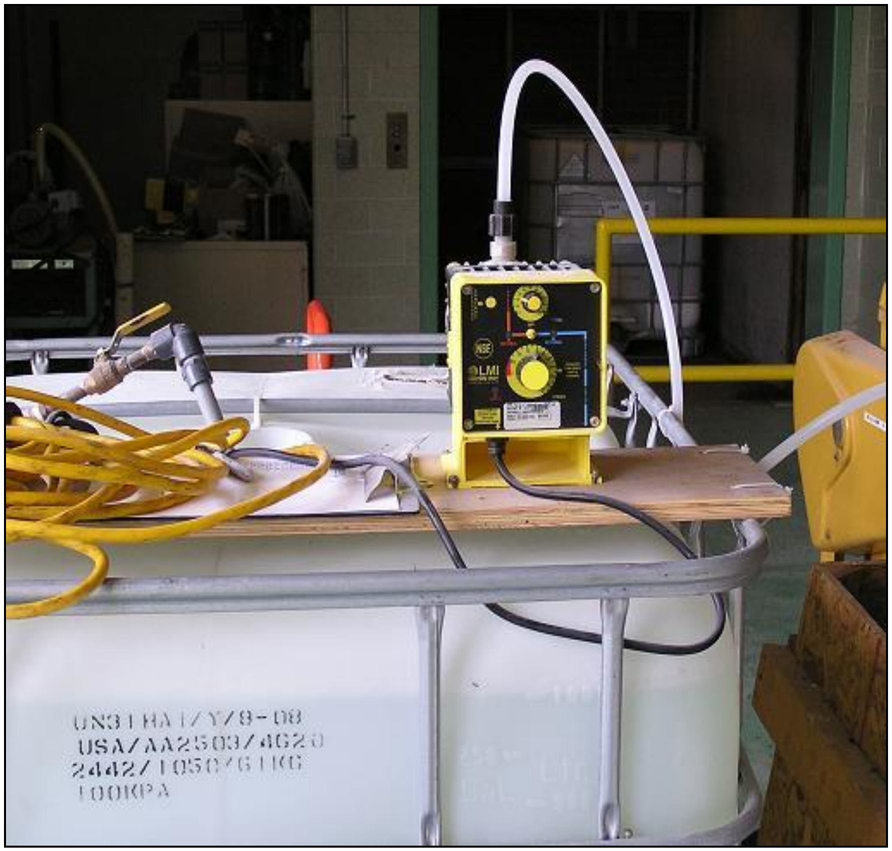
1 mg/L | 0.5 mg/L | 0.26 mg/L | 0.44 mg/L

$$2Al_2Cl(OH)_5 + Ca(HCO_3)_2 \Rightarrow 4Al(OH)_3 + CaCl_2 + 2CO_2$$

1 mg/L | 0.29 mg/L | 0.89 mg/L | 0.25 mg/L

Lower dosage, less alkalinity consumption, less CO_2 production essentially eliminated lime feed for pH adjustment.

Elyria Water Pumping Plant



ACH tote and temporary feed pump

- Plant trial 60 days
- Stopped alum feed
- Washed all filters
  - Alum-ACH gel
- Initiated ACH feed
- Stopped lime feed
- Observed reduction in fluoride feed
  - Lime consuming F- in raw channel

Elyria Water Pumping Plant

- Average ACH dosage 6.7 mg/L compared to alum dosing at 29 mg/L
  - ACH likely would be 75% lower than alum
- Settled water turbidity 1.6 NTU
  - Under wet weather turbidity occurrences
- Filtered turbidities 0.06 NTU to 0.08 NTU
- Water pH 7.53 versus 7.3 using alum
  - No lime feed using ACH
- TOC reduction about the same as alum
  - Average 27%
- Sludge production
  - 67% less than alum

Elyria Water Pumping Plant

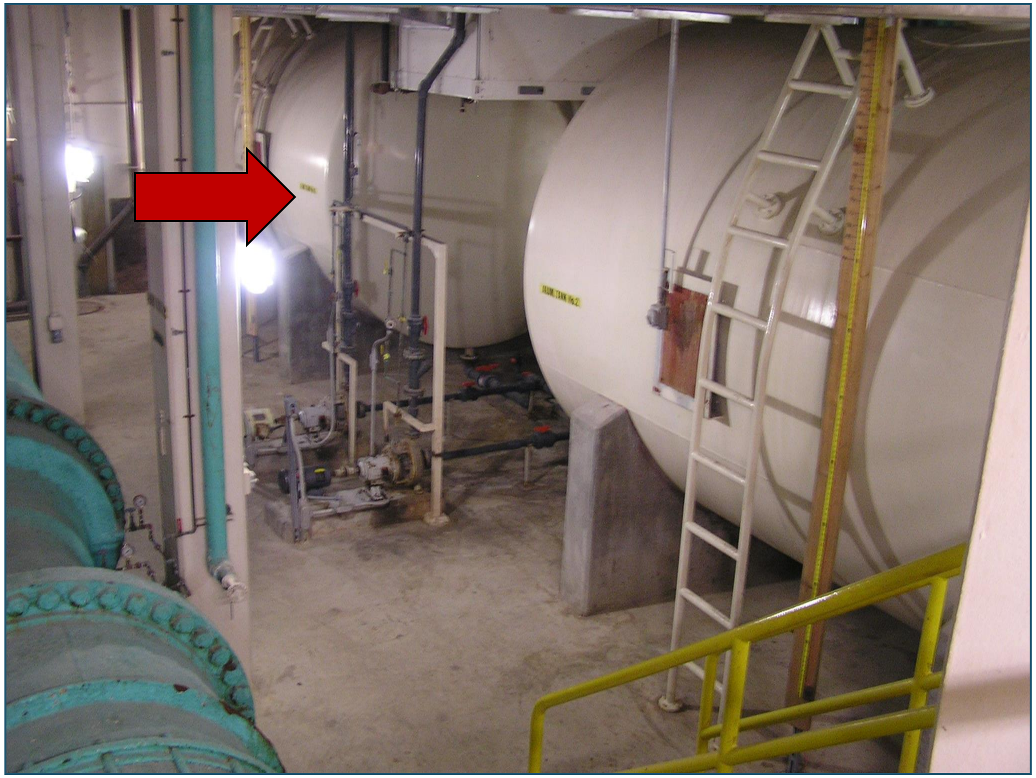
Item	Alum	Acid alum	$FeCl_3$	$Fe_2(SO_4)_3$	ACH
Coagulant, mg/L	26	16.3	11.2	23	4
Lime, mg/L	6	8.5	8	10	0
Solids, gal/yr (2.6%)	6,744,000	5,771,000	4,498,000	4,938,000	2,827,000
Fluoride, mg/L	1.2	1.2	1.35	1.35	1.0
Coagulant, $/yr	$184,681	$114,912	$107,399	$138,866	$49,722
Lime, $/yr	$15,982	$22,641	$21,309	$26,637	$0
Disposal, $/yr	$155,116	$132,743	$103,454	$113,576	$65,020
Fluoride, $/yr	$28,351	$28,351	$31,959	$31,959	$25,996
Combined, $/yr	$384,130	$298,647	$264,121	$311,038	$140,738

