How Innovative Tools and Site Specific Data Helped Save $20M in WWTP Wet Weather Upgrades

TACWA - January 25, 2019

Hazen

Project Objective and Challenges

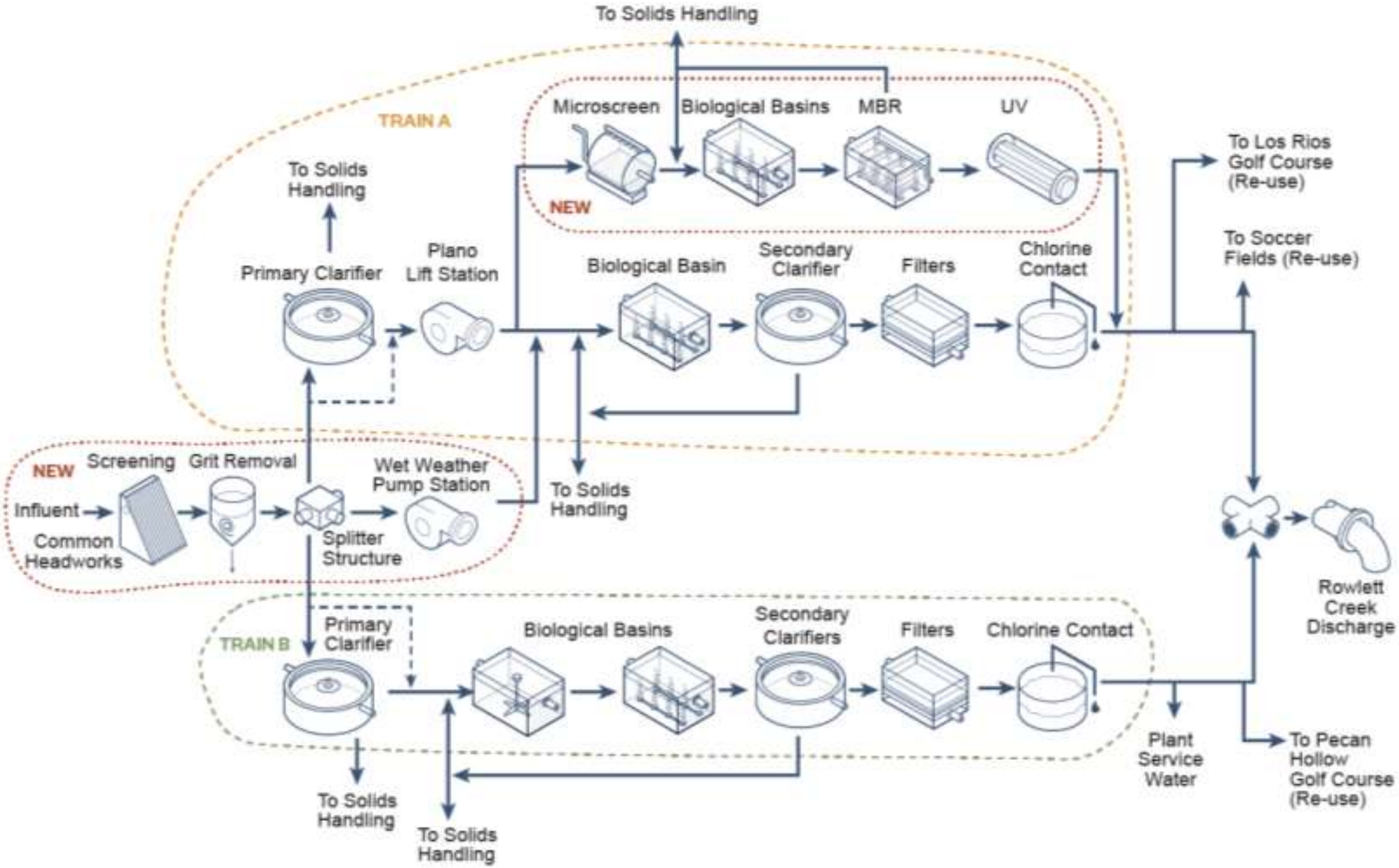
Overall: Develop robust and operationally flexible treatment configuration to treat both average and wet weather flows at a sustainable cost

Challenges:

- Site constraints
- Reliability through redundancy
- Peaking factors
- Operation year round

Plant Overview and Project Approach

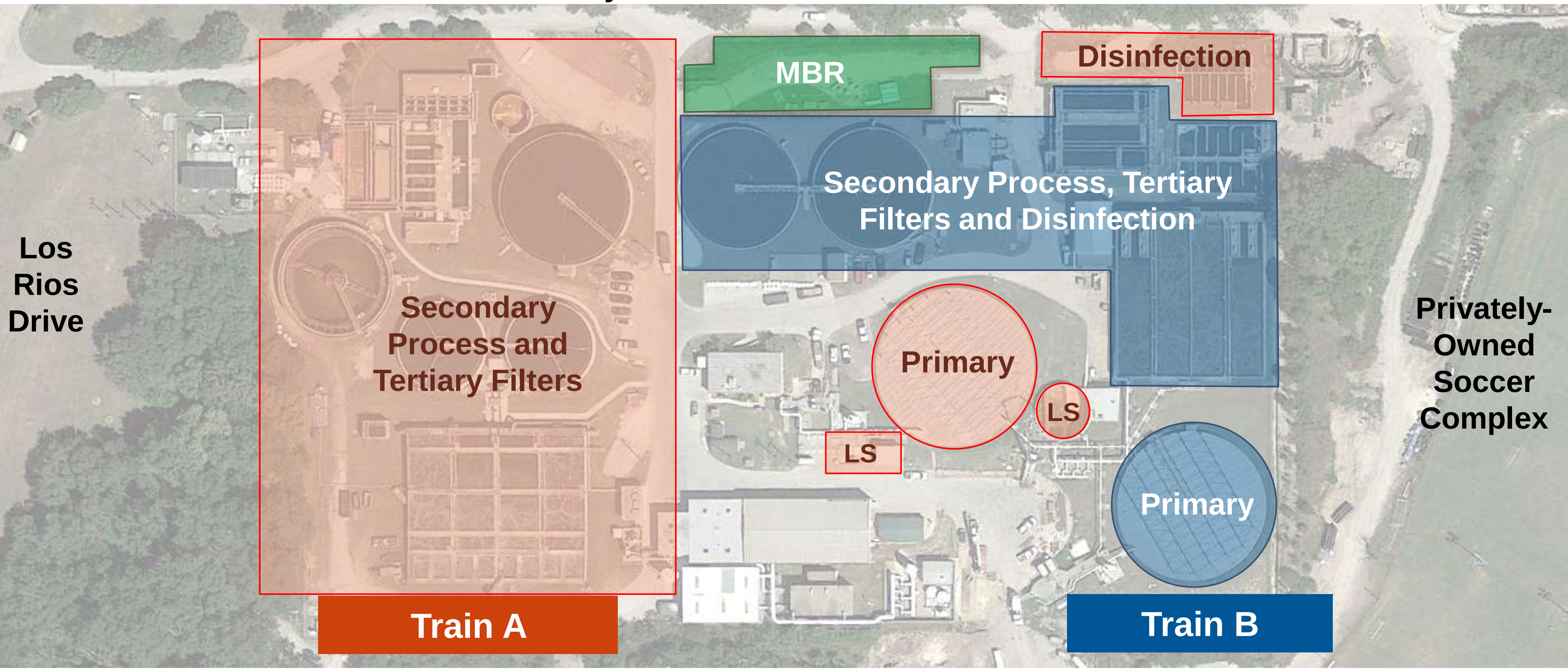
Rowlett Creek RWWTP Liquid Process Post-Phase I



Site Overview

Site Overview

City of Plano Los Rios Golf Course



Privately-Owned Soccer Complex

Current Effluent Discharge Permit Flow

- TPDES Permit No. WQ0010363001

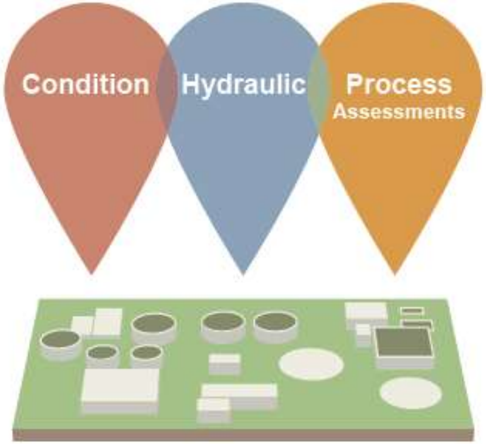
- Average Annual Flow = 24 mgd
- Current Peak 2-Hr. Flow = 60 mgd
- Phase I Peak 2-Hr. Flow = 77.5 mgd
- **Phase II Peak 2-Hr. Flow = 95 mgd**
- **Ultimate Peak 2-Hr. Flow = 120 mgd**

Current Effluent Discharge Limitations

Effluent Characteristic	Daily Avg. mg/L (ppd)	7-day Avg. mg/L	Daily Max mg/L	Single Grab mg/L
Carbonaceous BOD_5				
December – March	7 (1,401)	11	17	30
April - November	5 (1,001)	10	20	30
Total Suspended Solids				
December – March	12 (2,402)	20	40	60
April - November	5 (1,001)	10	20	30
Ammonia Nitrogen				
December – February	3 (600)	6	10	15
March	2 (400)	5	10	15
April - November	1.2 (240)	5	10	15
Total Phosphorus	1.0 (200)	N/A	Report	N/A
Sulfate, Total Dissolved Solids and *E.Coli* not shown.				

Project Approach

Whole plant perspective

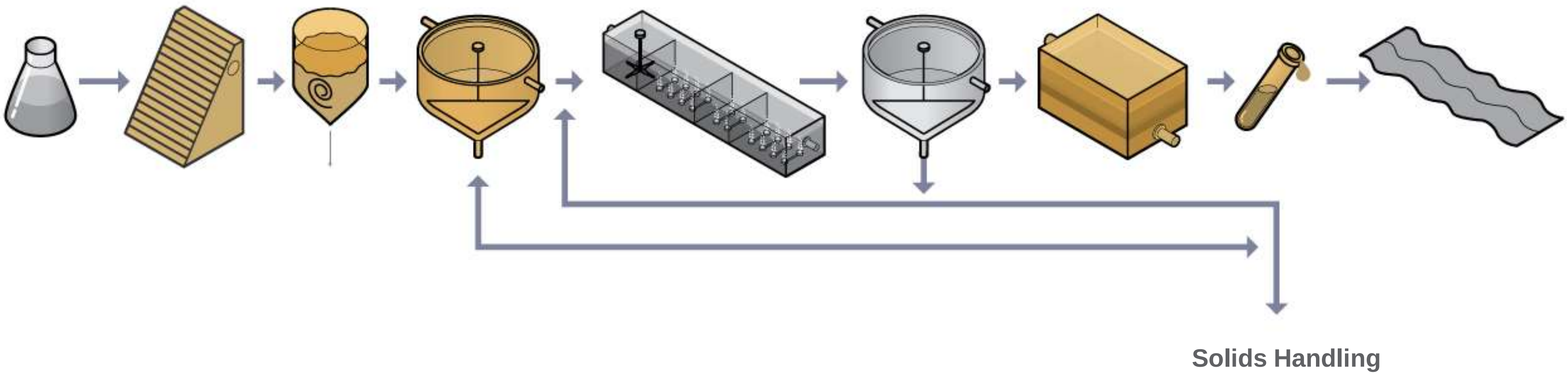


Establish the "true" peak capacity of existing

Evaluate alternatives

Defining Treatment Capacity

Defining Treatment Capacity



- Hydraulic loading rate
- Solids loading rate
- Contact time
- Pump capacity
- Velocity and pipe size

Defining Treatment Capacity – Secondary Process

Process and Treatment Factors

- Influent characteristics
- Discharge permit
- Climate / temperature
- Configuration

Solids Separation

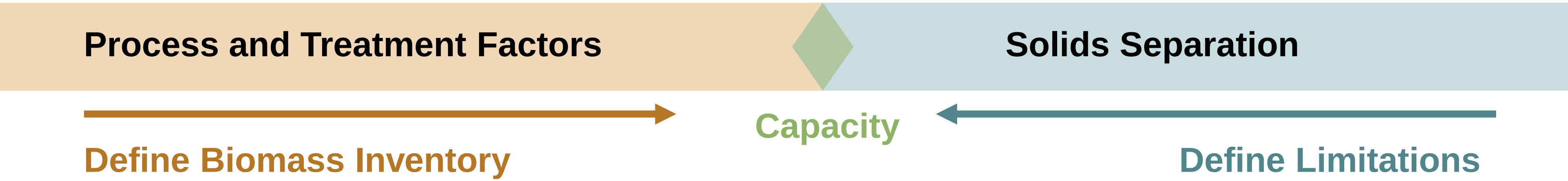
- Multi-phase hydrodynamics
- Settling characteristics
- Configuration
- Flow distribution

