Increasing Removal Efficiency of Primary Settling through Influent Solids Characterization and CFD Modeling

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Project Team

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01 Background

Philadelphia Water Department (PWD)

- Municipal government-owned utility
- ~2000 full-time employees
- "One Water" services:
  - Water treatment
  - Wastewater treatment
  - Stormwater management
  - Watershed protection
  - Distribution
  - Conveyance

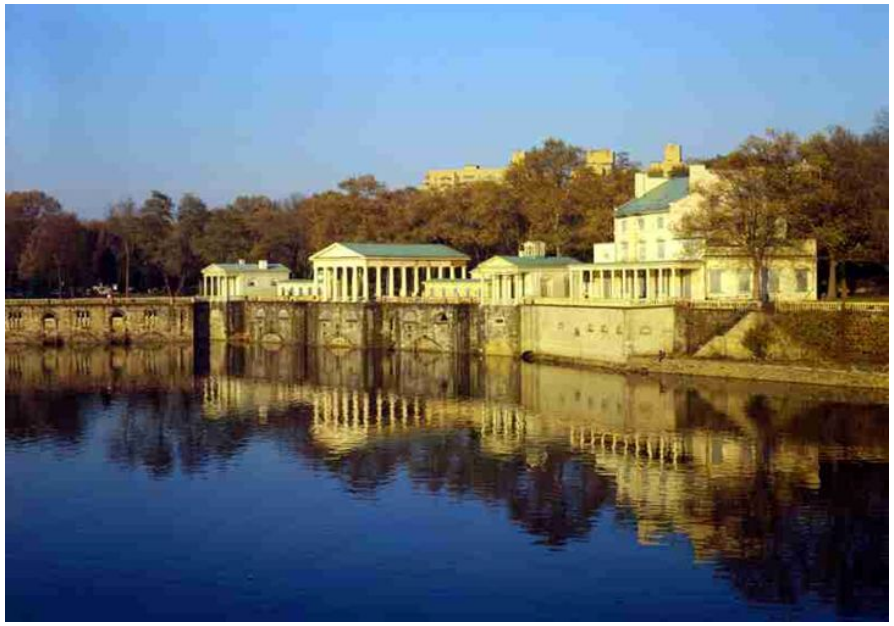
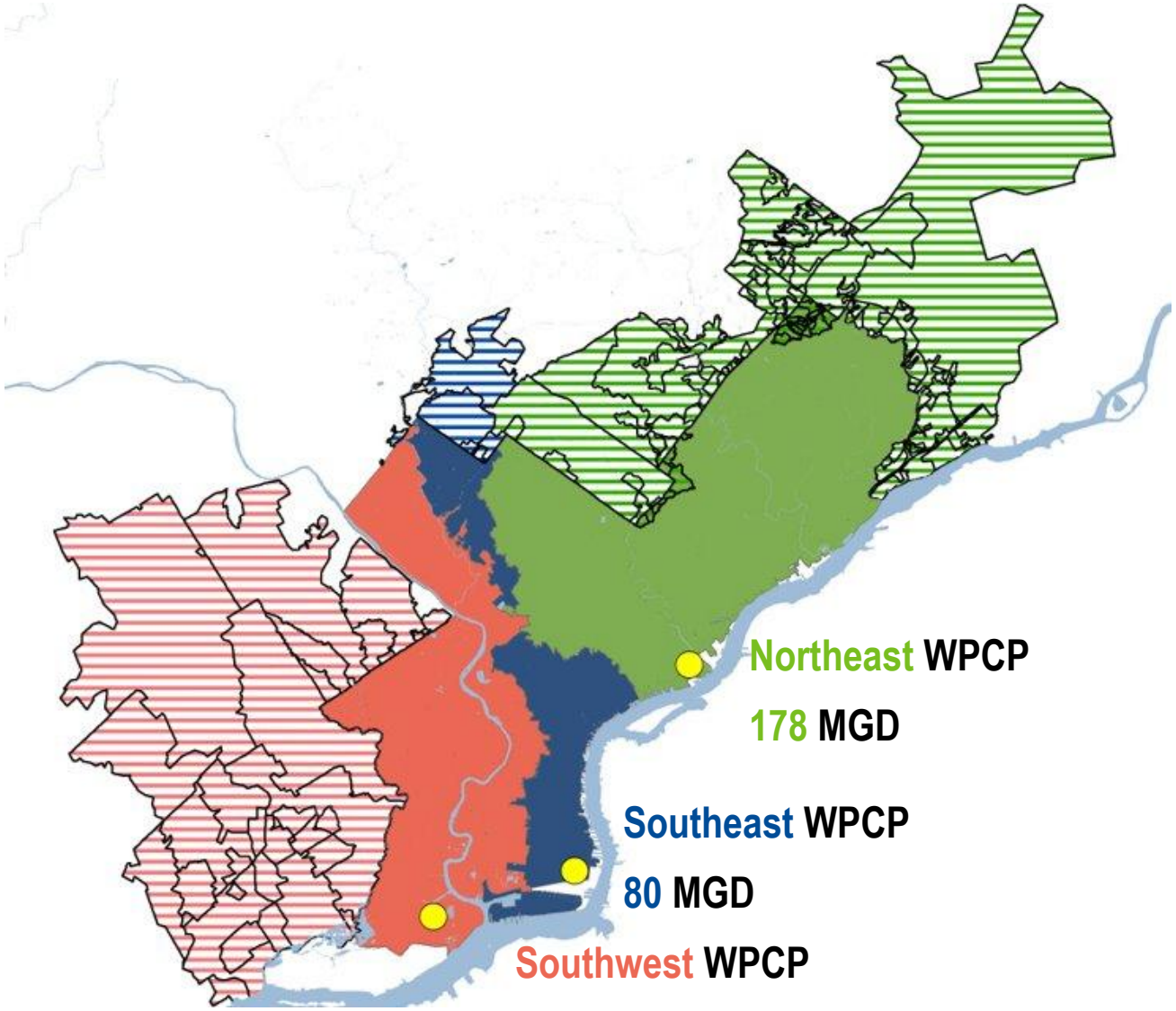


Image from goodfreephotos.com (2018)

PWD Treatment Facilities

- Drinking Water Treatment
  - Baxter WTP
  - Belmont WTP
  - Queen Lane WTP
- Wastewater Treatment
  - Northeast WPCP
  - Southeast WPCP
  - Southwest WPCP
- Pump Stations
  - 12 drinking water
  - 16 wastewater
  - 3 stormwater

PWD Drainage Districts



Legend:

- NEDD (City)
- NEDD (Suburbs)
- SEDD (City)
- SEDD (Suburbs)
- SWDD (City)
- SWDD (Suburbs)