Elyria Water Pumping Plant

- ACH provided lower applied turbidity and increased filter run times
- ACH eliminated lime dosing for pH adjustment
  - Maintained higher pH levels than alum/lime
  - Fluoride feed reduced due to lime elimination
- TOC removals similar to alum
  - TTHM values similar to alum (averaged 41 μg/L)
- Lead/copper projections
  - 8.7 μg/L and 160 μg/L, respectively
- Solids production
  - 67% less than alum/lime
- Overall 63% reduction in operating costs as compared to alum
  - Annual cost savings projected at more than $243,000

Elyria Water Pumping Plant

- Converted one alum storage tank to ACH
- Installed new day tank and feed pumps near raw water line in basement
  - Tapped raw water for new feed connection
- Initiated ACH full scale operations spring 2010



MSVD Meander Water, Ohio

MSVD Meander Water

- 60 mgd surface water plant drawing from Meander Reservoir
  - Average daily production ≈25 mgd
- Coagulation/softening/filtration plant
  - Chemical treatment
  - Solids contact clarification
  - Solids handling
  - Disinfection and storage
- Finished water pumping to three wholesale distribution systems

MSVD Meander Water

MSVD Meander Water

- Solids contact clarifiers installed with plant improvements in 2013
  - Replaced old square clarifiers
  - New rapid mix induction equipment
  - New recarbonation feed system
  - Other plant improvements

MSVD Meander Water

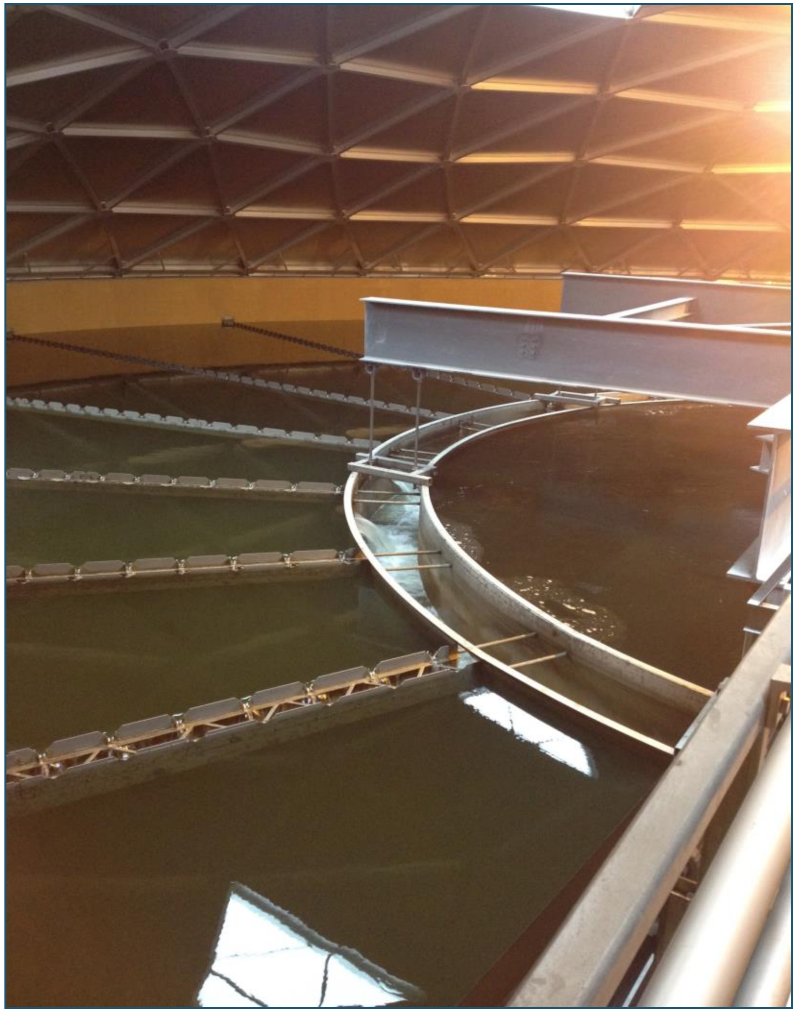
- Issues prompting optimization
  - Low solids recirculation in reaction zone
  - Less than desired settled water turbidities
  - Higher solids loadings to filters than necessary
  - Need to feed anionic polymer to help control turbidity
  - Assistance in establishing sludge blow-off cycles
  - Assistance in establishing mixer speeds for recirculation
  - New rapid mix effectiveness
  - Proper coagulant type and dosage
  - Better overall clarifier performance

MSVD Meander Water

Initial Operating Conditions 2014	
Apparent floc size	0.5 mm
Settled water turbidity	9 NTU
Reaction zone solids	3% by volume
Mixer operating speed	27% and 36%
Blow-off solids	99% (toothpaste consistency, dark color)
Blow-off volume	10,800 gpd
Effluent pH	11.1 - 11.2
Effluent TOC	4.5 mg/L (33%)
Hydroxide alkalinity	40 mg/L
Sodium aluminate	3 mg/L
Lime dosage	100 mg/L

MSVD Meander Water

Parameter	Existing	Target
Settled water turbidity	9 NTU	≤2 NTU
Reaction zone solids, by volume	3%	10%-15%
Mixer operating speed	27%/36%	45%-55%
Blow-off solids	99%	90%-95%
Blow-off volume	10,800	70,000
Effluent pH	11.1 - 11.2	10.9
Hydroxide alkalinity	40 mg/L	20 mg/L



Bottom recirculation ports blocked with sludge previously and cleaned (26% by weight)