Define Biomass Inventory

Capacity

Define Limitations

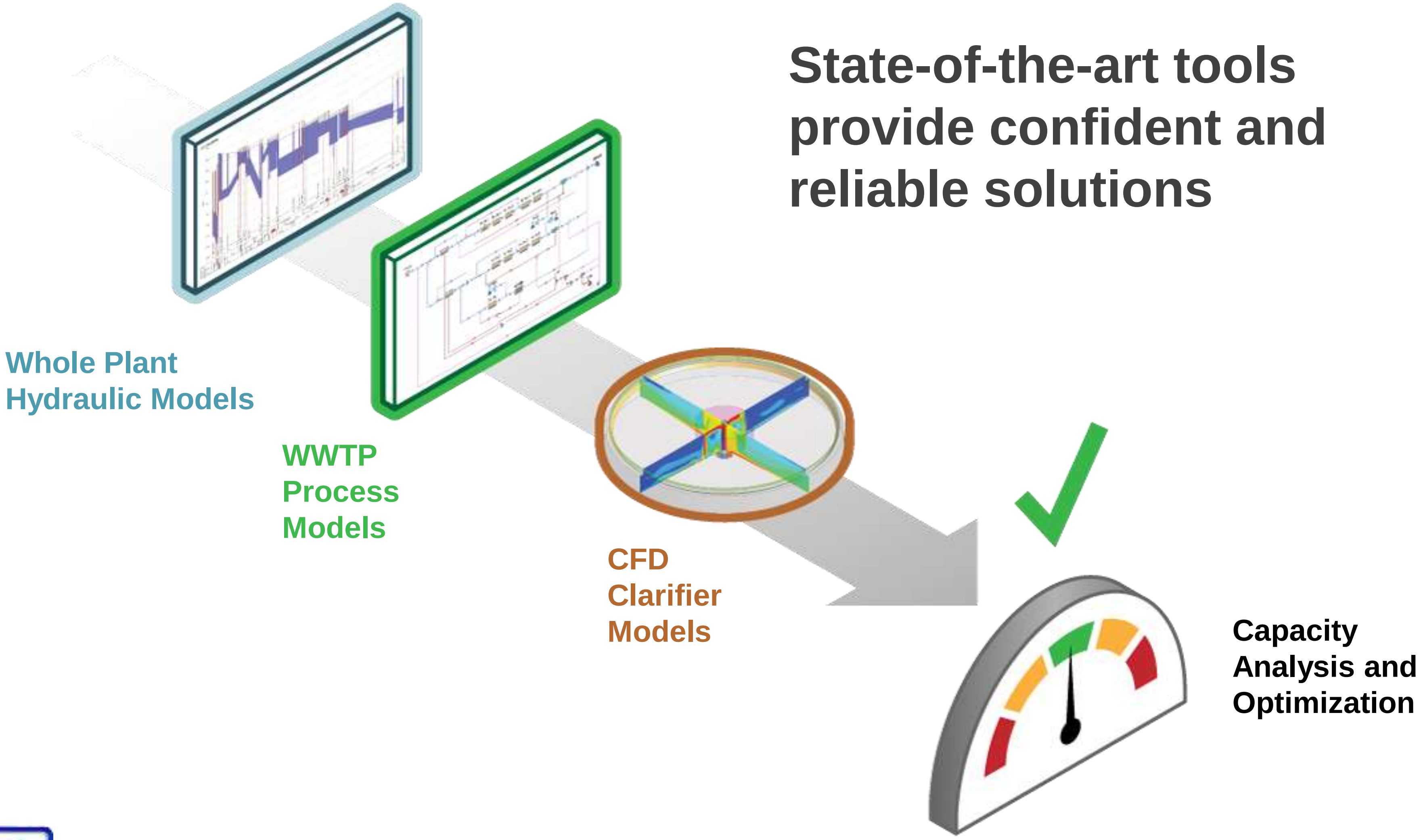
Defining Capacity – Challenge



Unique to the facility

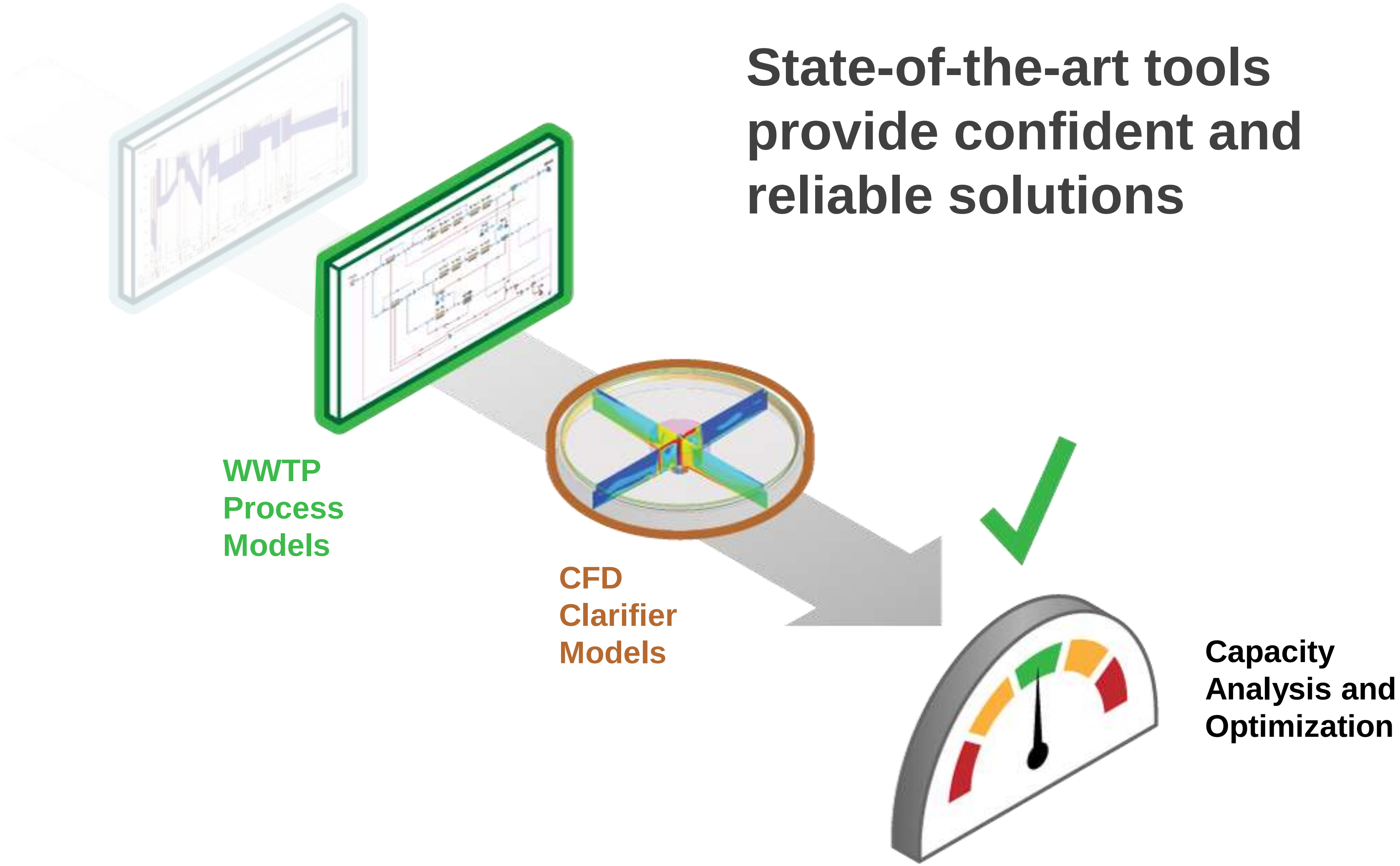
Steady state is not realistic

State-of-the-art tools provide confident and reliable solutions

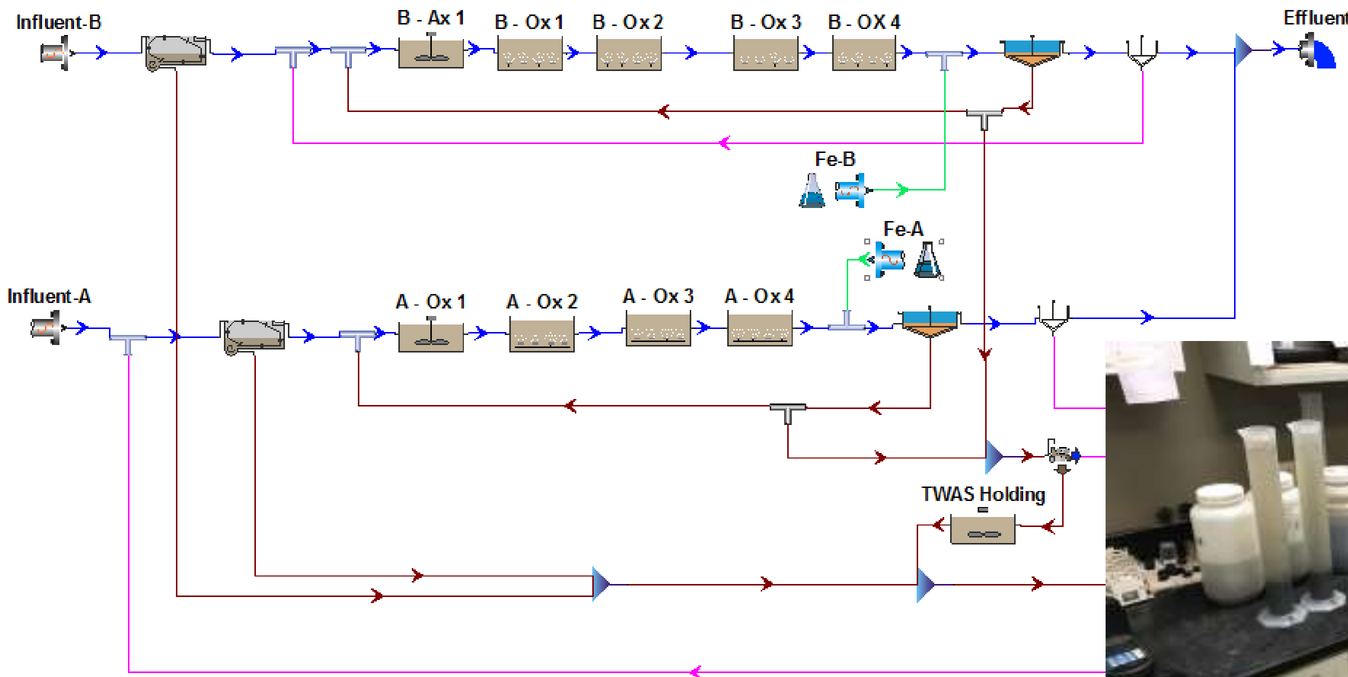


Applying State-of-the-Art Tools to Rowlett Creek RWWTP

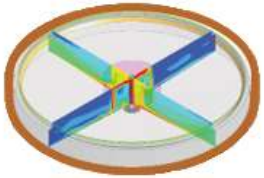
State-of-the-art tools provide confident and reliable solutions

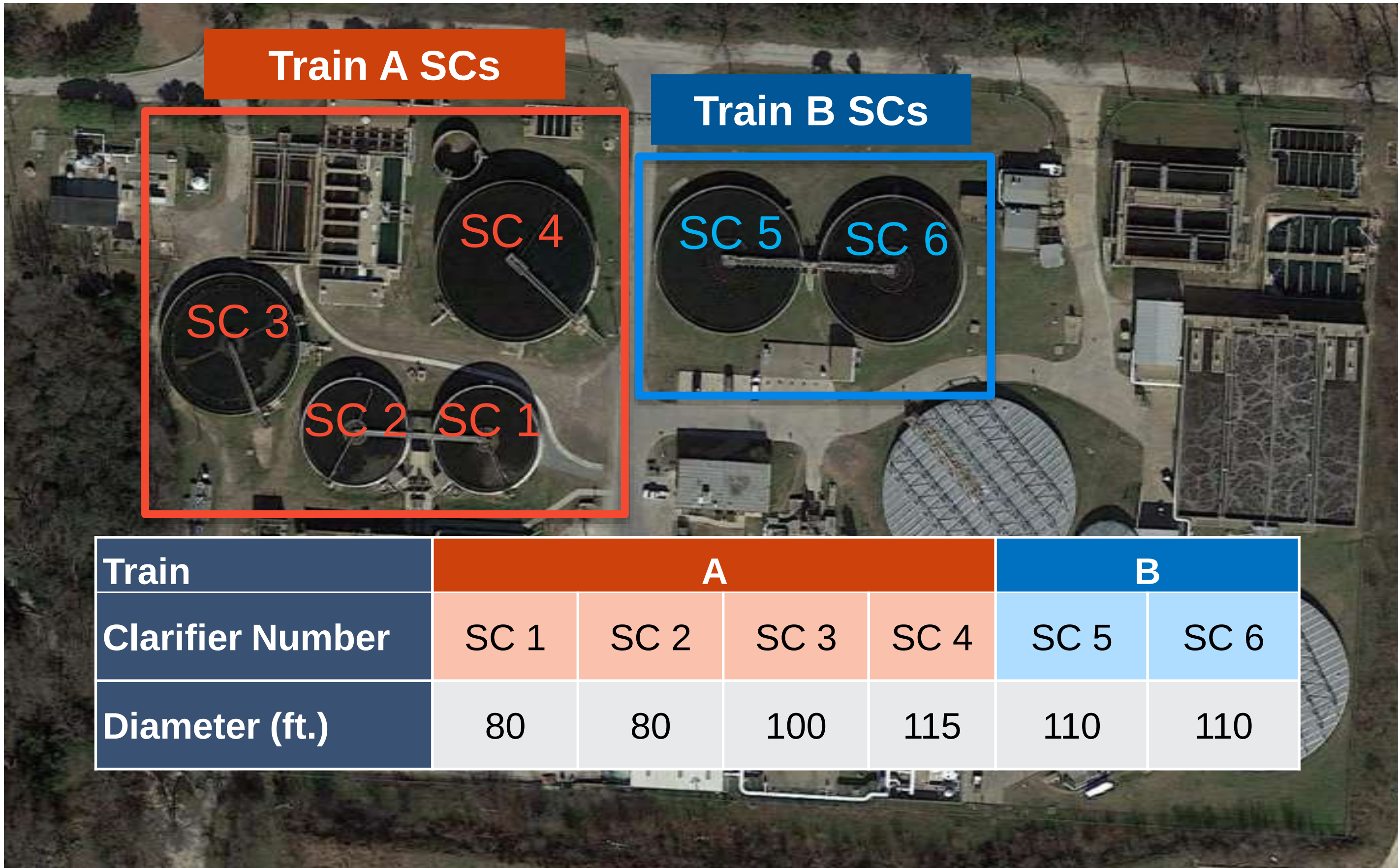


Process Model Development and Calibration



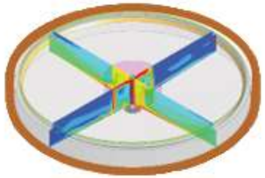
Rowlett Creek RWWTP Secondary Clarifiers





Train	A				B	
Clarifier Number	SC 1	SC 2	SC 3	SC 4	SC 5	SC 6
Diameter (ft.)	80	80	100	115	110	110

What's so complicated about a clarifier?