PWD Wastewater Master Plan

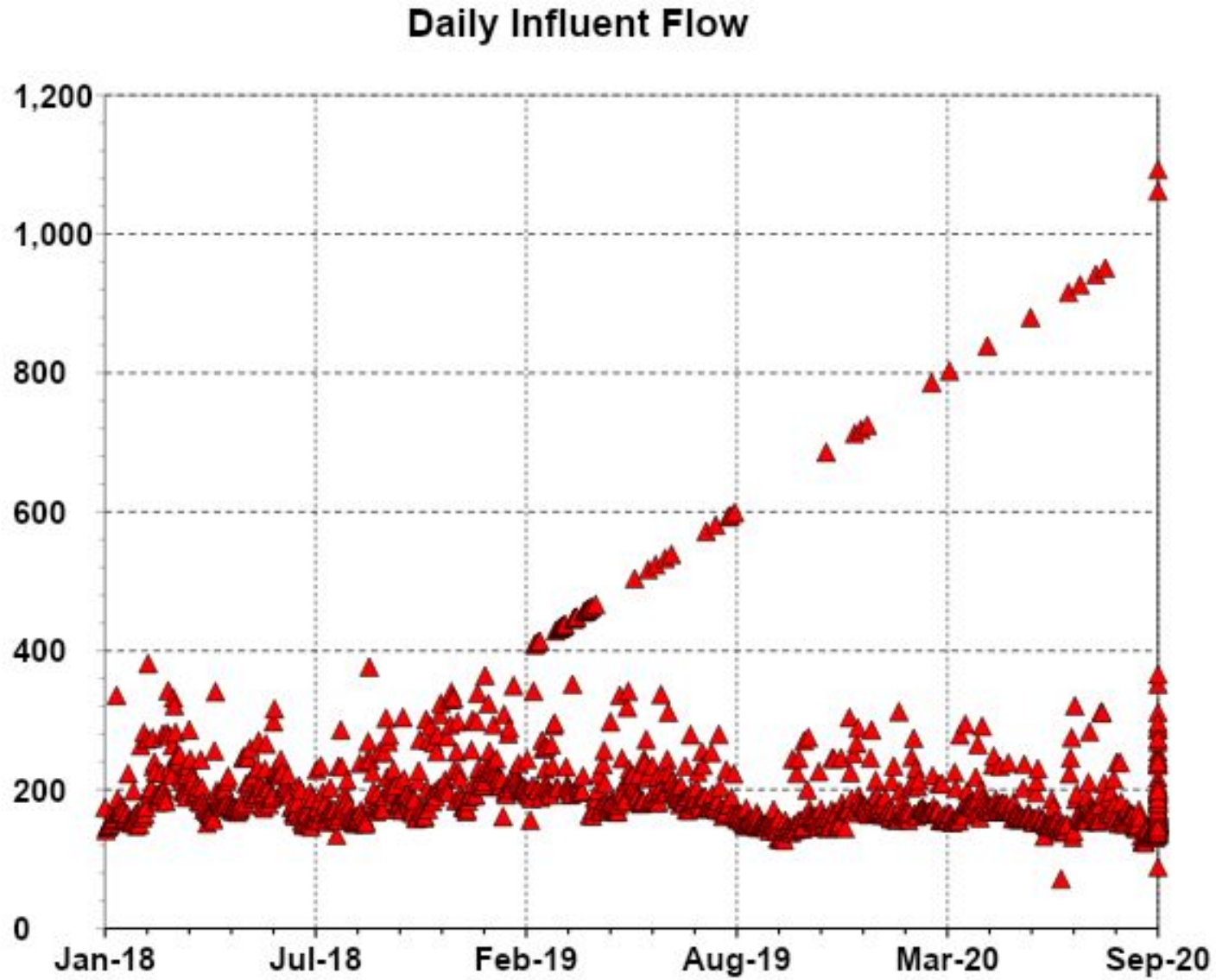
- 25-year Master Plan
- 5-year Updates
- Major Activities
  - Data monitoring and analysis
  - Plan for future regulations
  - Integrated asset management
  - Plan for future conditions (e.g., climate change)

02

Northeast WPCP

PWD Northeast WPCP

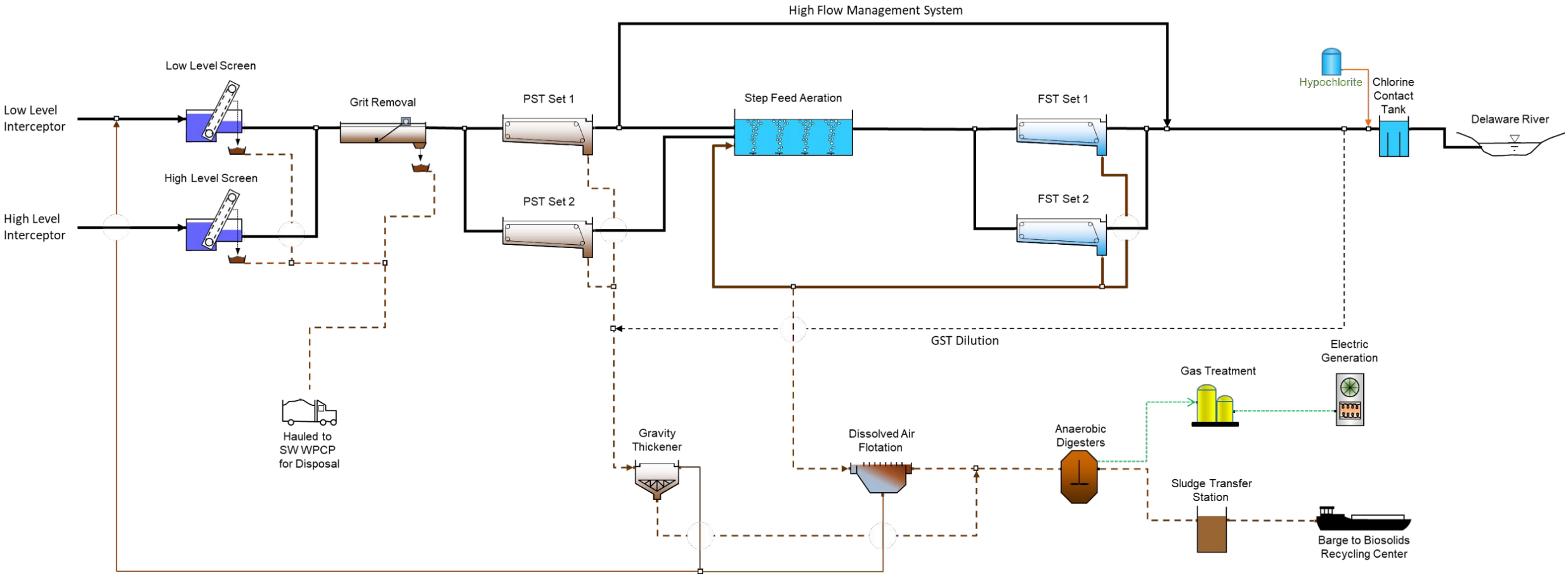
- Combined sewer system (dilute plant influent and high peaking factor)
- Annual average flow of ~160 mgd, Design flow of 210 mgd
- Discharges to Delaware Estuary (i.e., tidal portion)
- Combined heat and power (CHP) facility