MSVD Meander Water

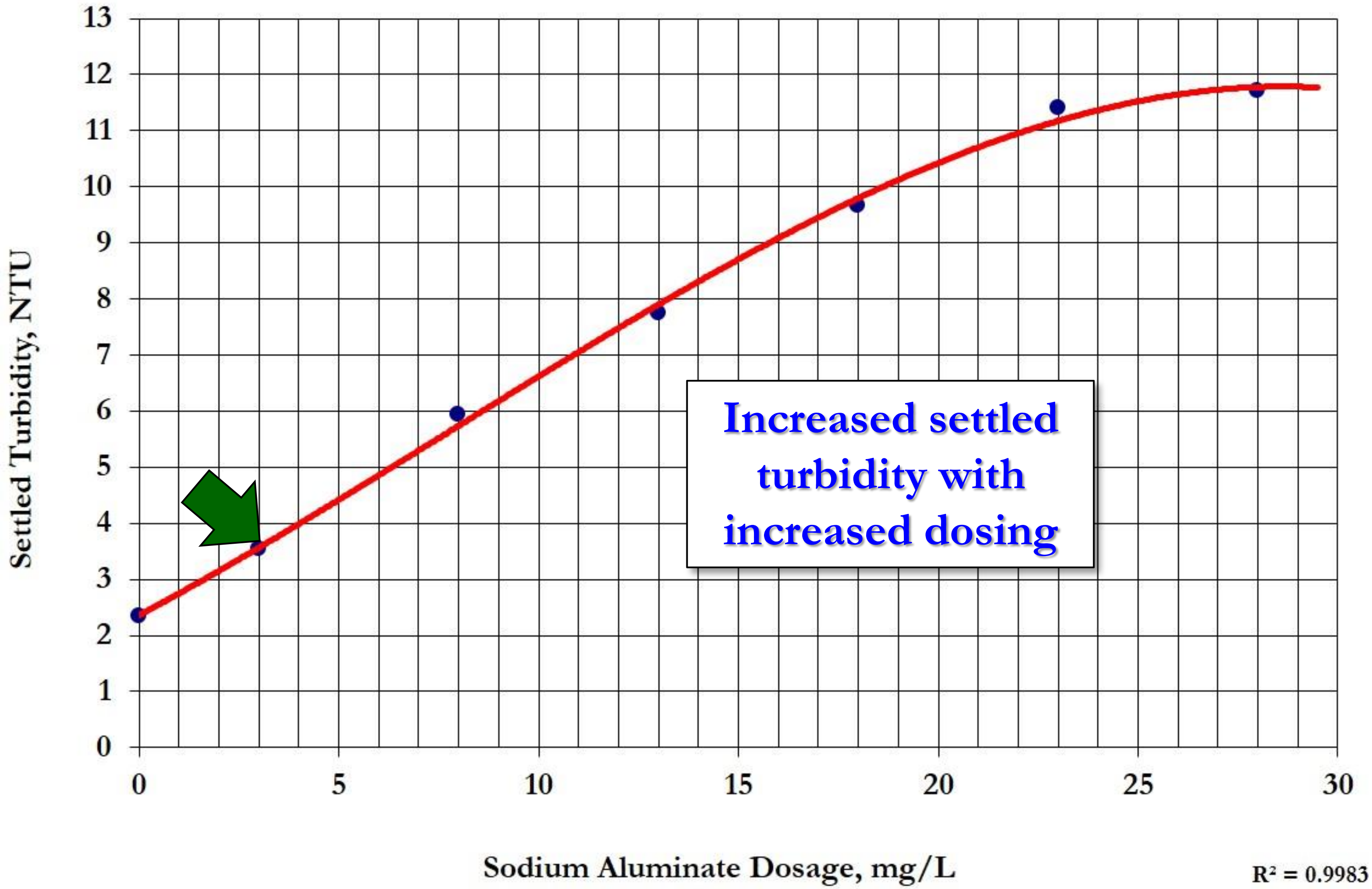
- Slowly increased mixer speed up to 52%
  - Observed floc density and size
  - Tracked recirculation solids (up to 7%v)
- Checked blow-off timers
  - Set up differently from vendor, reset to match
  - Calculated apparent solids production
    - Raw turbidity, chemical treatments
    - 70,000 gpd produced while blowing off 10,800 gpd
  - Manual sludge blow-off for remainder of the day
    - Remove old sludge and re-establish adequate sludge volume
    - More than 300,000 gallons sludge removed
    - Essential just storing sludge in clarifiers

MSVD Meander Water

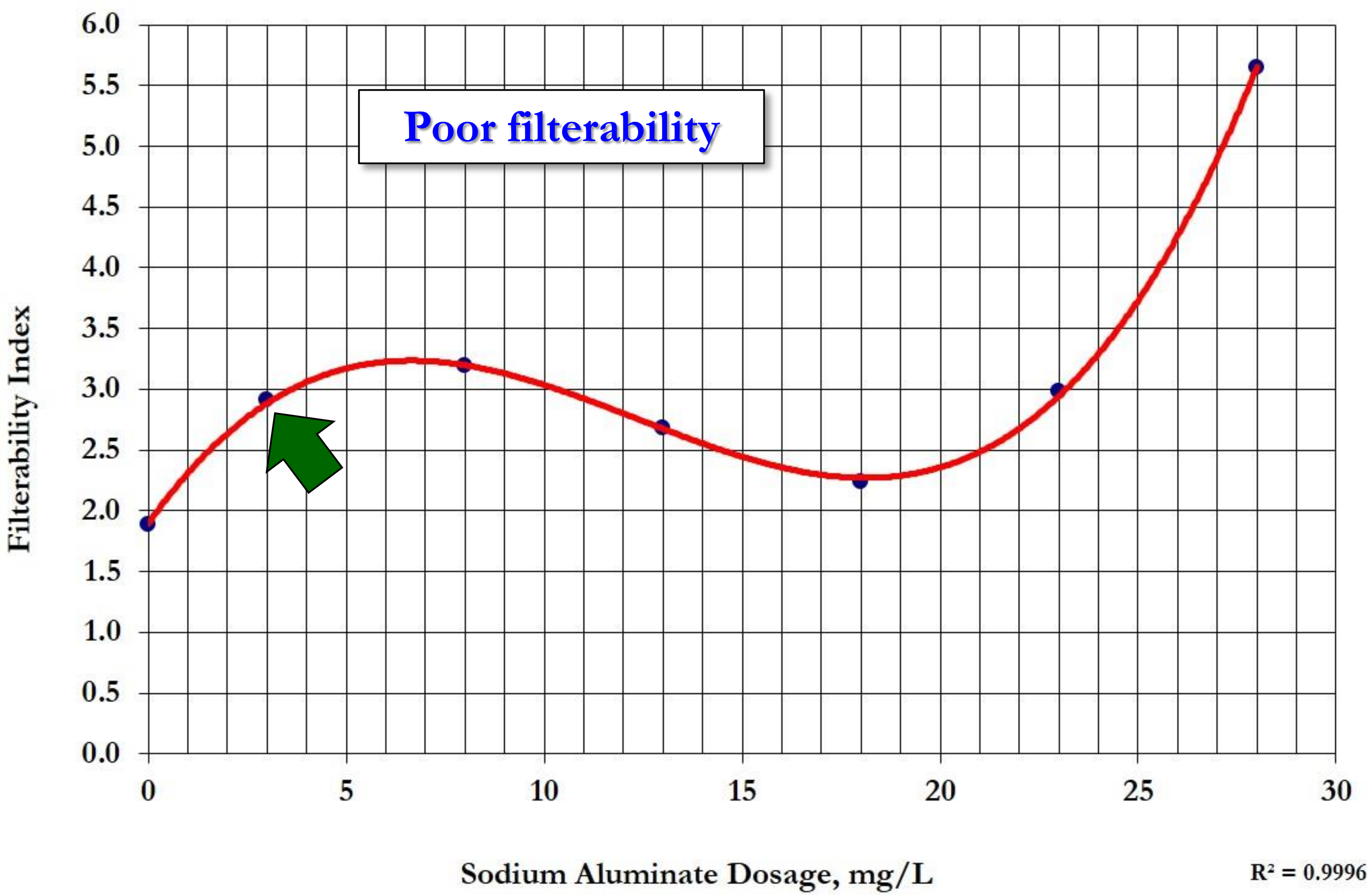
- Re-established sludge blow-off cycles
  - Flow meters provided each blow-off line
  - Initial blow-off cycle 1 minute every 4 hours
  - Reset blow-off cycle 50 seconds every hour
  - Maintained sludge at 90% in blow-off
    - About 35,000 gpd per clarifier
- Improved water quality within 3 days
  - Settled turbidity 3 NTU
- Jar testing showed coagulant change likely needed