Types of Settling

Non-settleable
Discrete settling (Type I)
Flocculent settling (Type II)
Hindered or zone settling (Type III)
Compression (Type IV)

Empirical Definitions

$$V_S = V_0 \cdot e^{(-K \cdot X_{TSS})}$$

$$C = a + (C_O - a) \cdot e^{-k \cdot t \cdot X}$$

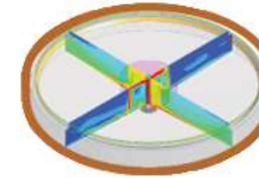
$$n_t = \frac{K_B \cdot G}{K_A} + \left(n_o - \frac{K_B \cdot G}{K_A} \right) \cdot e^{-K_A \cdot X \cdot G \cdot t}$$

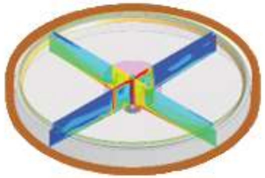
$$\frac{dn}{dt} = K_b \cdot X \cdot G^2 - K_a \cdot X \cdot n \cdot G$$

and more…

There are methods to quantify and tools to apply

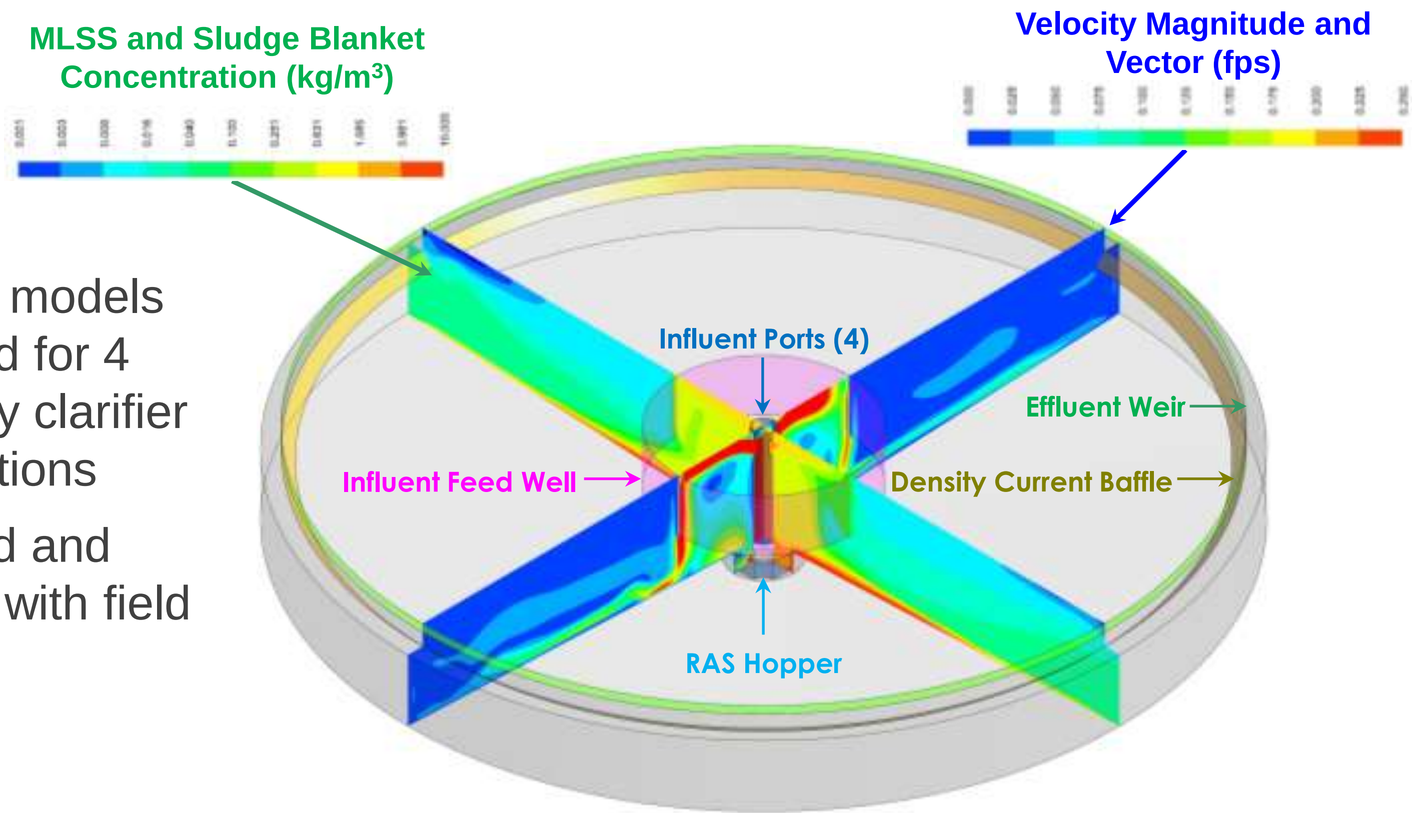
Secondary Clarifier Field Sampling



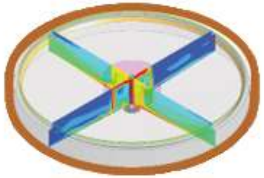


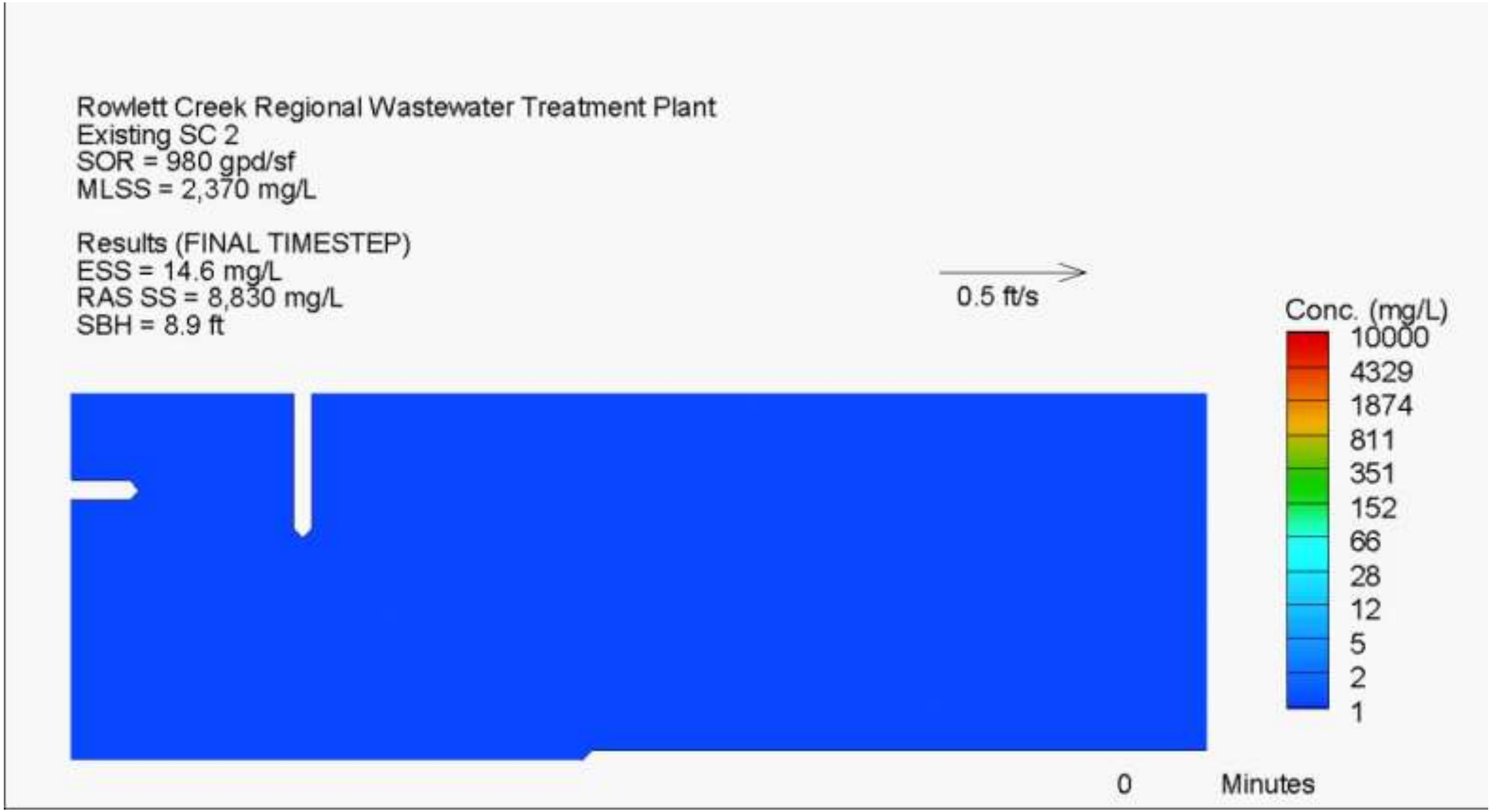
Applying Clarifier CFD Modeling

- 2Dc CFD models developed for 4 secondary clarifier configurations
- Calibrated and validated with field data

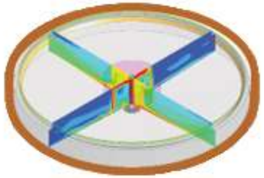


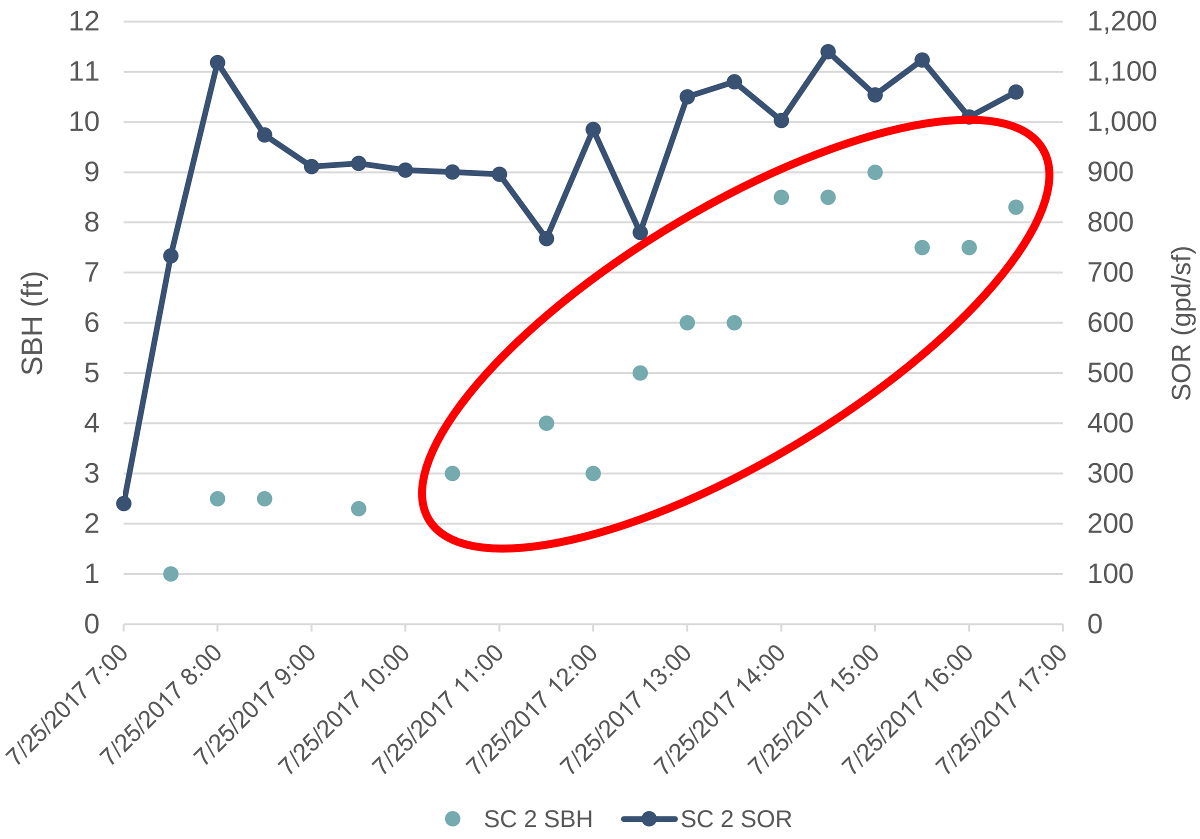
A calibrated simulation! Is it any good?