PWD Northeast WPCP Major Needs/Ongoing Projects

- CHP system engine replacement
- Improved nutrient removal
  - Currently nitrifying; potential future low NH_3 or TN limits
- Peak flow management
  - Backup and flooding of PSTs during high-flow/high-high-tide events
  - Use of high-flow management system

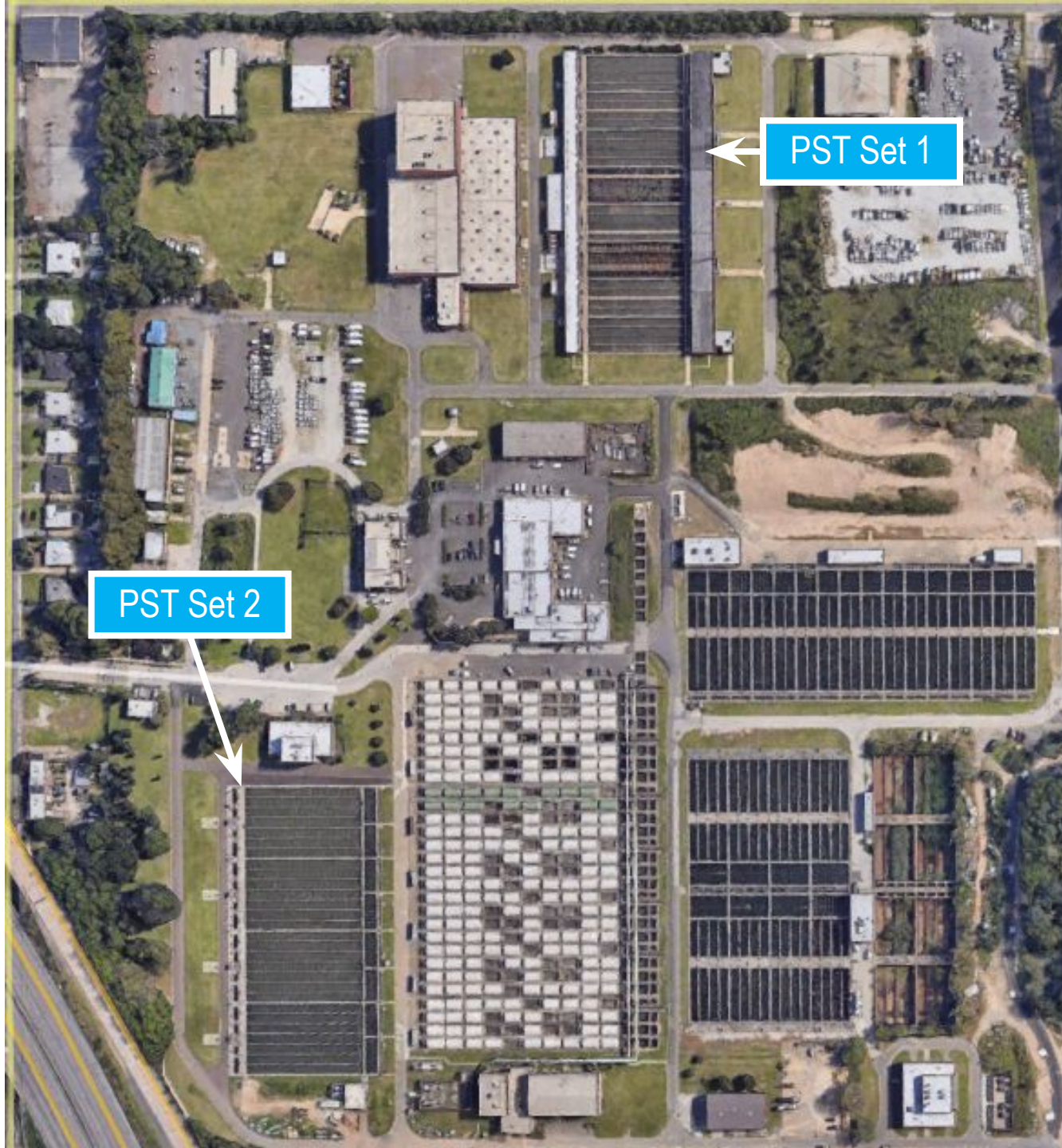
PWD Northeast WPCP Process Diagram



PWD Northeast WPCP

- Two sets of primary settling tanks (PSTs)
- Rectangular, chain and flight tanks
- Approximately 50-50 flow split during normal flow
- Flow hydraulically favors PST Set 1 during high flow

	PST Set 1	PST Set 2
Number of Tanks	8	4
Tank Dimensions	247 ft by 65 ft	250 ft by 125 ft
Inlets	Submerged	Submerged and non-submerged