5-munute settling test

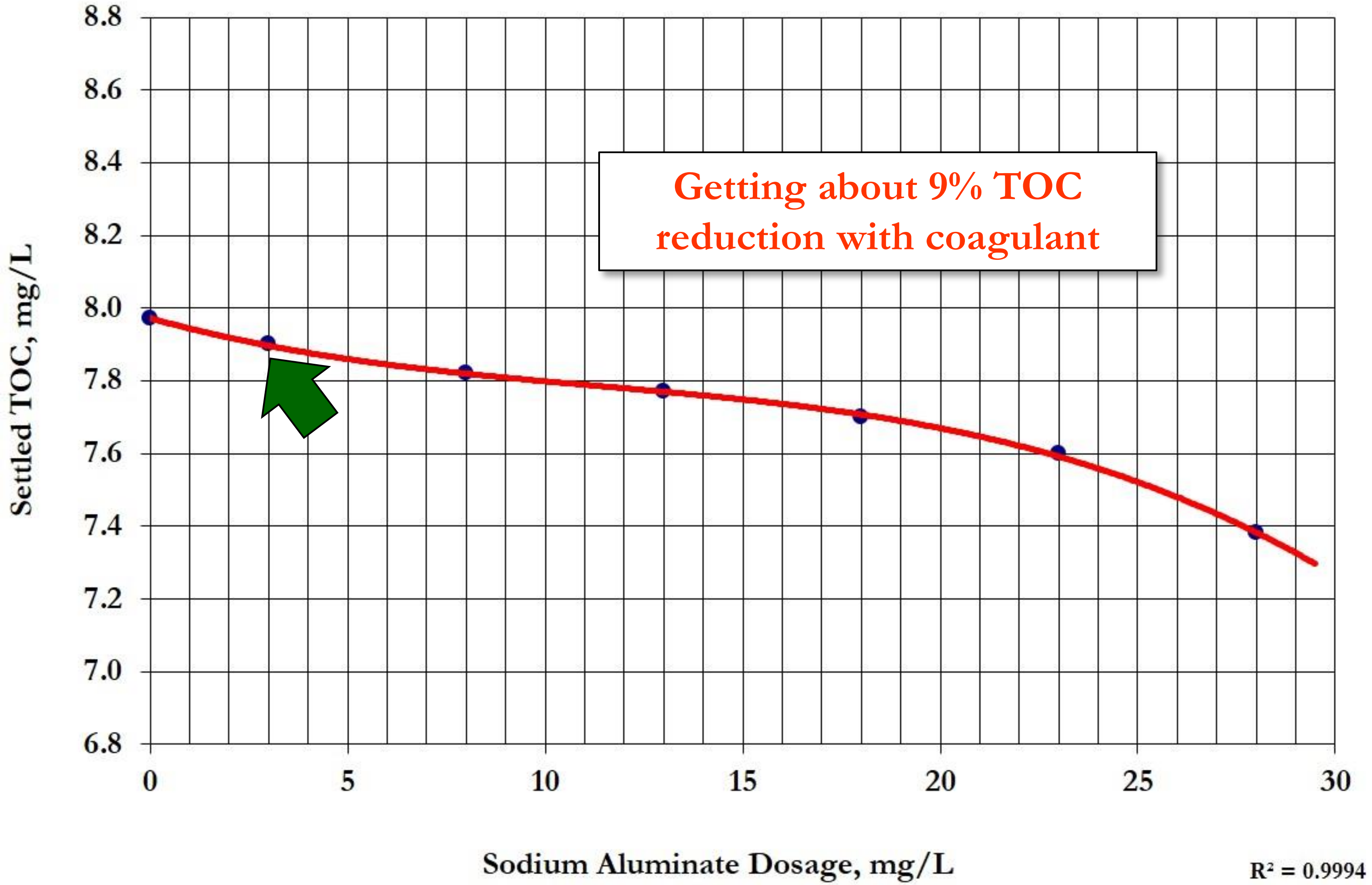
MSVD Meander Water



MSVD Meander Water

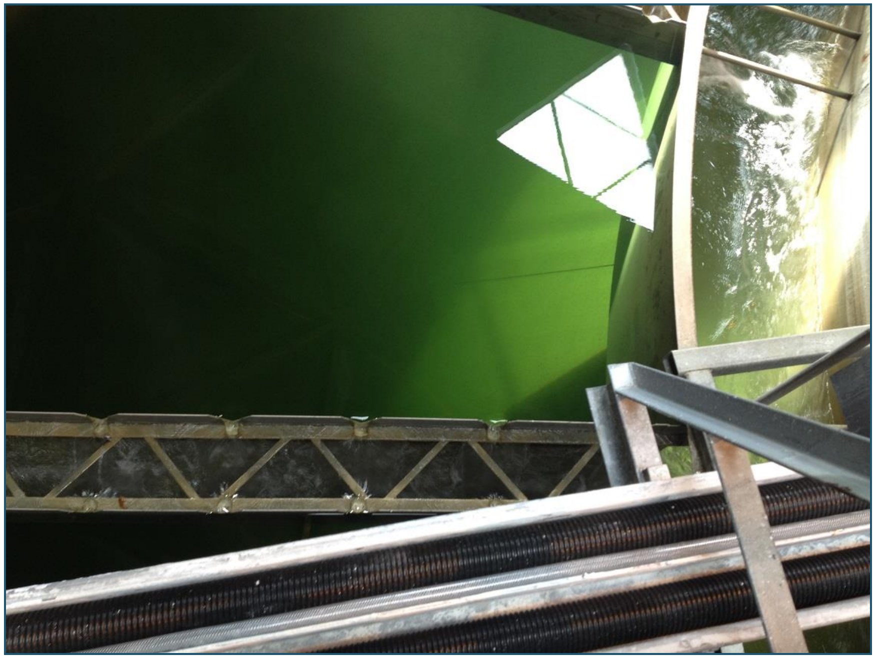


MSVD Meander Water



MSVD Meander Water

- Clarifier optimization led to other optimization projects, some are ongoing
  - Chemical optimization
  - Alternate coagulant demonstration and conversion
  - Filter optimization
  - Stabilization optimization