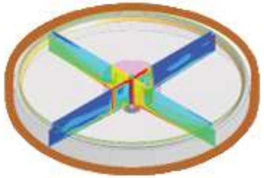




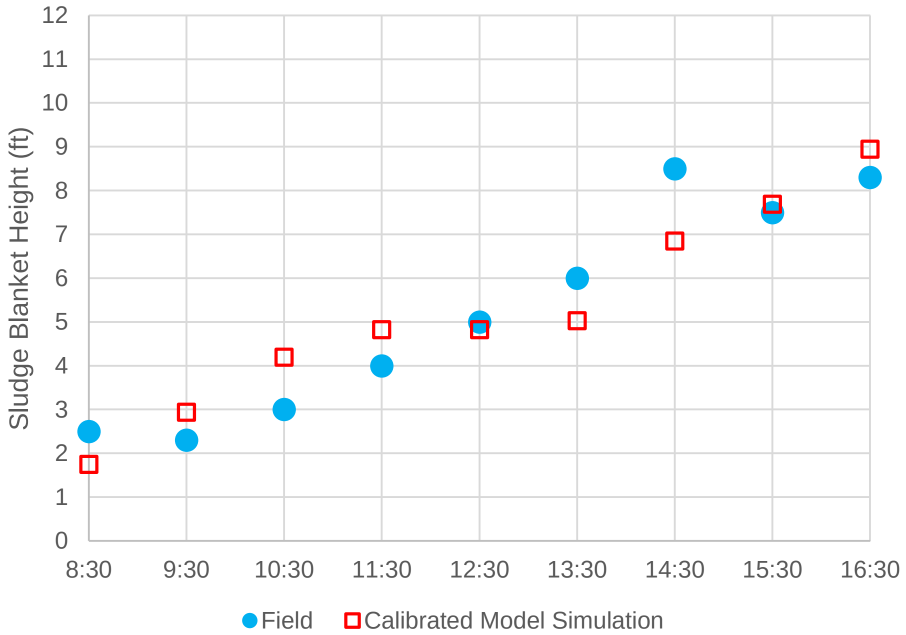
Observed – Sludge Blanket Height

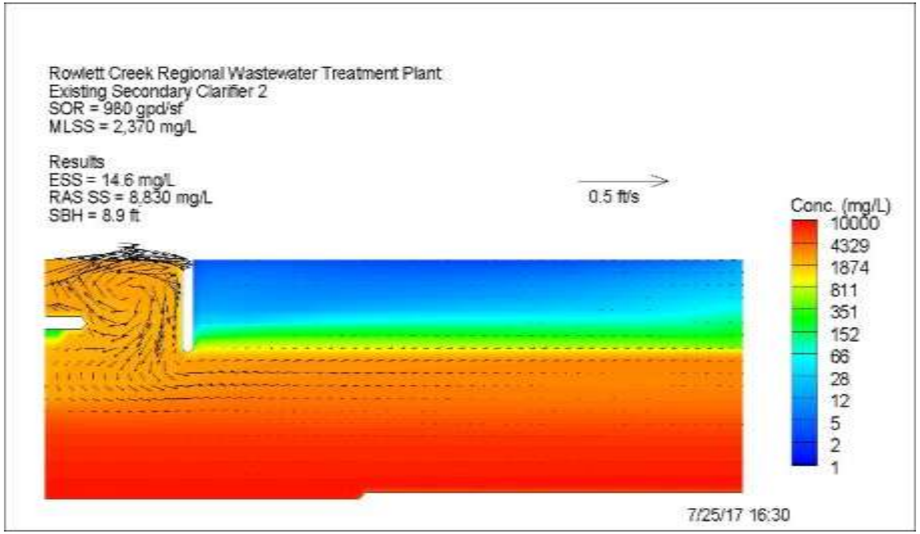






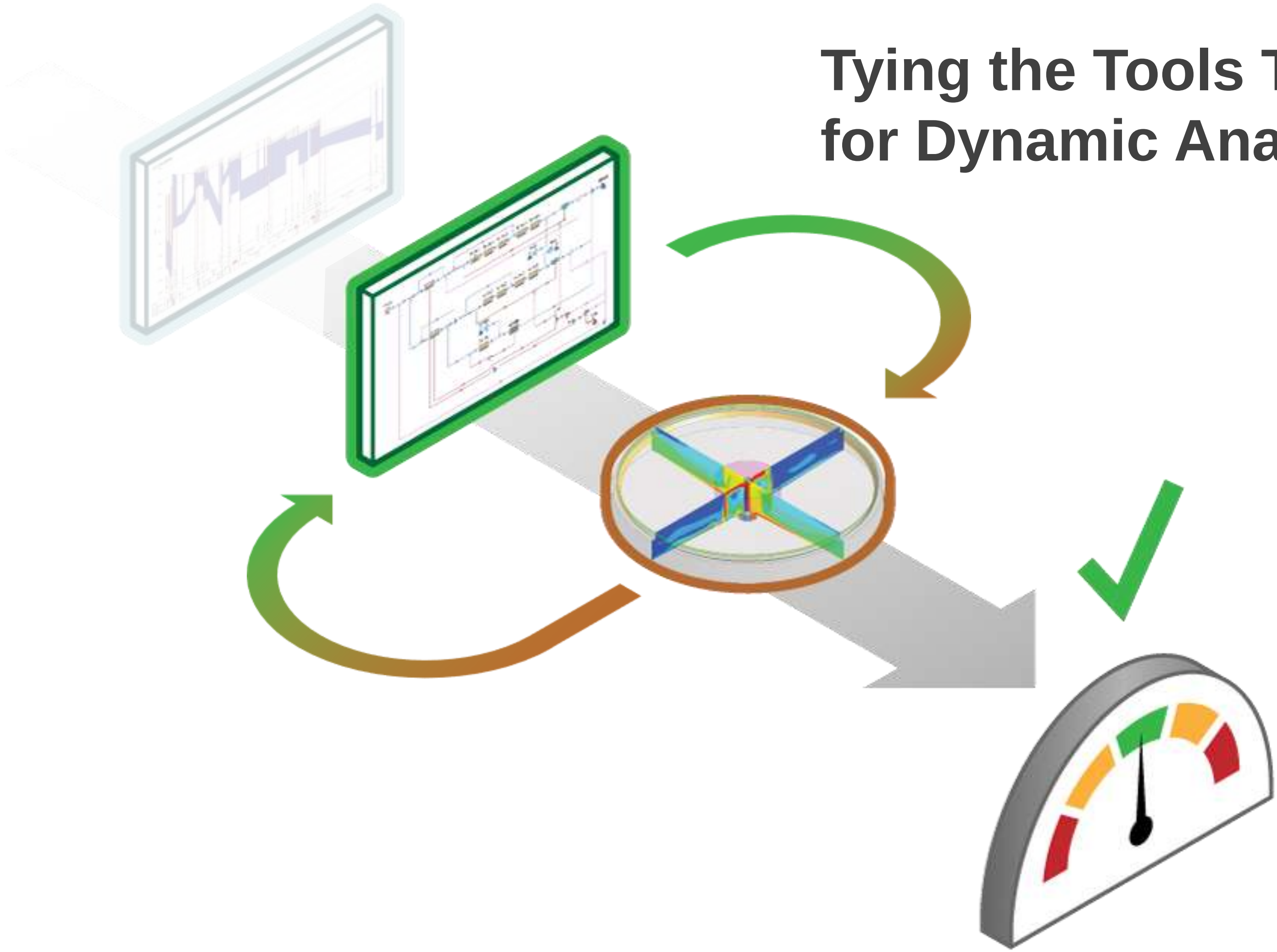
Validated – Sludge Blanket Height





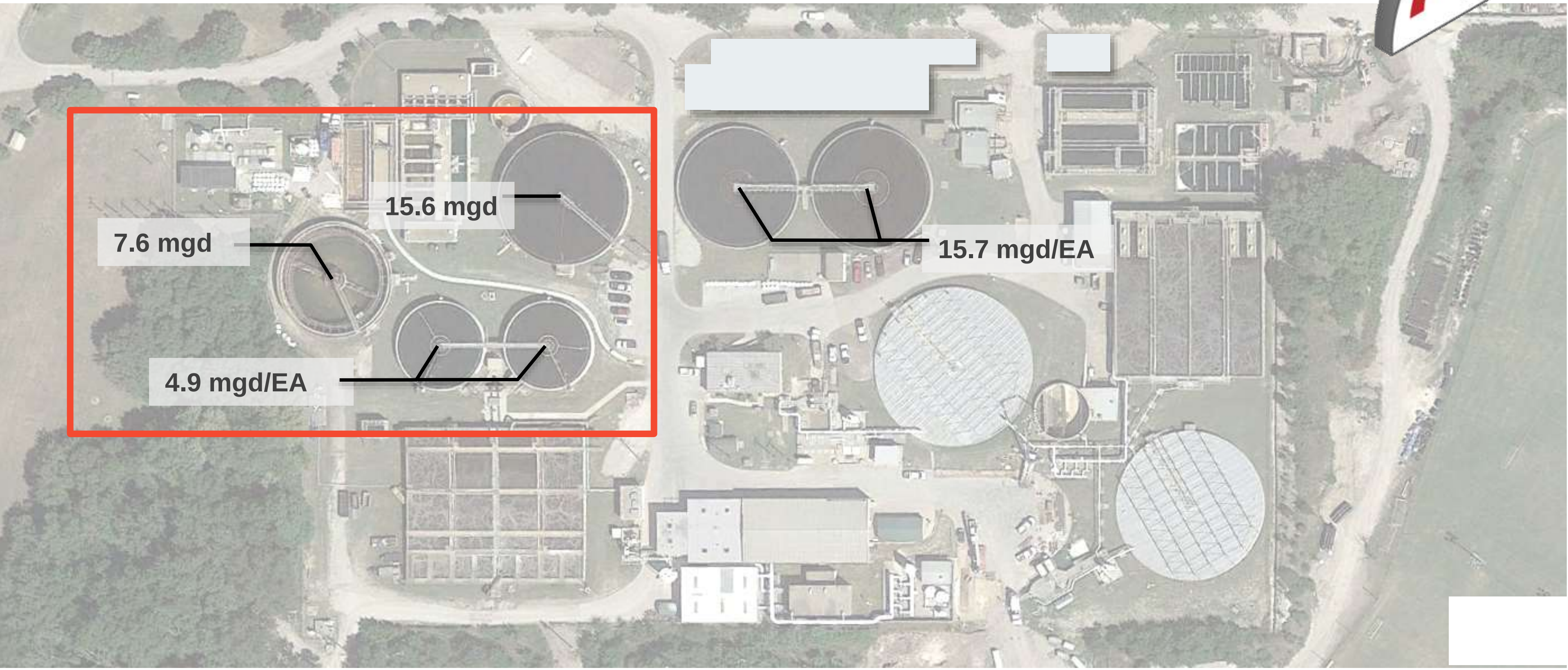
Hazen

Tying the Tools Together for Dynamic Analysis



Capacity Analysis and Optimization

Existing Asset Process Capacity without Improvements



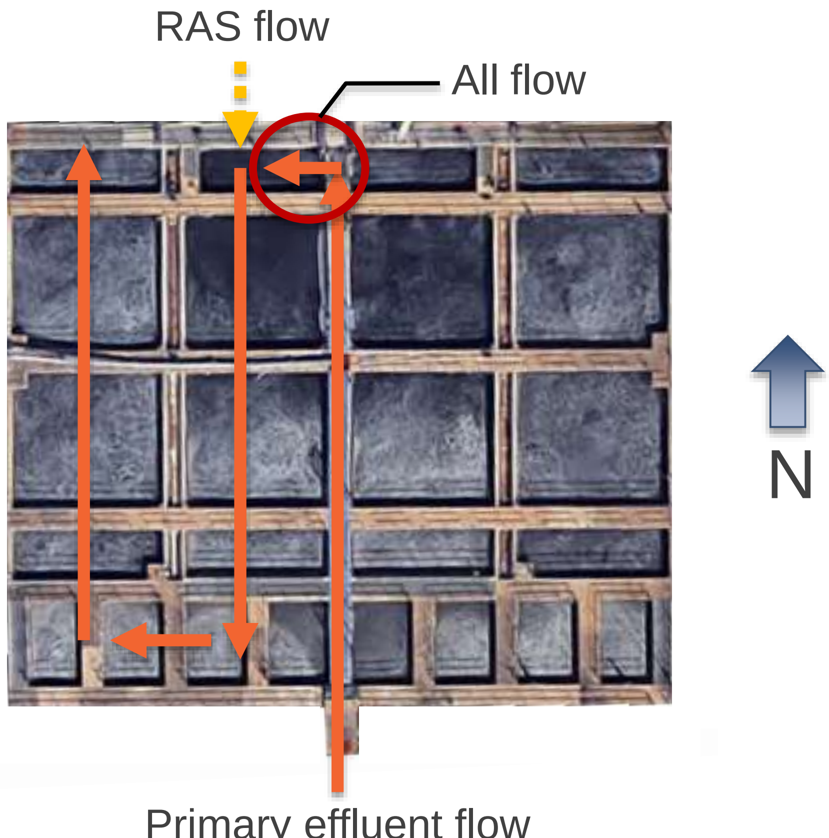
Average surface overflow rate of 1,350 gal/d/sf vs 1,250 gal/d/sf (design)