03

Primary Optimization Strategies

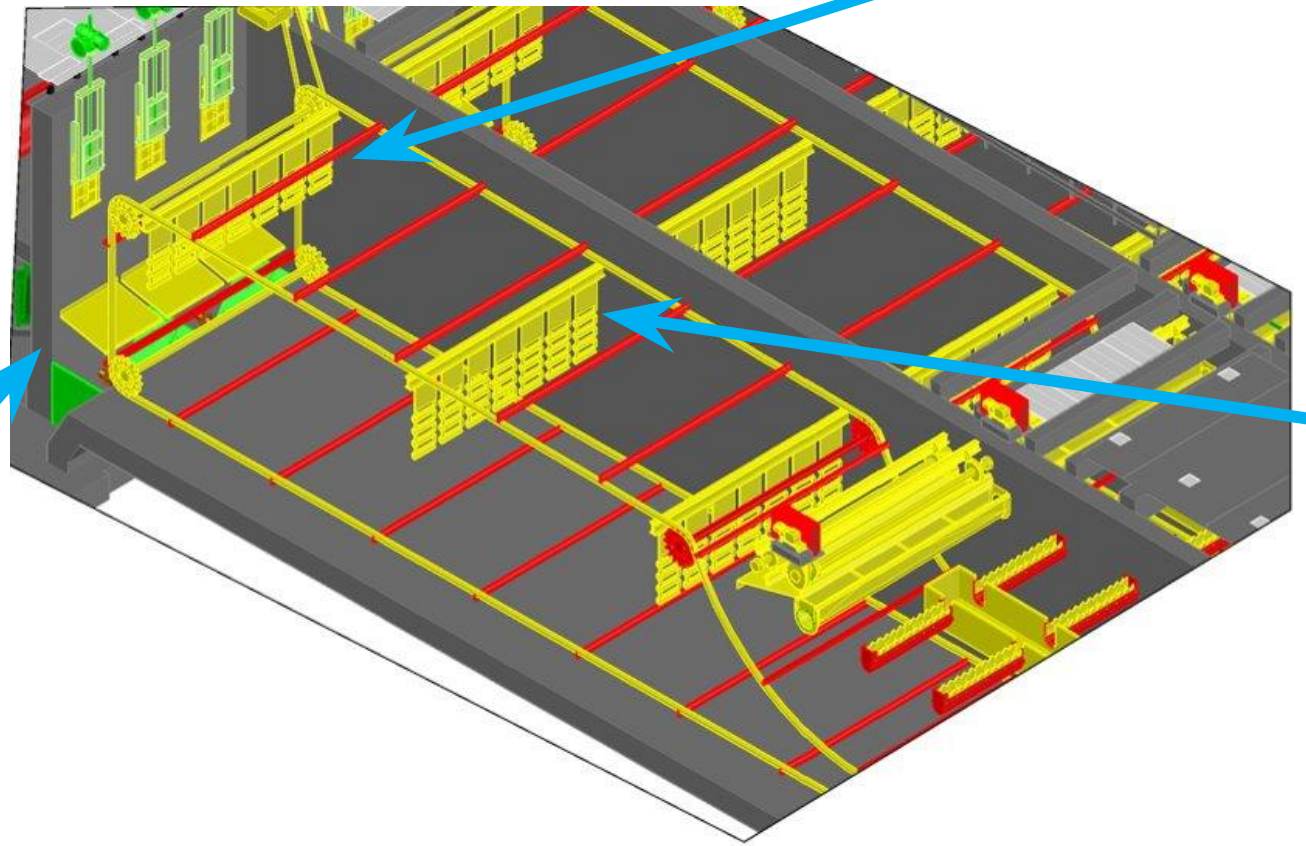
Drivers for Primary Optimization

- Increase solids/organics capture
  - Increase primary treatment capacity
  - Improve wet weather performance
- Increase biogas production (with anaerobic digesters)
- Increase downstream biological process capacity
- Decrease downstream oxygen demand