Tampa Regional, Florida

Tampa Regional

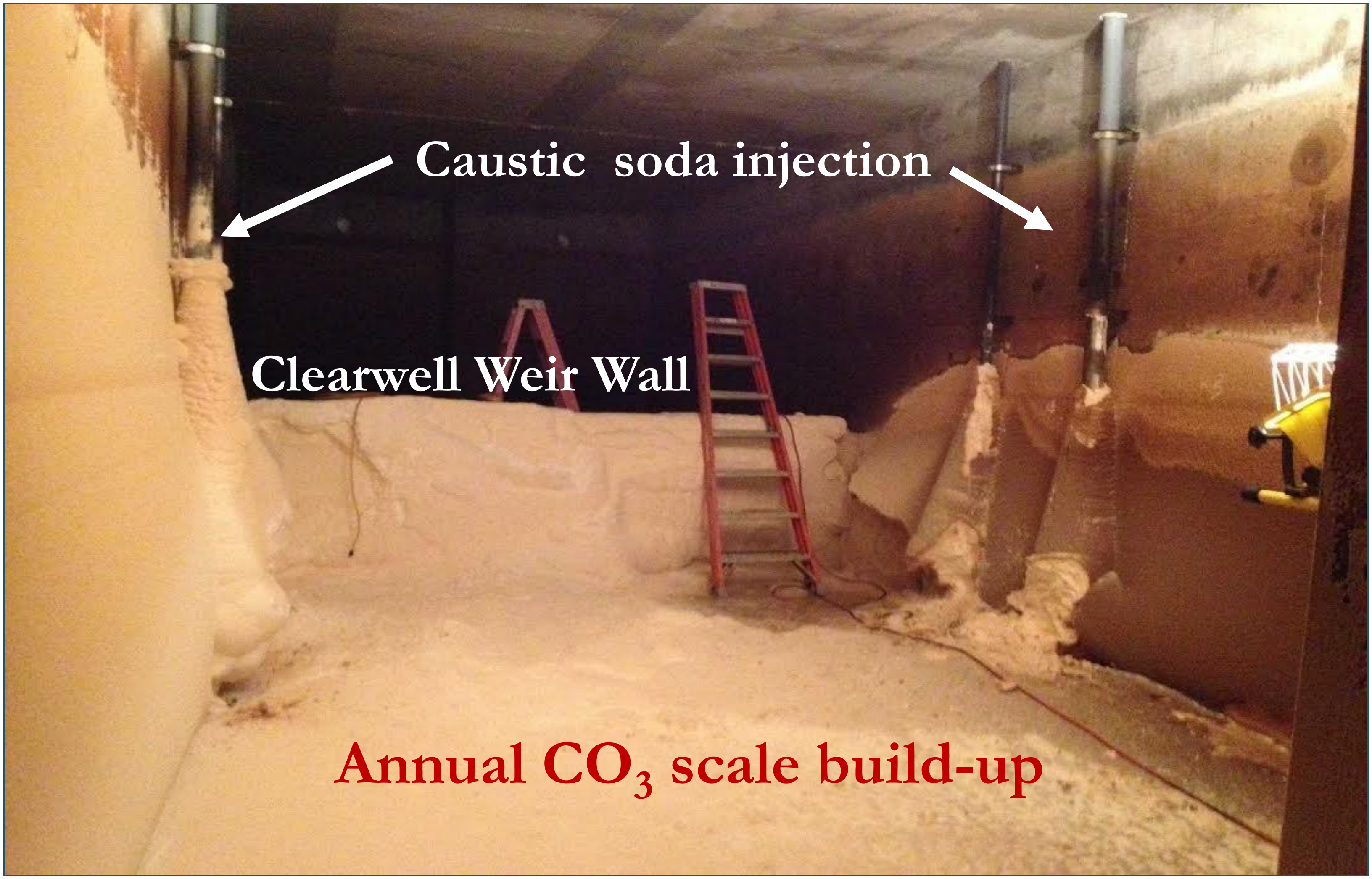
- 90 mgd surface water plant, 15 BG reservoir
    - Alifia River
    - Hillsborough River
    - Tampa Bypass Canal
  - Average daily production ≈52mgd
- Coagulation/ozonation/filtration plant
  - Chemical treatment
  - ActiFlo sand-ballasted clarification
  - Solids handling
  - Disinfection and storage
- Finished water pumping to Tampa Bay Water