Existing Asset Wet Weather Capacity without Improvements

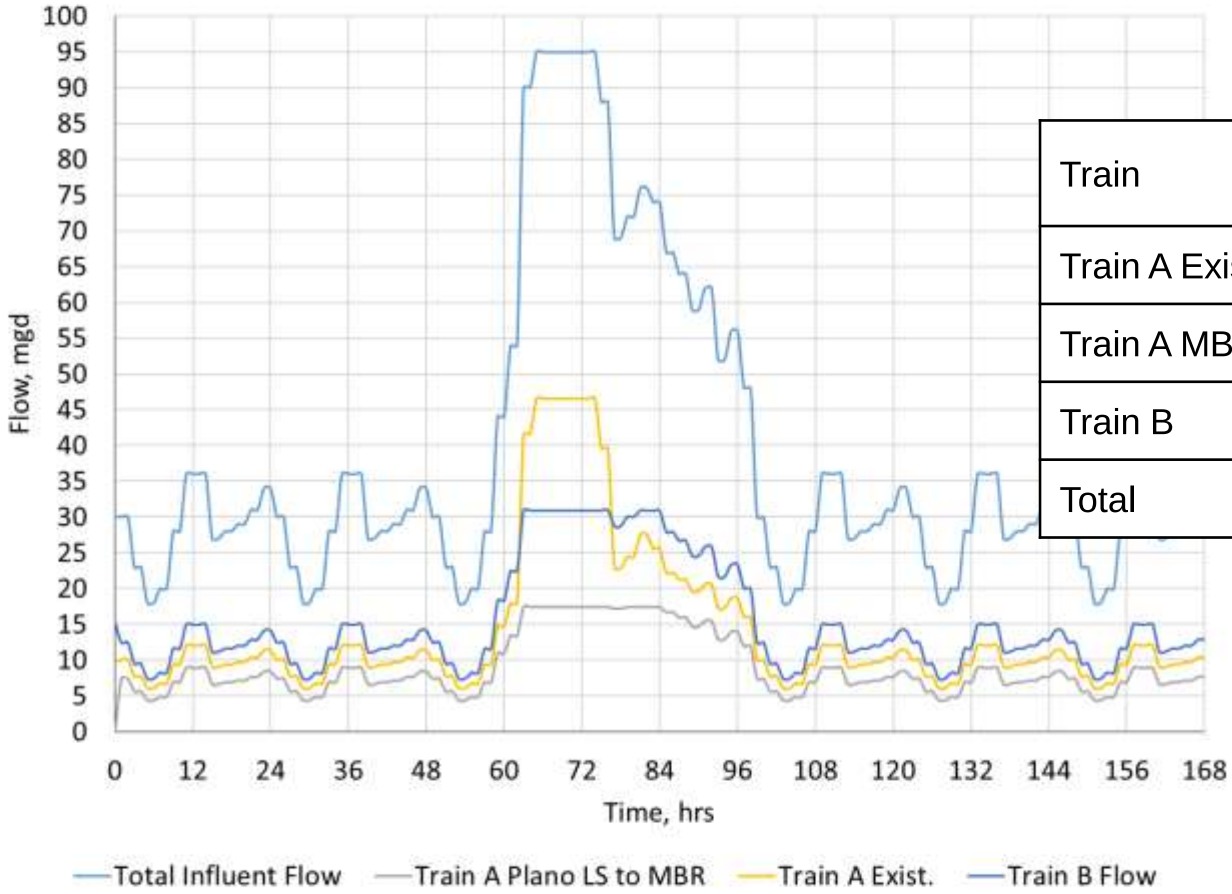
Unit Process	Peak Flow (MGD)		
	Train A	**Train B**	**Total**
Primary Clarifiers	35.0	25.0	60
Secondary Clarifiers	33.0	31.4	64.4
Filters	26.8	19.0	45.8
Chlorine Contact	30.5	25.0	55.5
Phase I MBR	17.5	-	17.5

Secondary Treatment Capacity = 81.9 MGD

Train A Current Flow Configuration

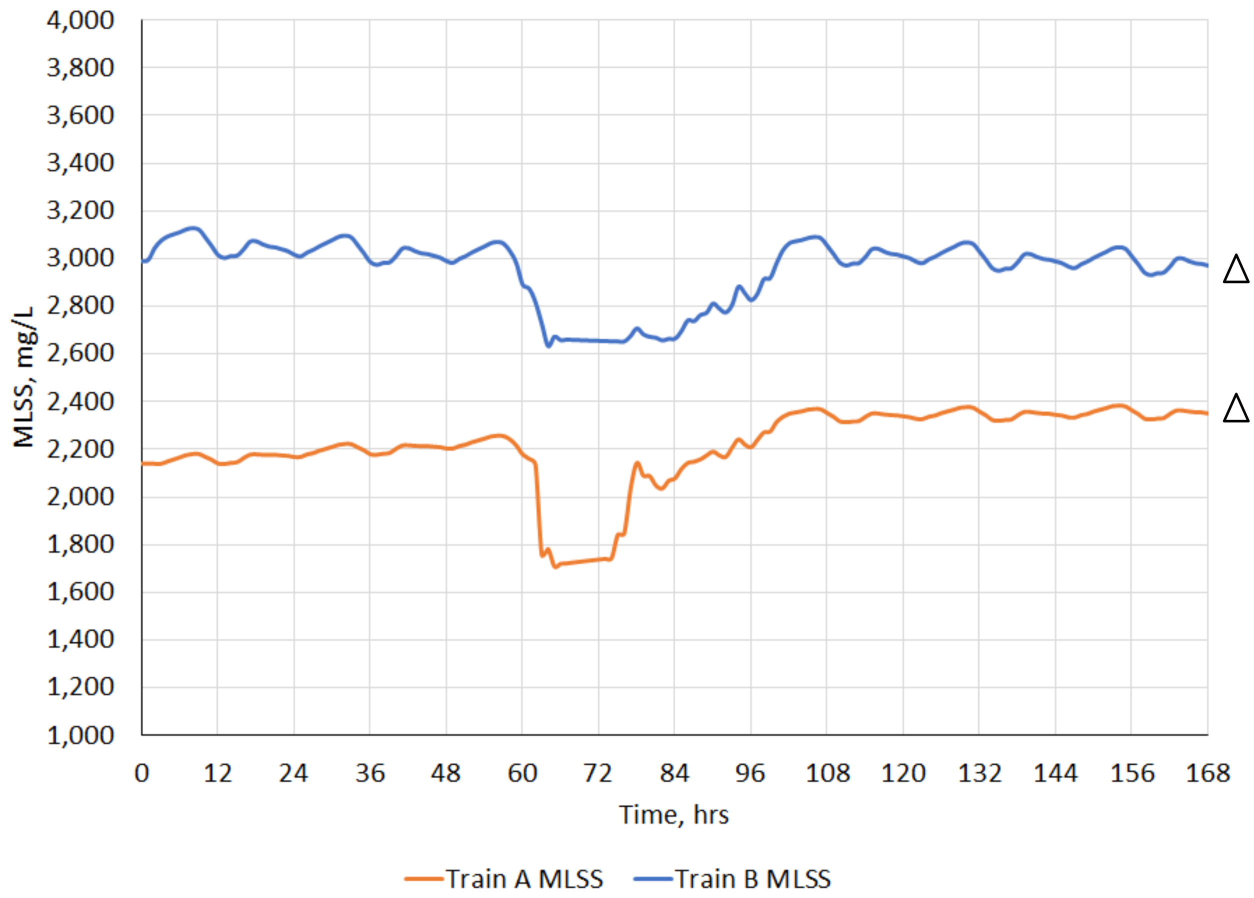


Phase II Storm (95 MGD) - Flow



Train	Flow, mgd	% of Total
Train A Existing	46.1	49%
Train A MBR	17.5	18%
Train B	31.4	33%
Total	95	100%

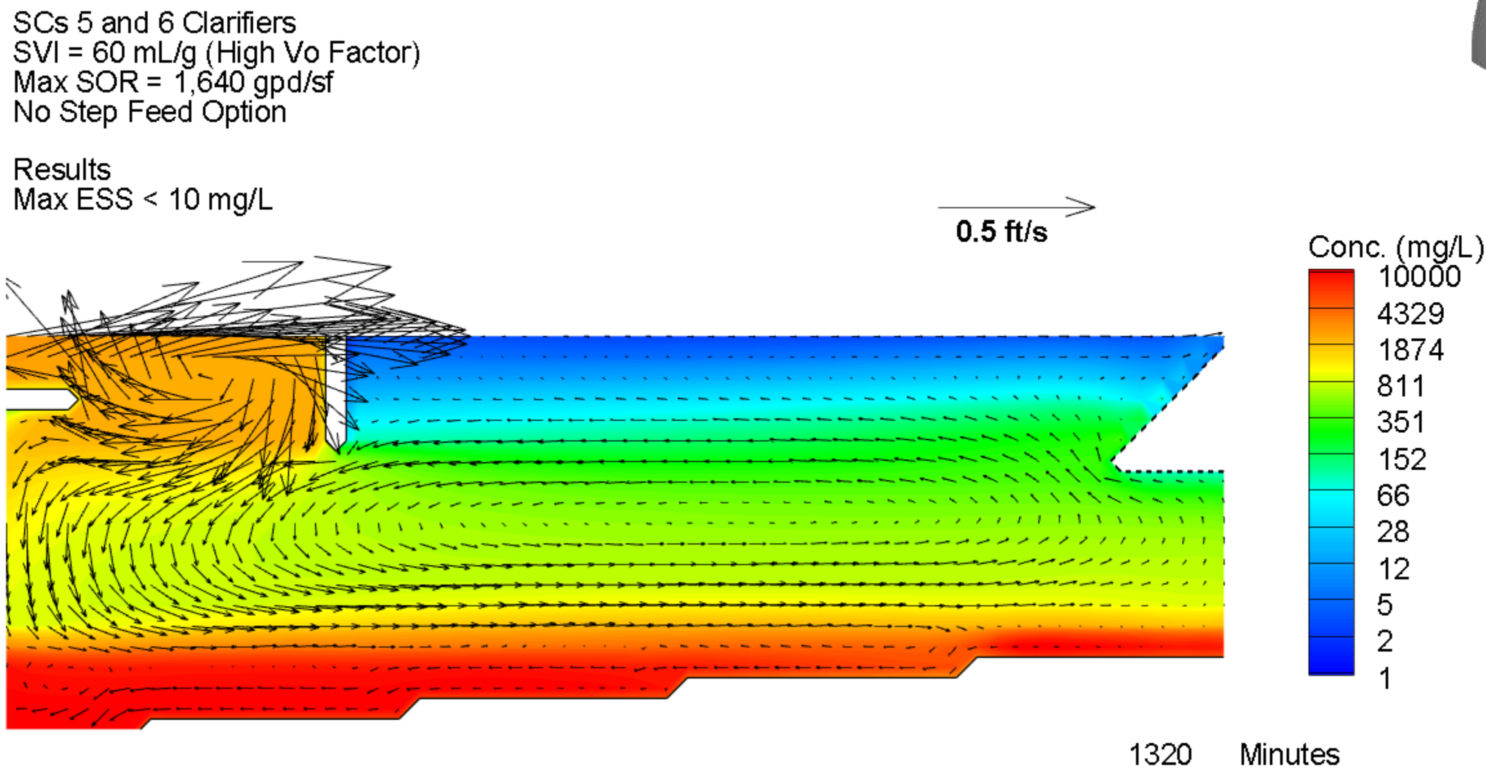
Phase II Storm (95 MGD) – Current Configuration



∆ MLSS = 300 mg/L

∆ MLSS = 500 mg/L

Secondary Clarifier Performance at SVI 60 mL/g

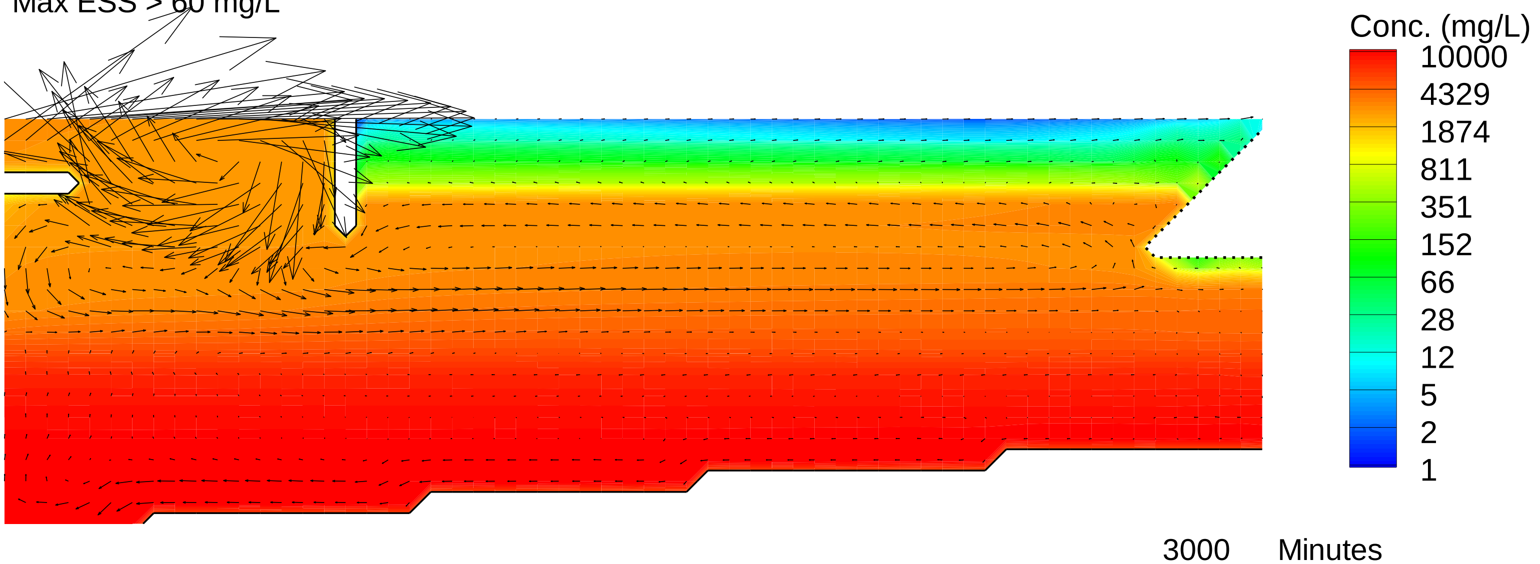


Capable of passing 95 MGD w/ average settling

Secondary Clarifier Performance at SVI 100 mL/g

Secondary Clarifiers 5 & 6
SVI = 100 mL/g (High Vo Factor)
Max SOR= 1,640 gpd/sf
No Step Feed Option