Structural Modifications to Improve Performance

- Influent distribution improvements
- Improve solids capture

Sludge Protector Baffles

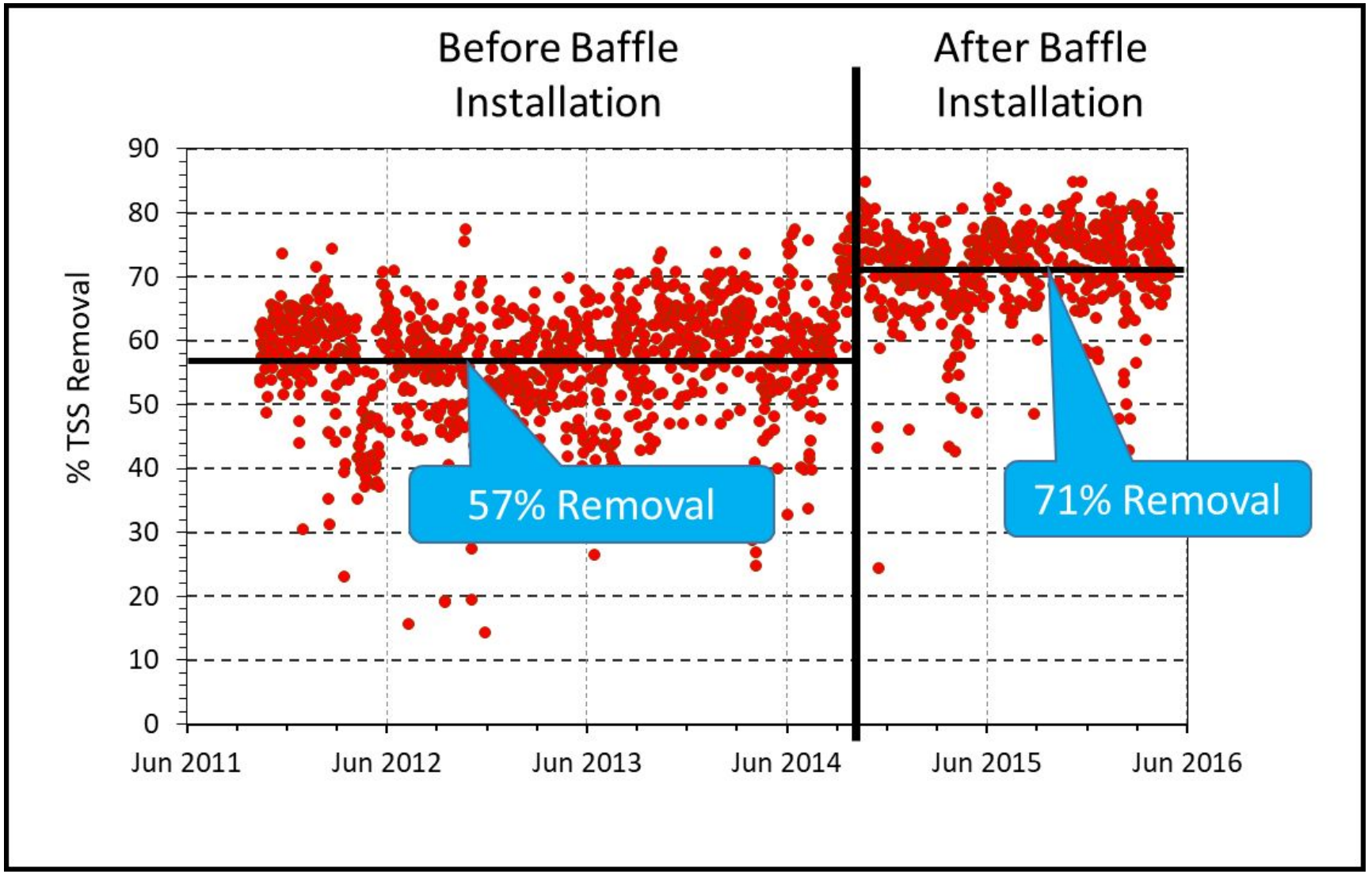


Flocculation Baffles

Mid-tank Baffles

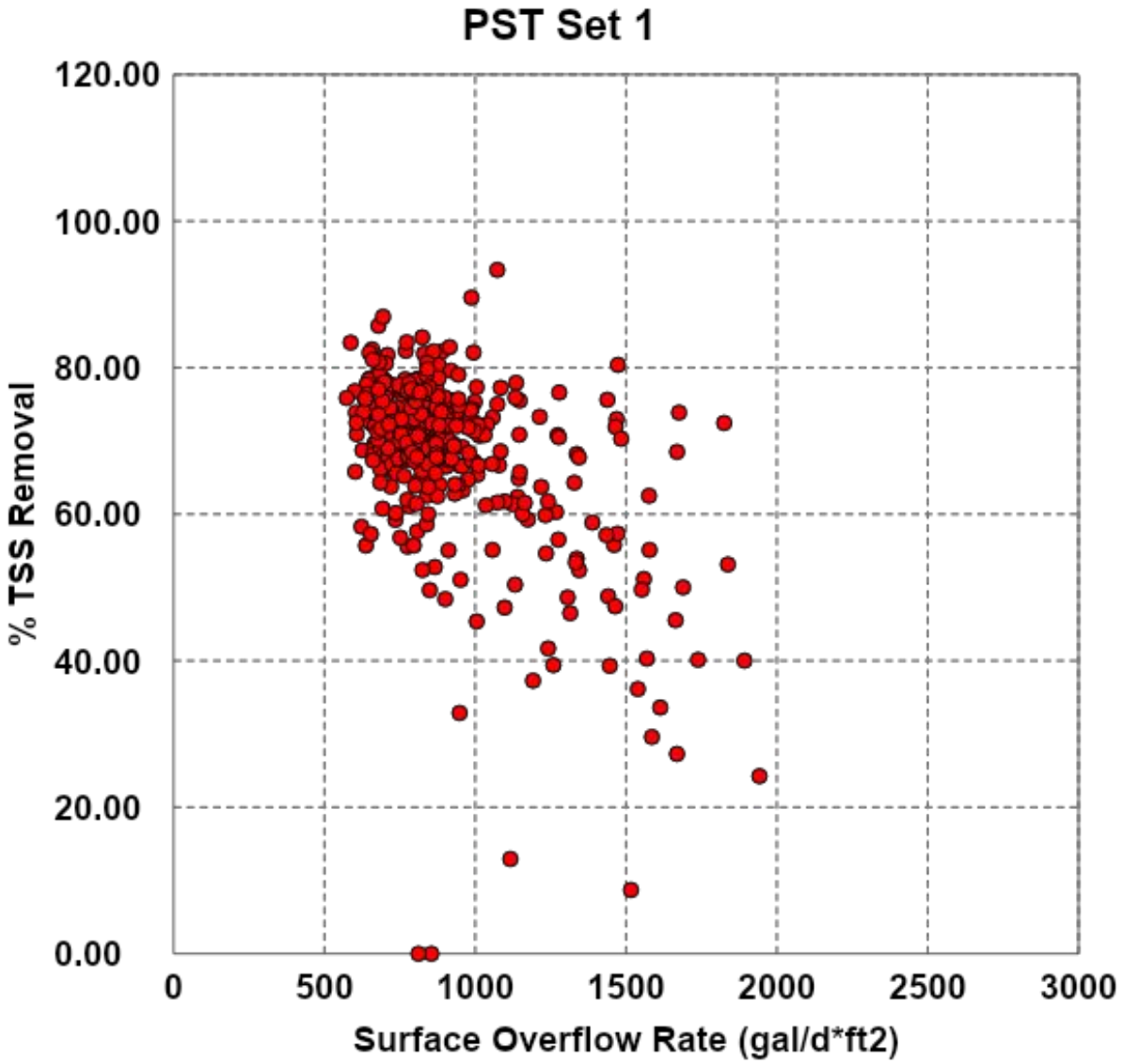
Structural Modifications Case Study

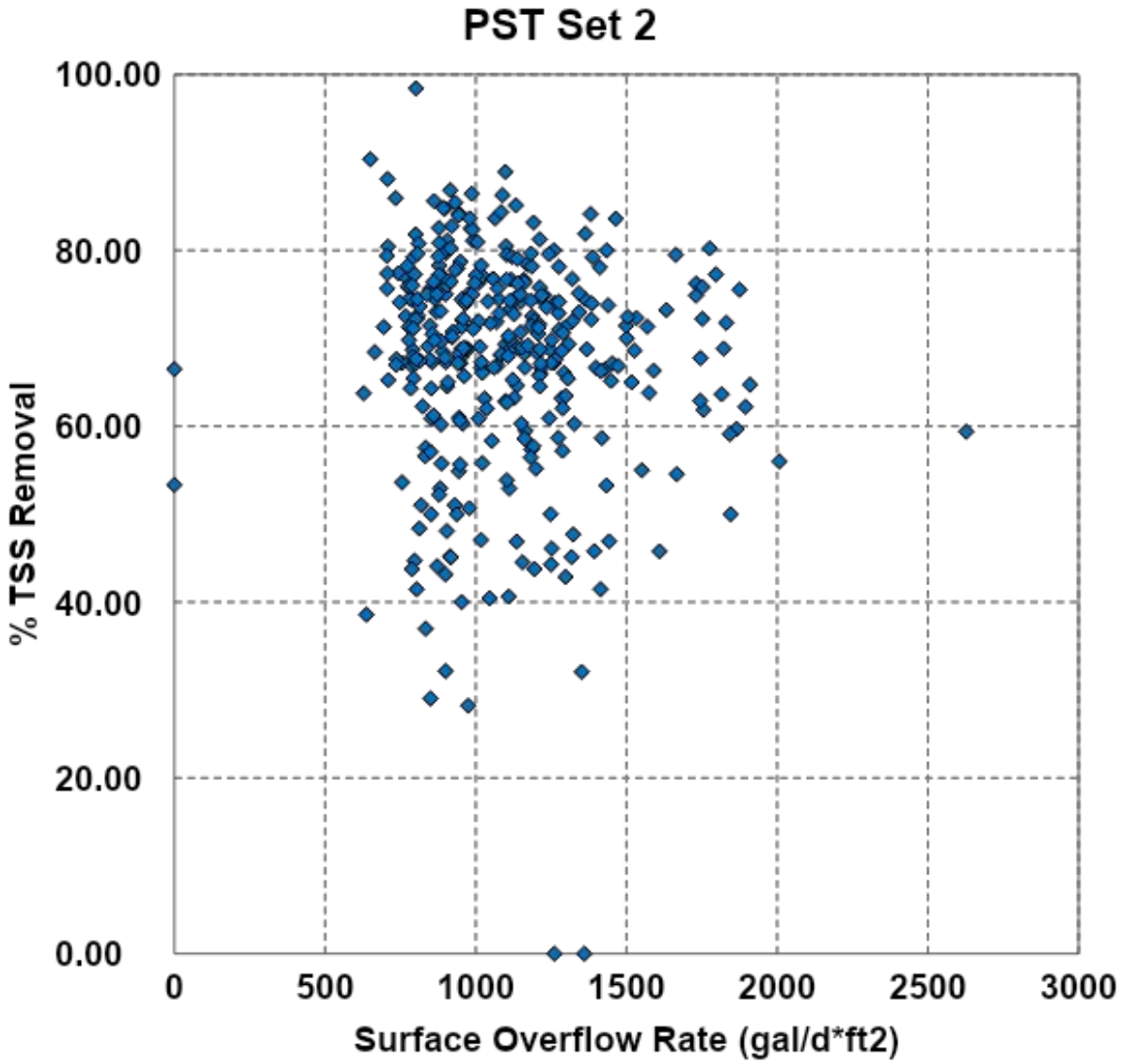
- Central Contra Costa Sanitary District, Martinez, CA
- 53.8 MGD Permitted Capacity