Tampa Regional

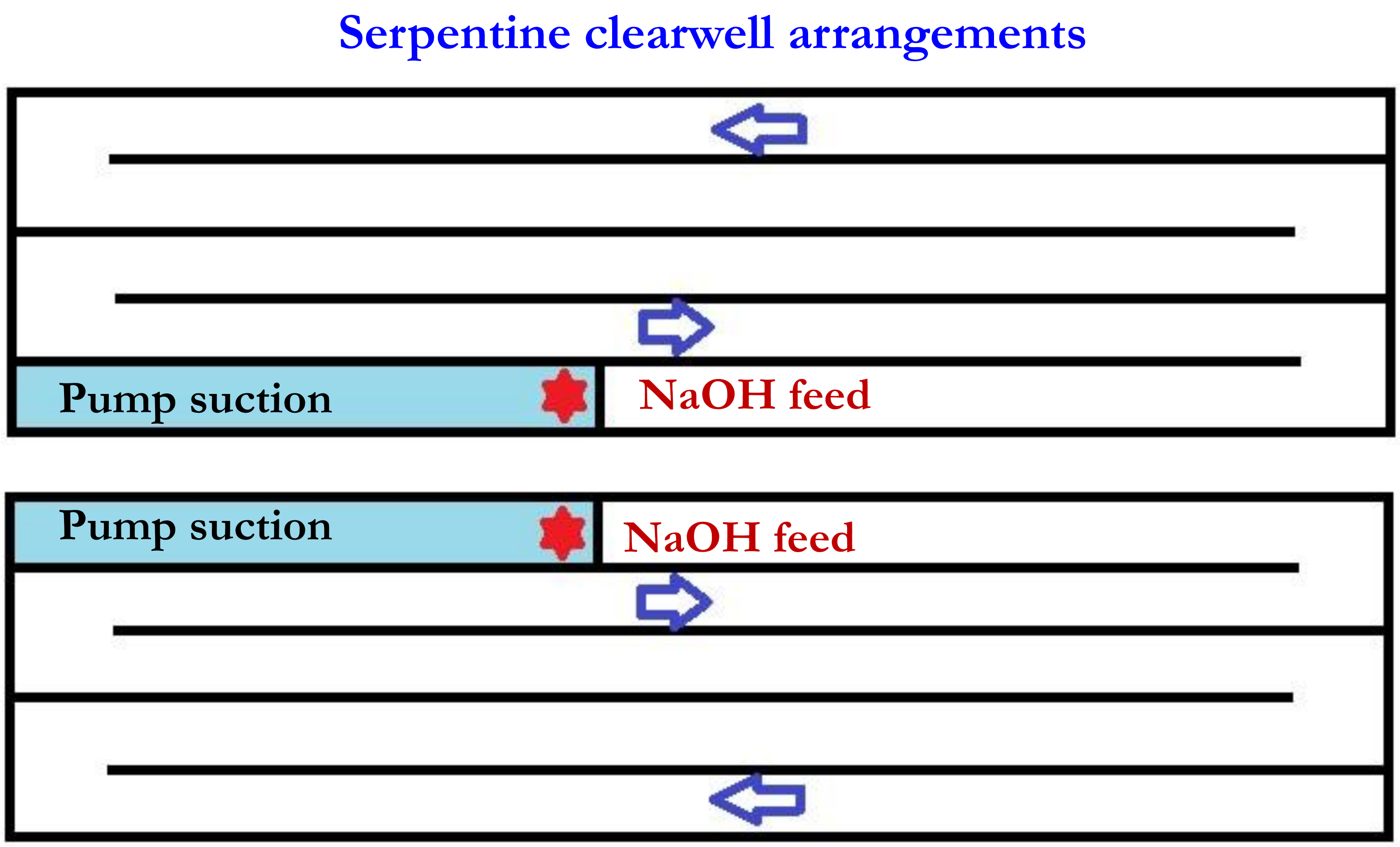
Tampa Regional

- Finished water pH adjustment
  - 50% NaOH to pH 7.6
  - Average dosage 12.5 mg/L
  - Significant fluctuations in pH levels
  - Annual caustic costs $451,434
- Chemical application
  - NaOH fed downstream of clearwell weir wall
    - 60 feet upstream of high service pumps
  - Significant scaling, annual pump cleaning
    - $150,000
  - Questionable mixing at feed point