Results
Max ESS > 60 mg/L



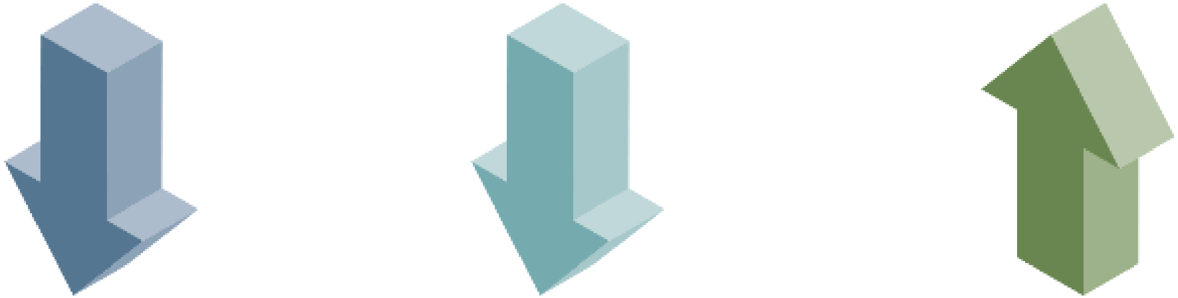
Poor settling is an issue

Implementation of Step Feed as a Wet Weather Strategy

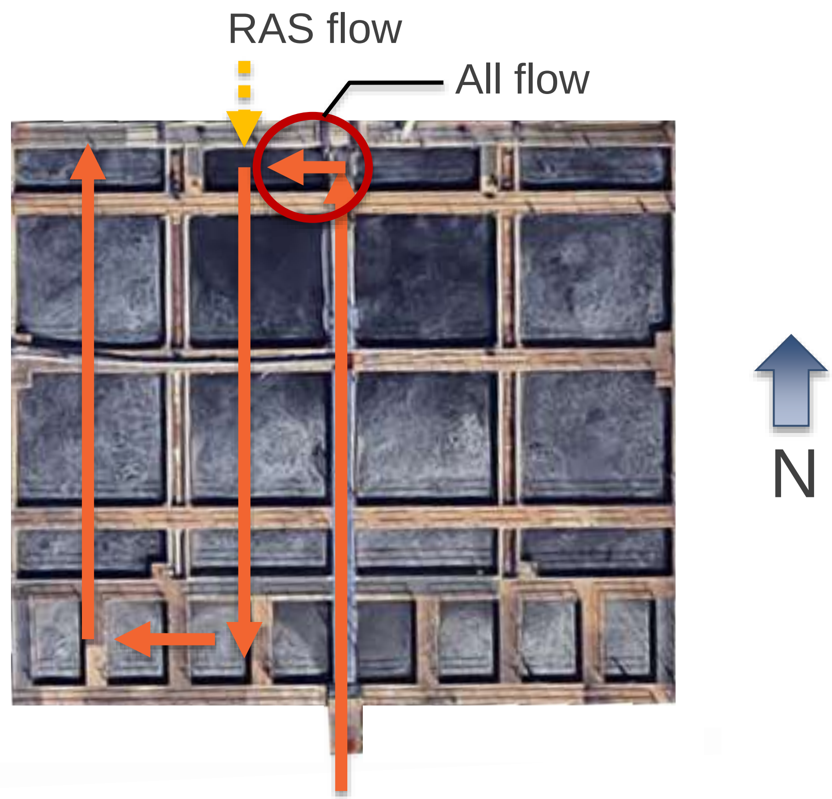
Compare impact of influent feed location:

- No Step Feed, Current Configuration
- 50% Step Feed
- Contact Stabilization

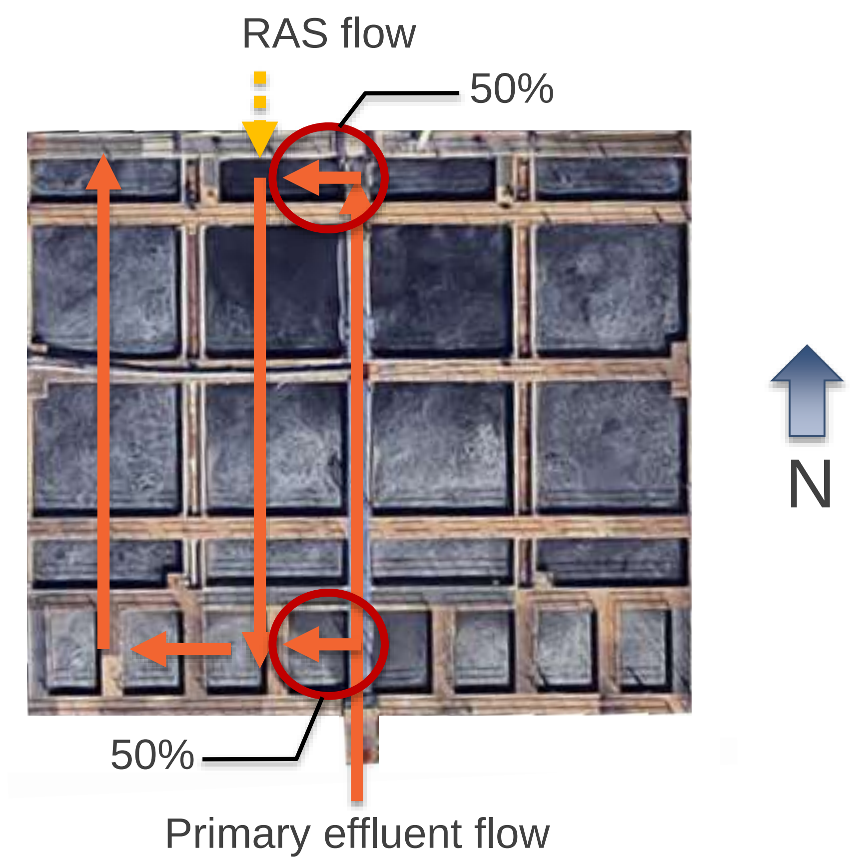
MLSS	Clarifier Solids Loading Rate	Clarifier Overflow Rate



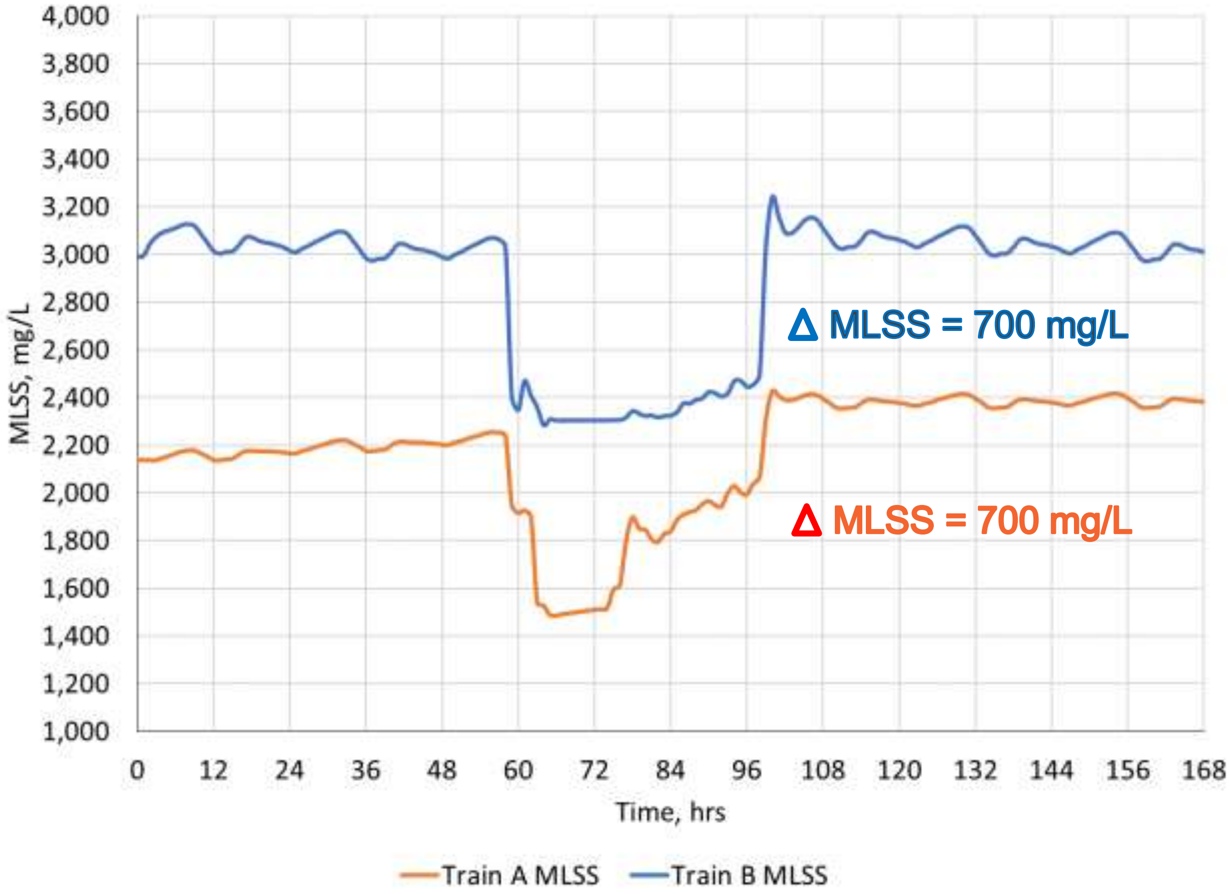
Train A Flow Schematic – Current Configuration



Train A Flow Schematic – Step Feed



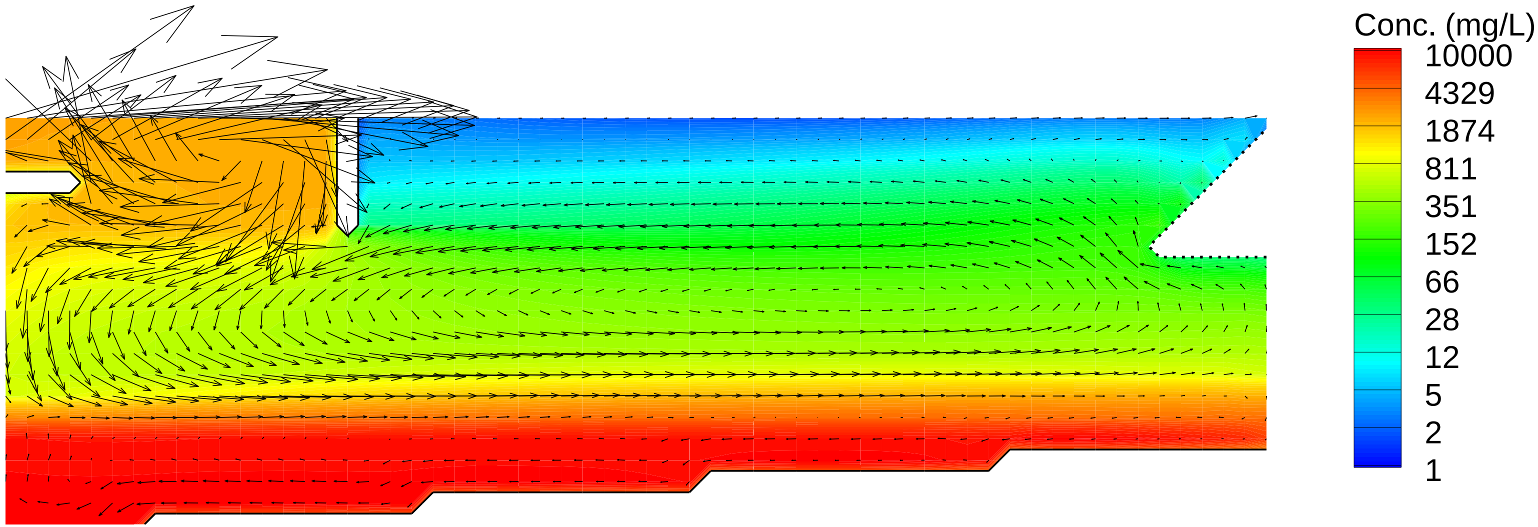
Phase II Storm (95 MGD) – MLSS with 50% Step Feed