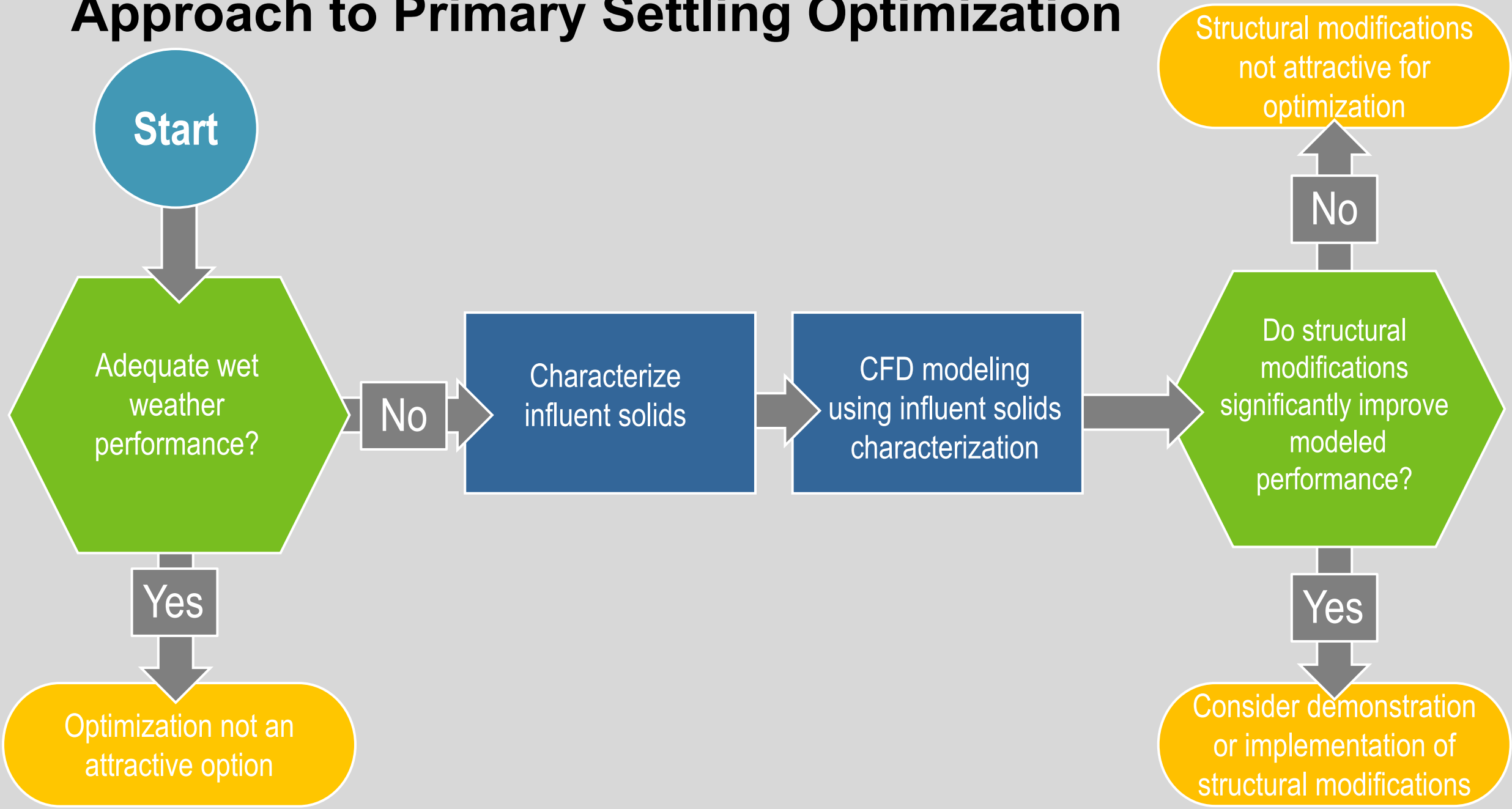
04 Treatment Performance

Treatment Performance





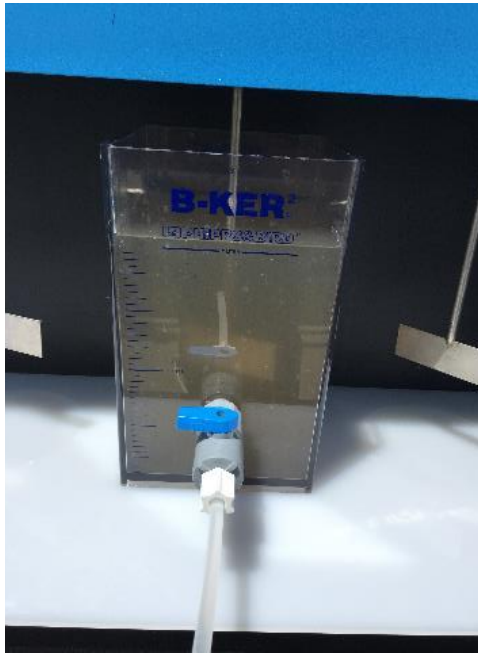
Approach to Primary Settling Optimization