Tampa Regional

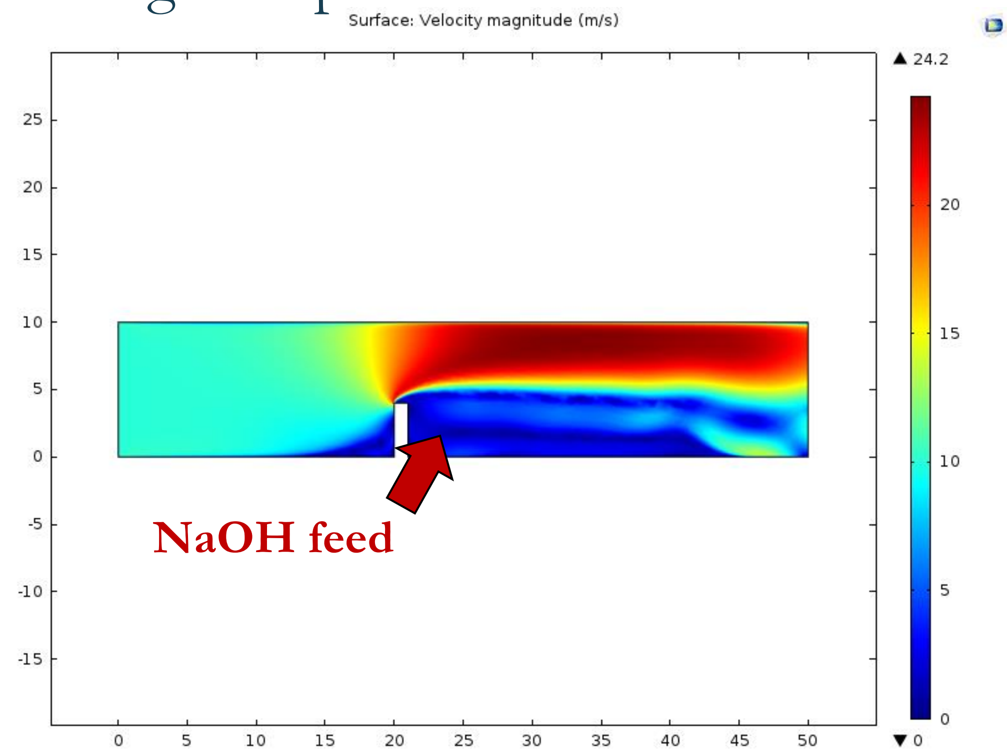


Tampa Regional

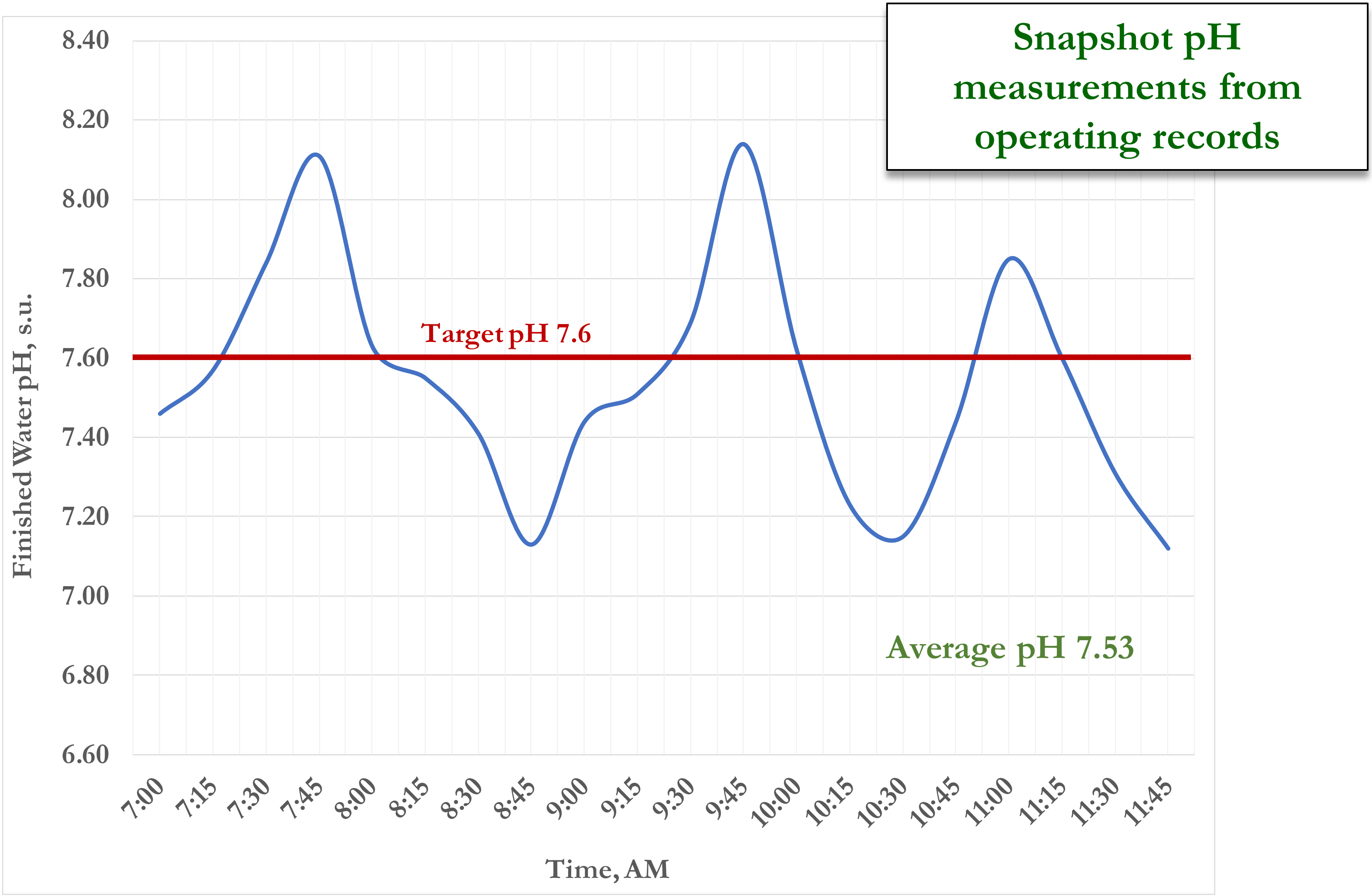


Tampa Regional

- CFD analysis conducted of mixing at weir wall
  - Predominant mixing energy at top of weir wall
  - Very little mixing energy at existing feed point
    - Leads to scale build-up
    - Annual pump cleaning
    - Pump downtime