Secondary Clarifier Performance at SVI 100 mL/g

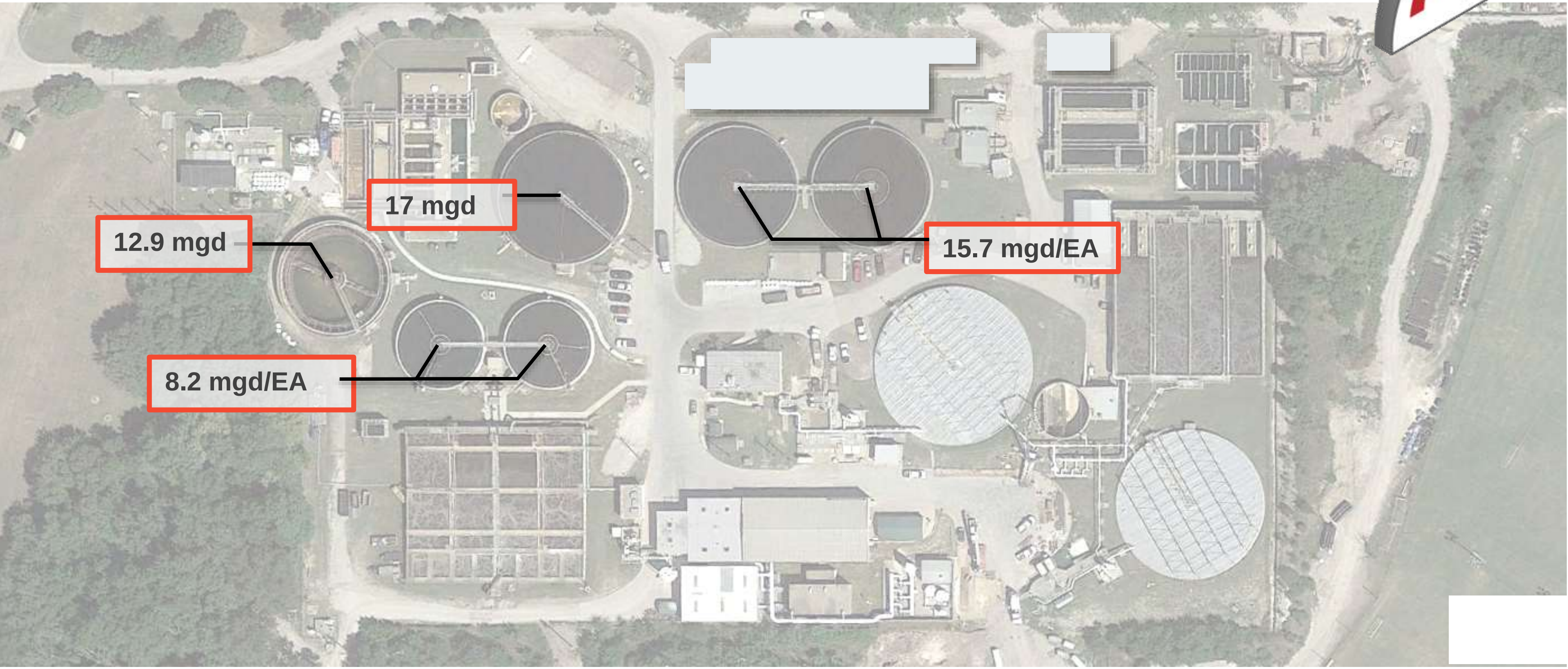
Secondary Clarifiers 5 & 6
SVI = 100 mL/g (High Vo Factor)
Max SOR= 1,640 gpd/sf
50% Step Feed Option

Results
Max ESS < 30 mg/L



Poor settling is no longer an issue

Existing Process Capacity with Step Feed Flexibility



Average surface overflow rate of 1,650 gal/d/sf vs 1,250 gal/d/sf (design)

Existing Process Capacity with Step Feed Flexibility

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Secondary Clarifiers	46.3	31.4	77.7
Filters	26.8	19.0	45.8
Chlorine Contact	30.5	25.0	55.5
Phase I MBR	17.5		17.5

Secondary Treatment Capacity = 95.2 MGD

Alternatives for Peak Flow Expansion

Short-Listed Alternatives

Base Case – MBR conversion

Alternative 1 – Step feed configuration

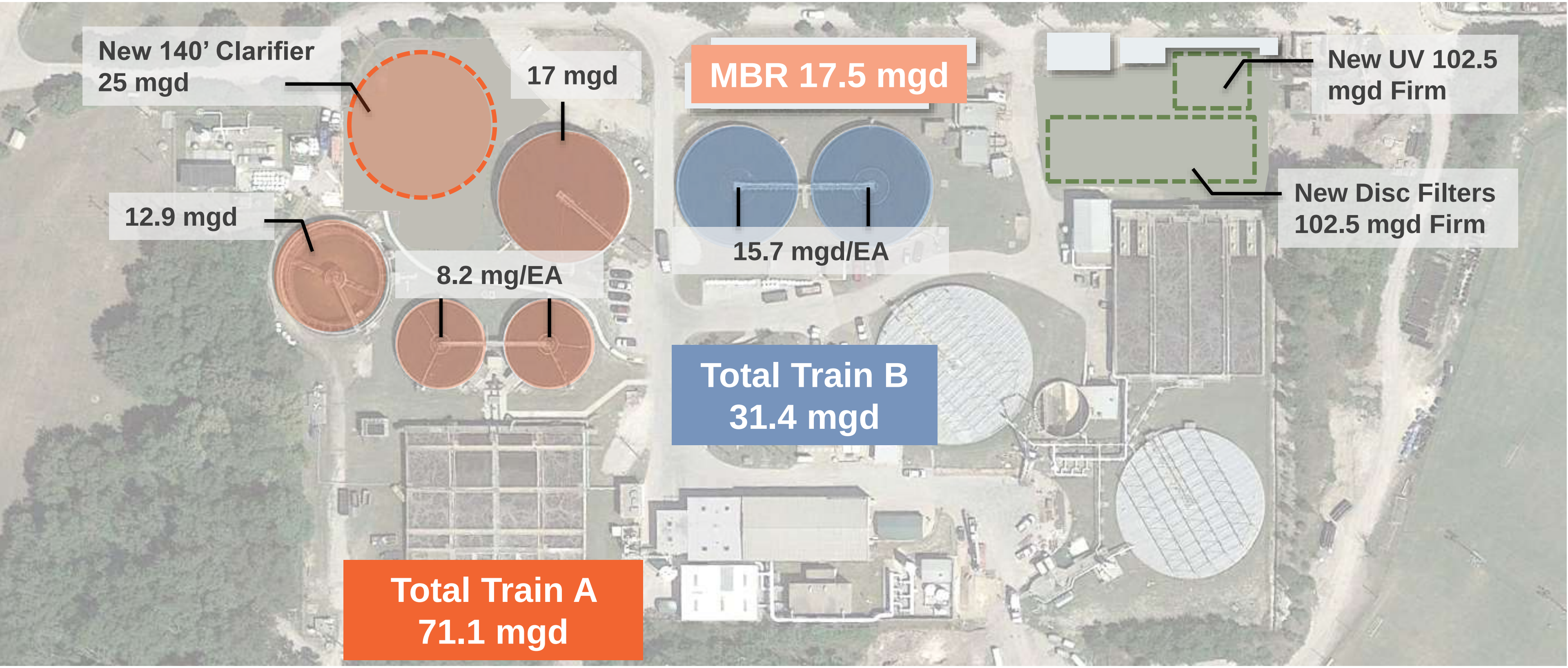
Alternative 2 – Converting Train A to biological high rate clarifier (bio-HRC) and Train B to step feed

Alternative 3 – Combination of step feed and bio-HRC for Train A and Train B step feed

Base Case – Site Plan

By others

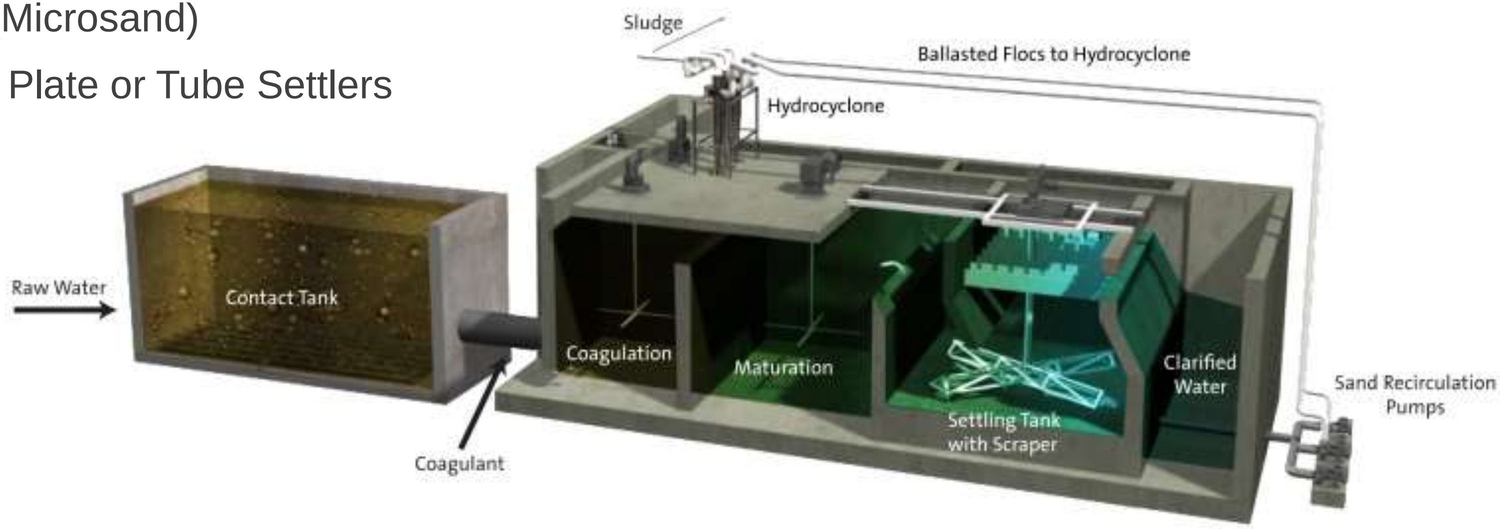
Alt. 1: Step Feed = 120 MGD – Operation During Peak