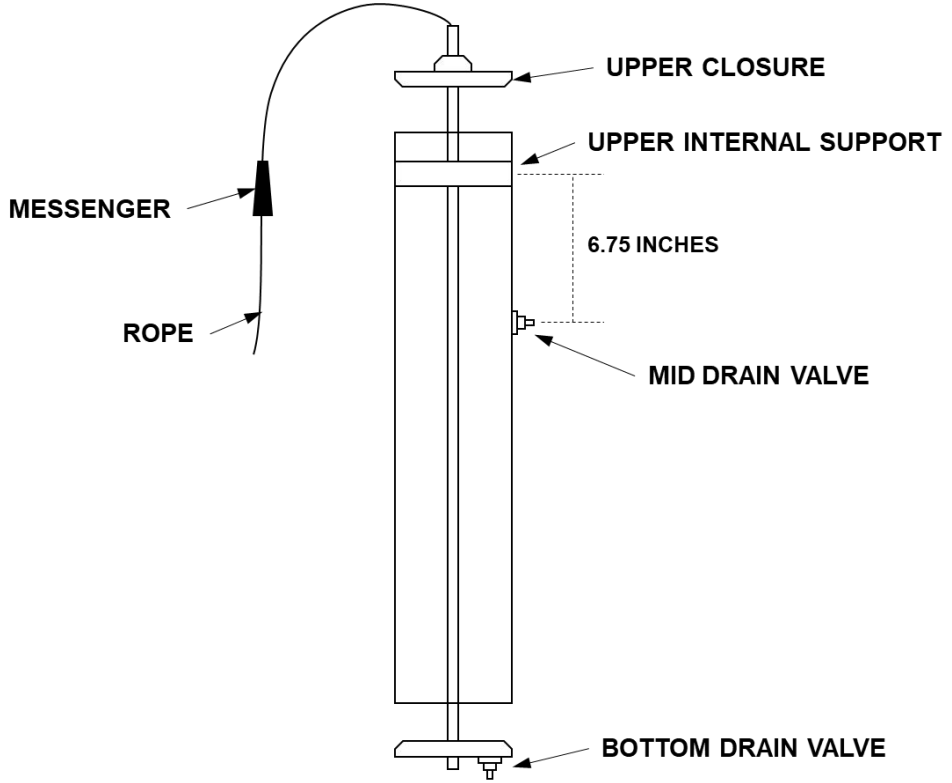


05 Field Sampling

Field Sampling

- Determine settling characteristics of influent solids
  - Settling velocity distribution
  - Influent TSS
  - Non-settleable solids (NSS)
  - Flocculated non-settleable solids (FNSS)
- Used to build CFD model to examine limitations and optimization options