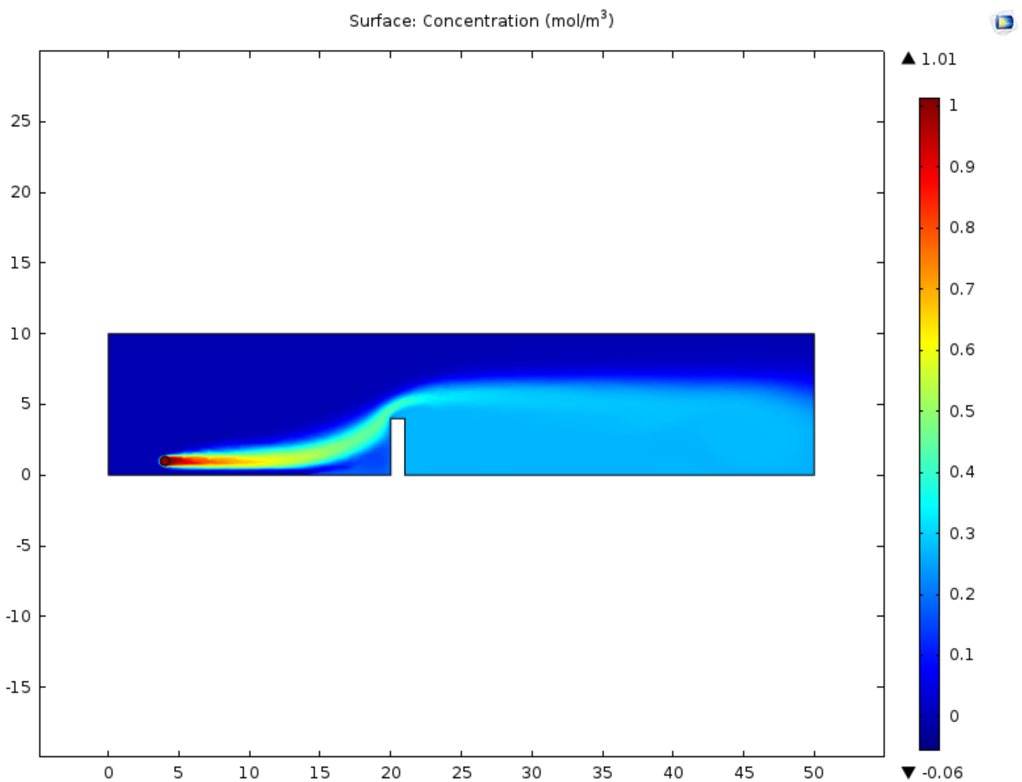
Tampa Regional



Tampa Regional

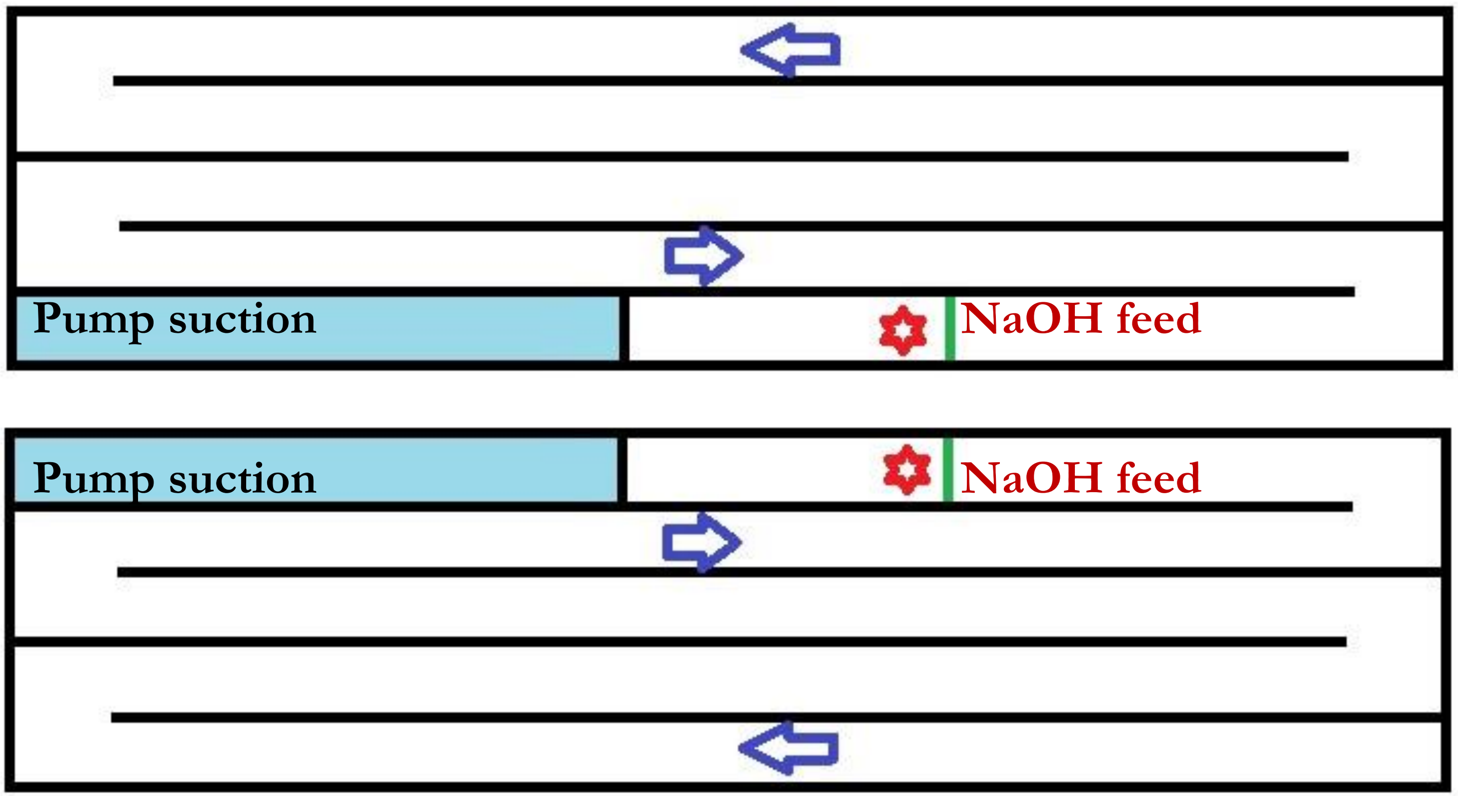
- Relocation of NaOH feed point better mixing
  - Slice gate about 50 feet upstream of weir wall
    - CFD analysis confirmed improved mixing
    - Piloted NaOH soda feed at new location
    - Improvements in pH measurements
    - Reduced NaOH feed rates

Tampa Regional

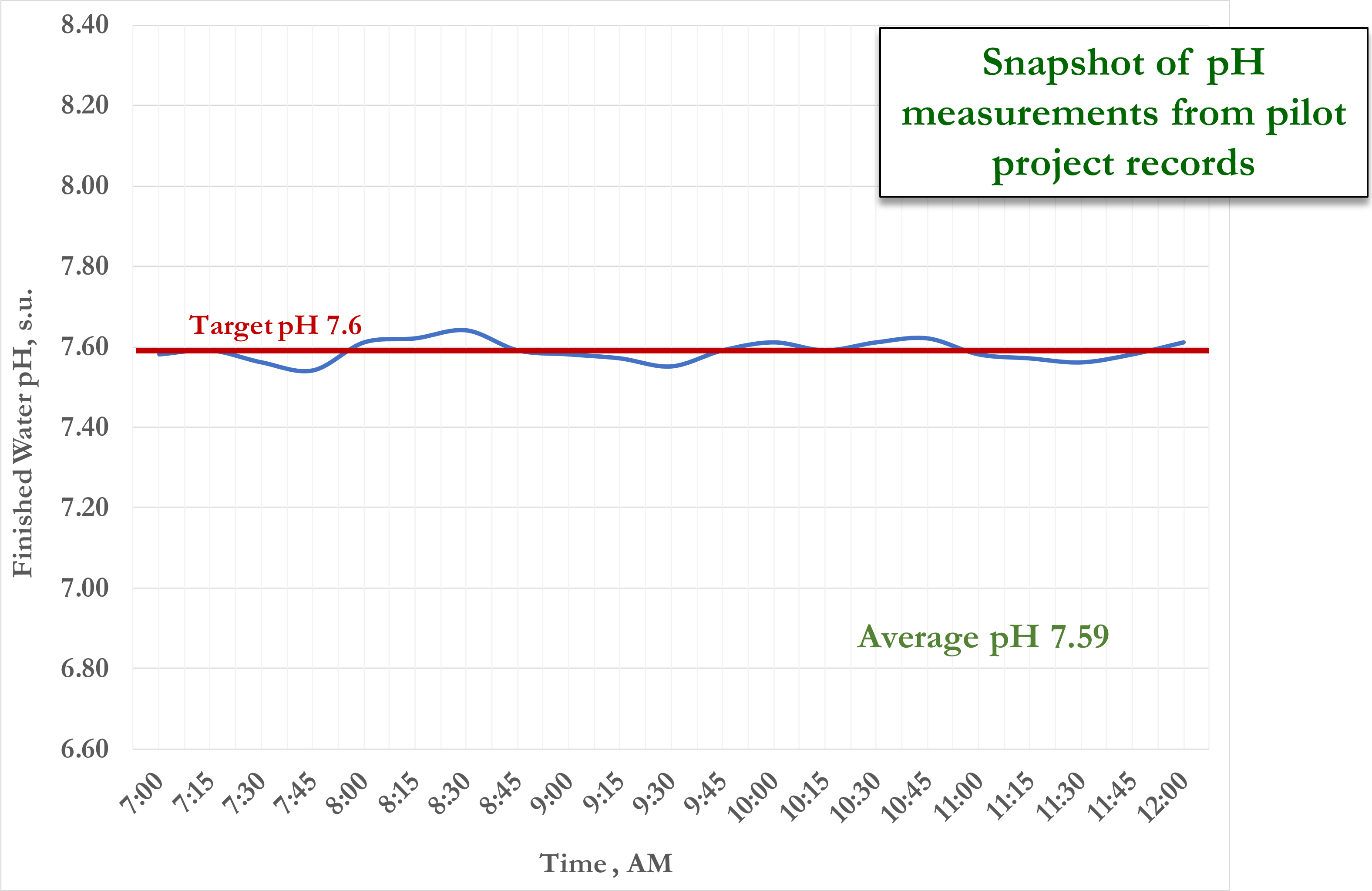


- CFD analysis for relocating NaOH feed
  - Nearly complete mixing upstream of weir wall
  - Expected to reduce feed rates and stabilize pH measurements

Tampa Regional



Tampa Regional



Tampa Regional

pH Adjustment Operating Costs		
	2016	Future
Caustic soda feed	$451,434	$343,090
Pump cleaning	$150,000	$0
Annual costs	$601,434	$343,090
Eng./Const.		$270,000
Cost savings		**$258,344**
ROI		12.5 months

24% reduction in NaOH feed

Conclusions

- Optimization can produce excellent results
  - Better performance in many applications
  - Follow scientific principles and established procedures
  - Document findings and projections
  - Verify with first-year field data
  - Often improves water quality and can produce cost savings
- Start making you own stories

Questions

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