Alt. 2 Biological High Rate Clarification

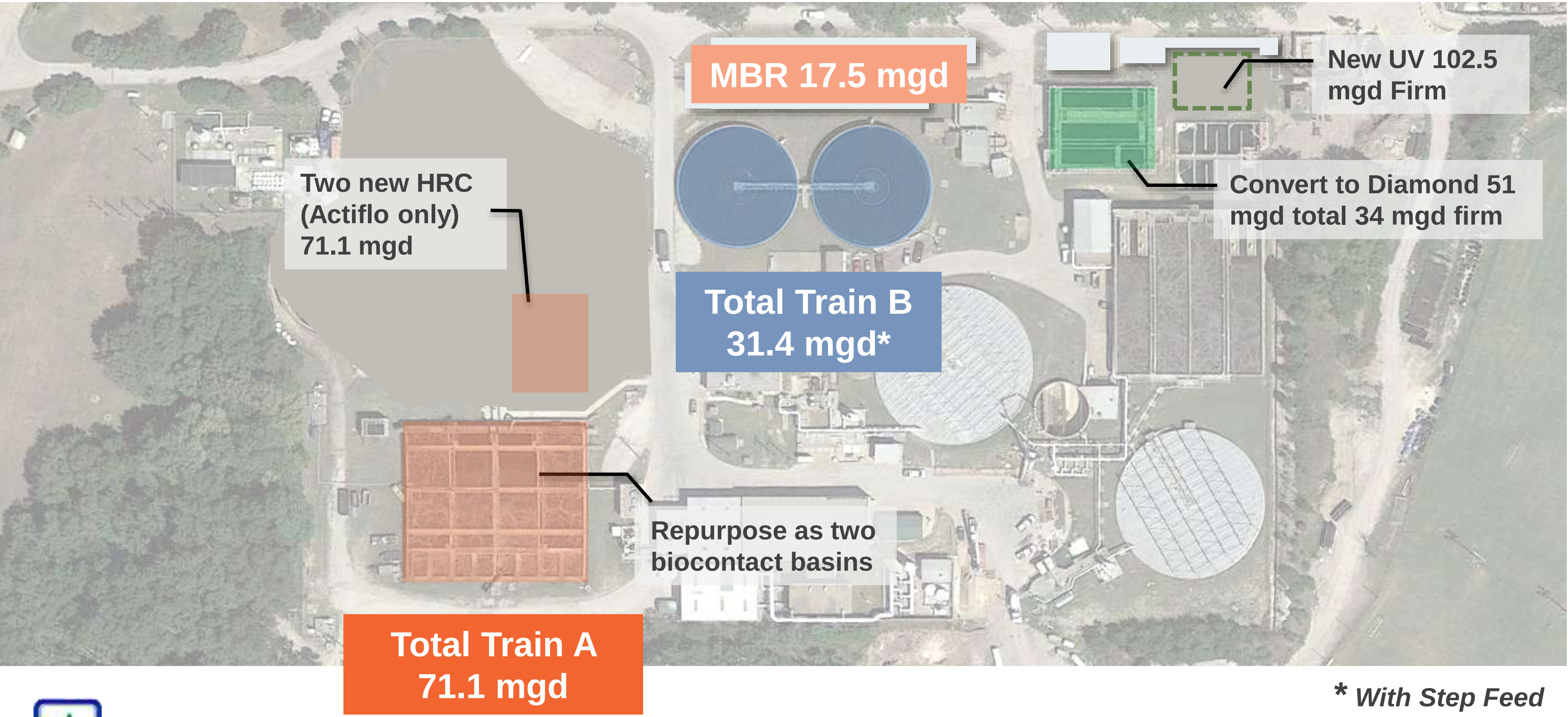
High Rate Physical-Chemical Treatment

- Polymer + Coagulant
- Ballast (Microsand)
- Lamella Plate or Tube Settlers



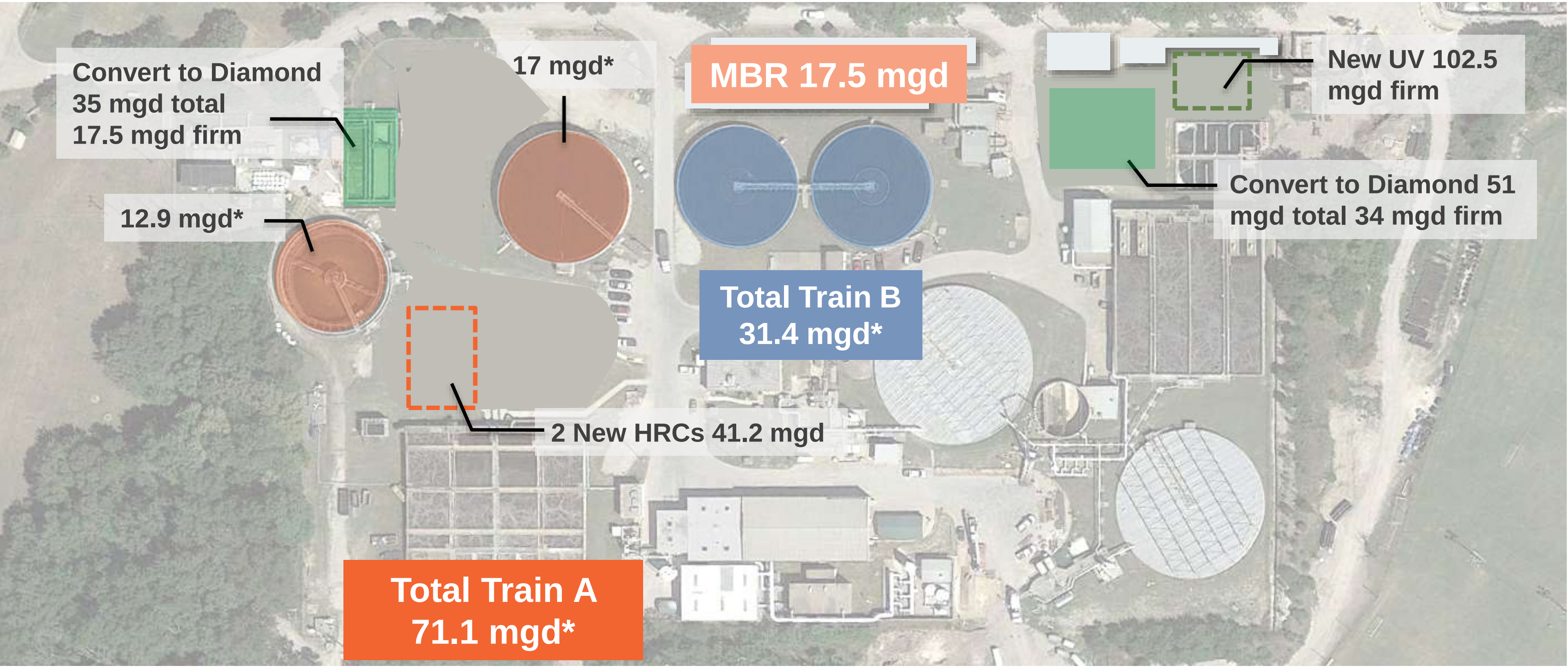
Kruger BioActiflo®

Alt. 2: HRC = 120 MGD – Operation During Peak



** With Step Feed*

Alt. 3: HRC/Step Feed Combo = 120 MGD – Operation During Peak



** With Step Feed*

Phase III Liquid Process Cost Summary

Shortlisted Alternatives	Capital Cost	20-Year O&M Present Value	Life Cycle Cost 20-Year NPV
Base Case: MBR Conversion	$81M	$61M	$142M
1: Step Feed and Additional Clarifier	**$60M**	**$28M**	**$87M**
2: Train A - High Rate; Train B - Step Feed	$57M	$41M	$98M
3: Train A - Hybrid (High Rate and Step Feed); Train B – Step Feed	$63M	$33M	$97M

$21M savings

in liquid process improvements with recommended alternative

Conclusions

- Re-rating capacity is site-specific
- Build confidence through dynamic evaluation tools
- Account for year-round operation and flexibility
- Whole-plant perspective

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Project Partner: Gupta and Associates

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Bullpen

Settling Tank (SST) models

Four Types of SST Models are Generally Available:

Zero-Dimensional (0-D)

- Mass Balance +/- Heuristics

Hazen (1904), Camp-Dobbins (1944, 1946)

One-Dimensional (1-D)

- Layered Models

Vesilind, State-Point, Drift-Flux Model (BioWin)

Two-Dimensional (2-D)

- Computational Fluid Dynamics (CFD)

Larsen (1977), LaRock; McCorquodale et al; Rodi et al (1980-2000); Griborio and McCorquodale (2004)

Three-Dimensional (3-D)

- CFD

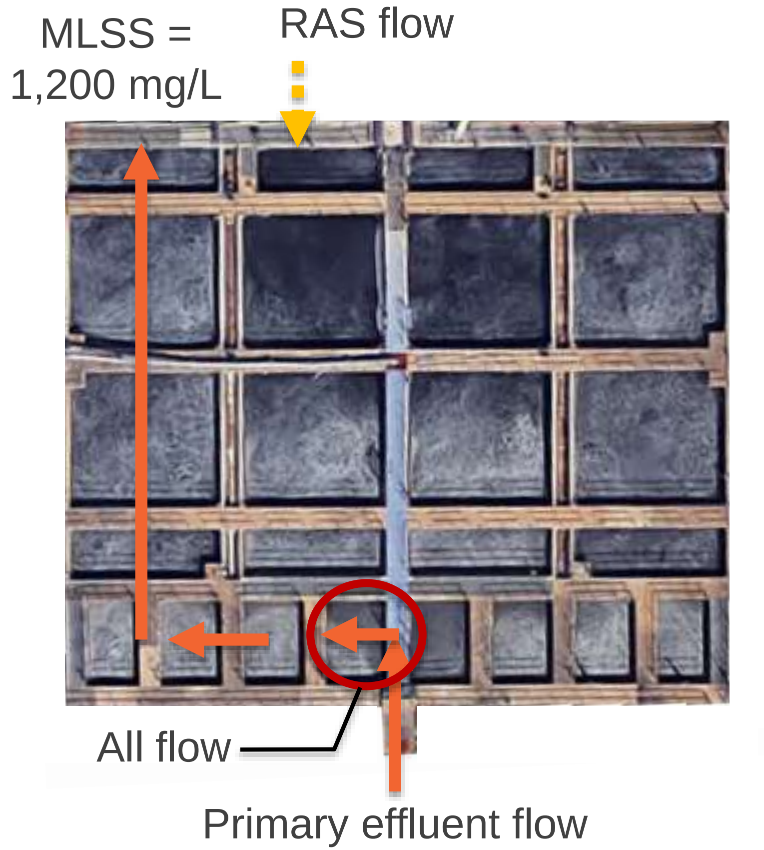
Richardson (2000), CCNY, Hazen (2017)

SC 1 and 2 Stress Testing Observations

SC 1

SC 2

Train A Flow Schematic – Contact Stabilization



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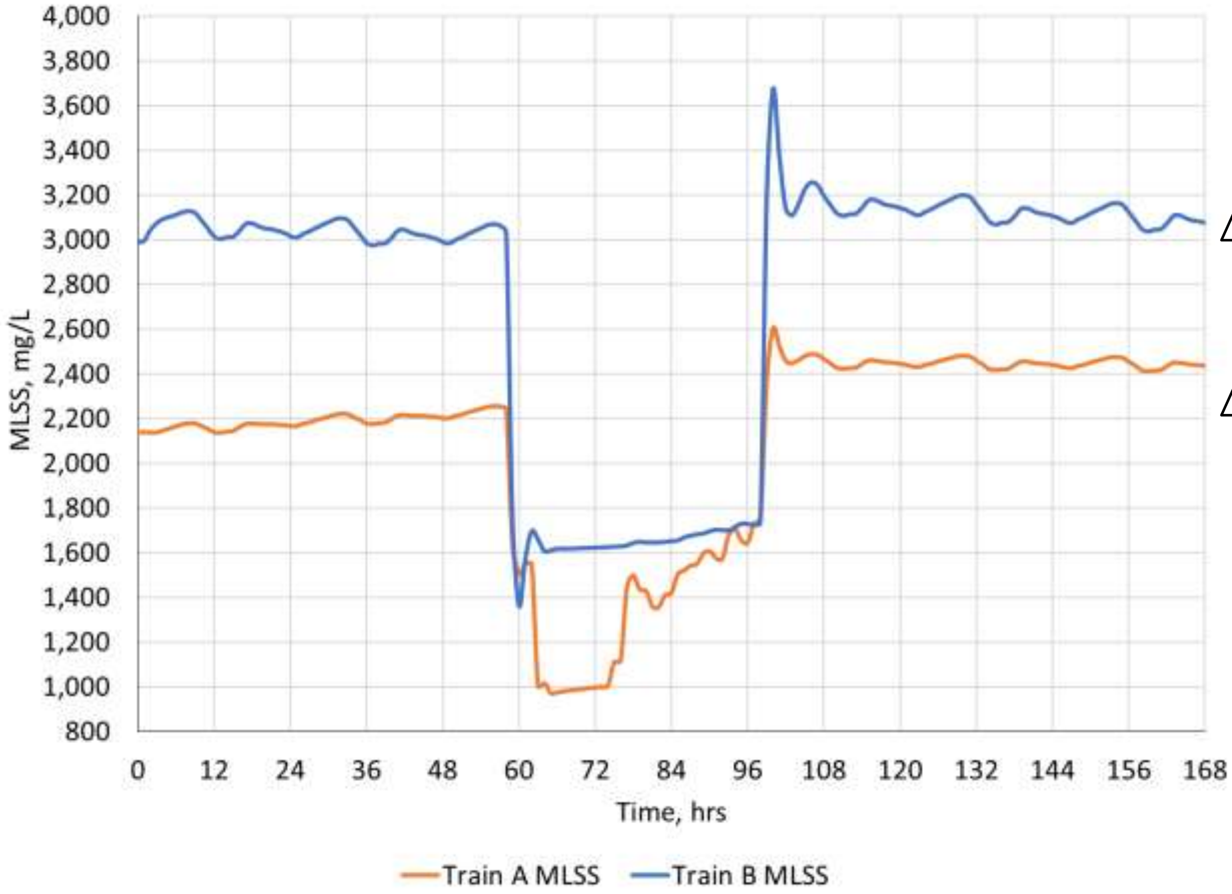
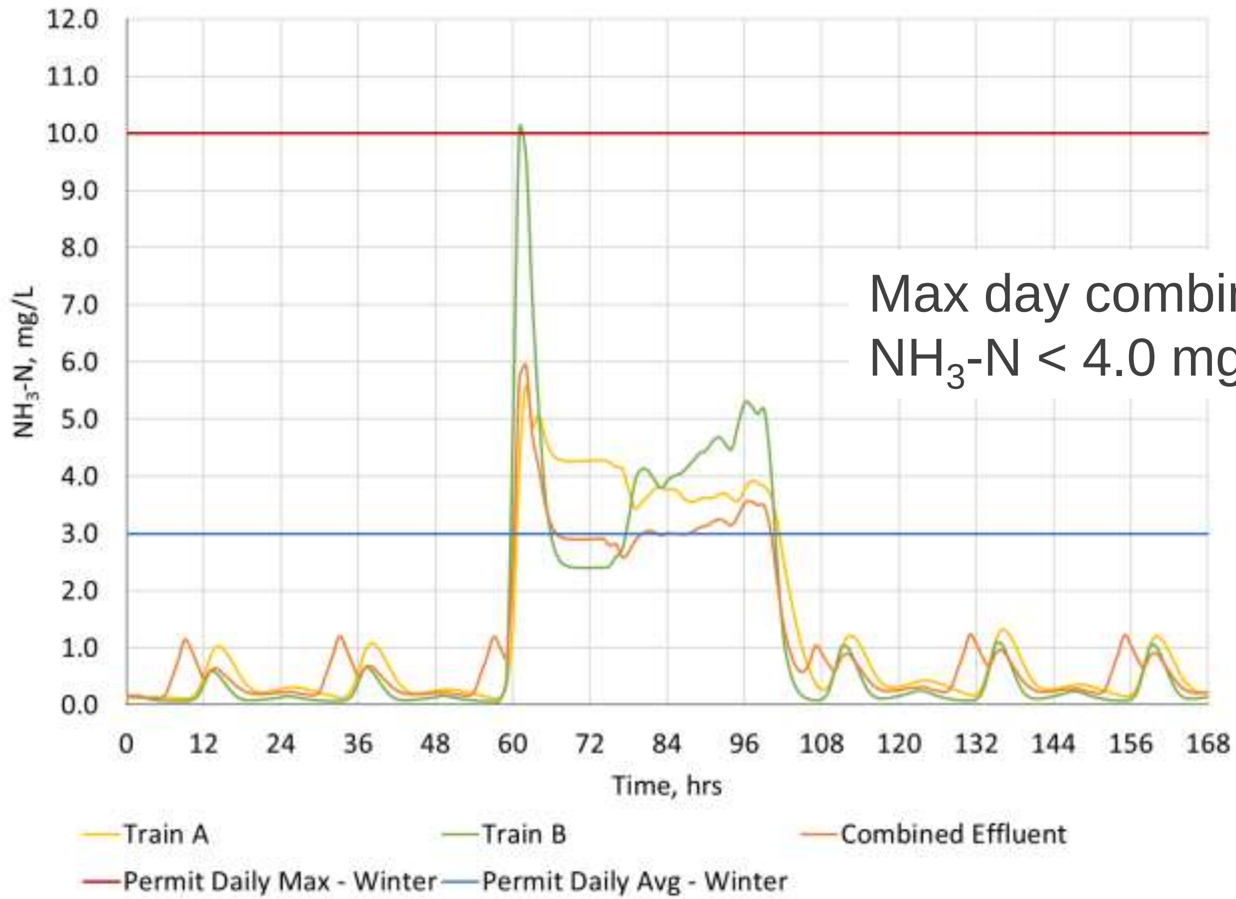
Phase II Storm (95 MGD) – MLSS with Contact Stabilization



△ MLSS = 1,400 mg/L

△ MLSS = 1,000 mg/L

Phase II Storm (95 MGD) – Effluent NH_3-N



Max day combined effluent NH_3-N < 4.0 mg/L

Clarifier Capacity Analysis Results – Contact Stabilization