Kemmerer Sampler

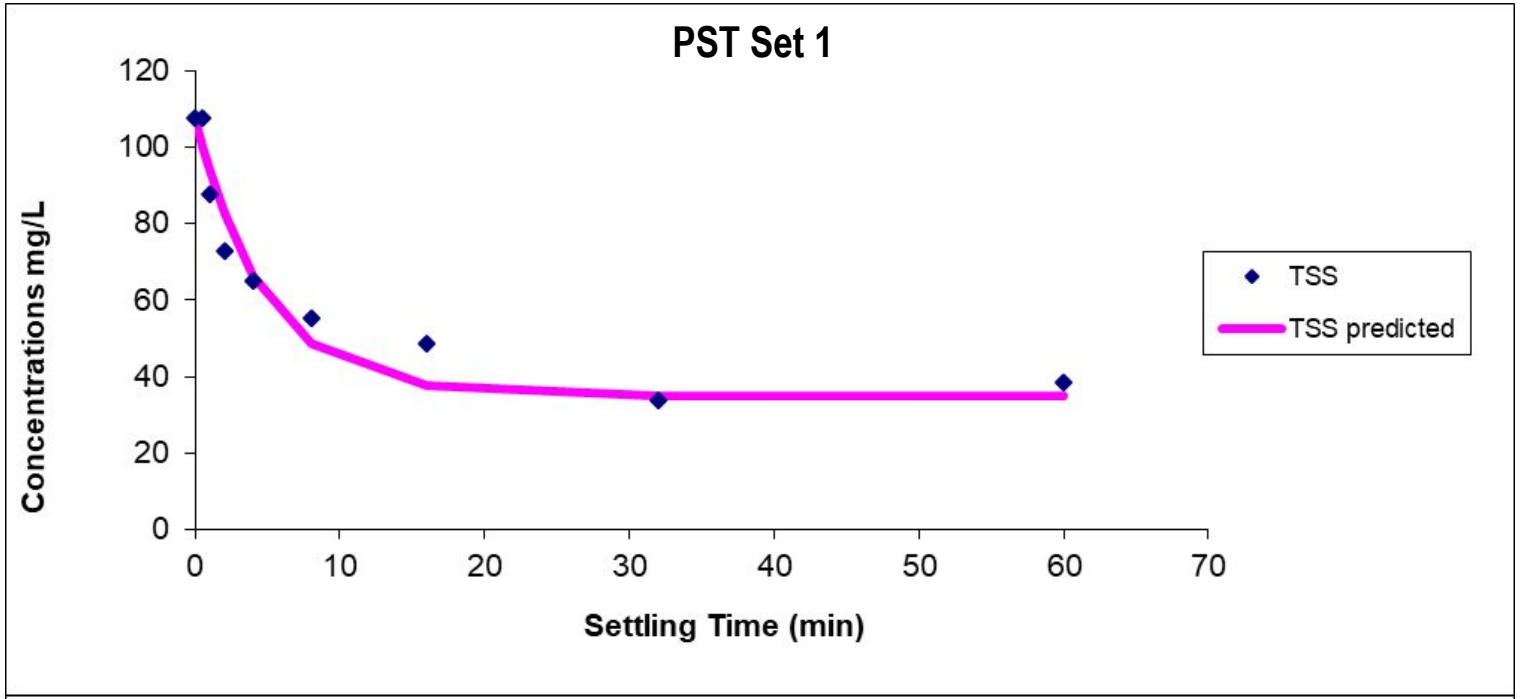
Field Sampling Results

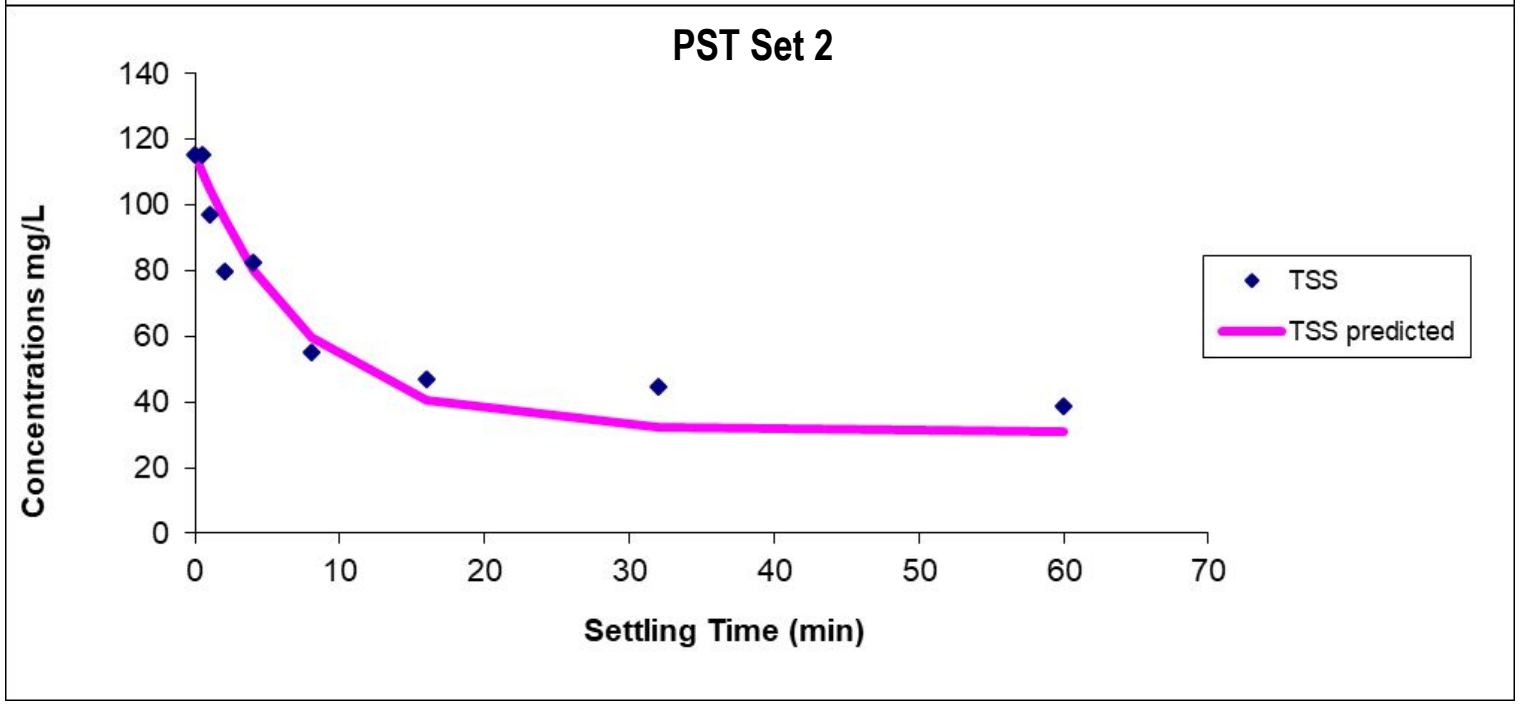
- Storm event occurred the first day of sampling
- Influent TSS lower than historic annual average (~200 mg/L)
- Influent TSS to particulate BOD ratio was approximately 2.0
- Percent NSS of TSS also higher than may be expected
- NSS concentration lower than industry standards (about 40-80 mg/L)
- FNSS lower than NSS indicating potential for improved removal in PSTs

Analysis	PST Set 1	PST Set 2
Influent TSS (mg/L)	110	115
Non-settleable solids (mg/L)	35	30
Flocculated non-settleable solids (mg/L)	26	18

Field Sampling Results

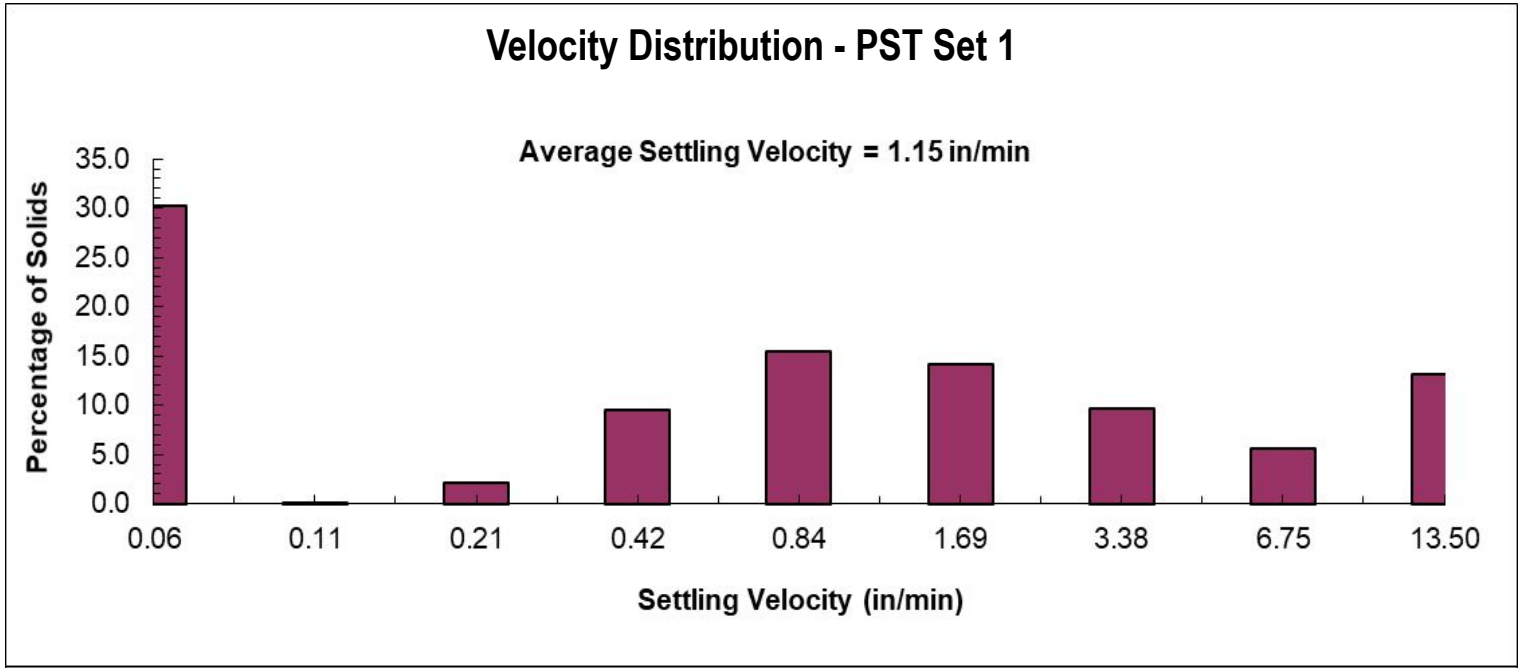
- Supernatant TSS plotted vs time allowed to settle
- Used to create settling velocity distribution

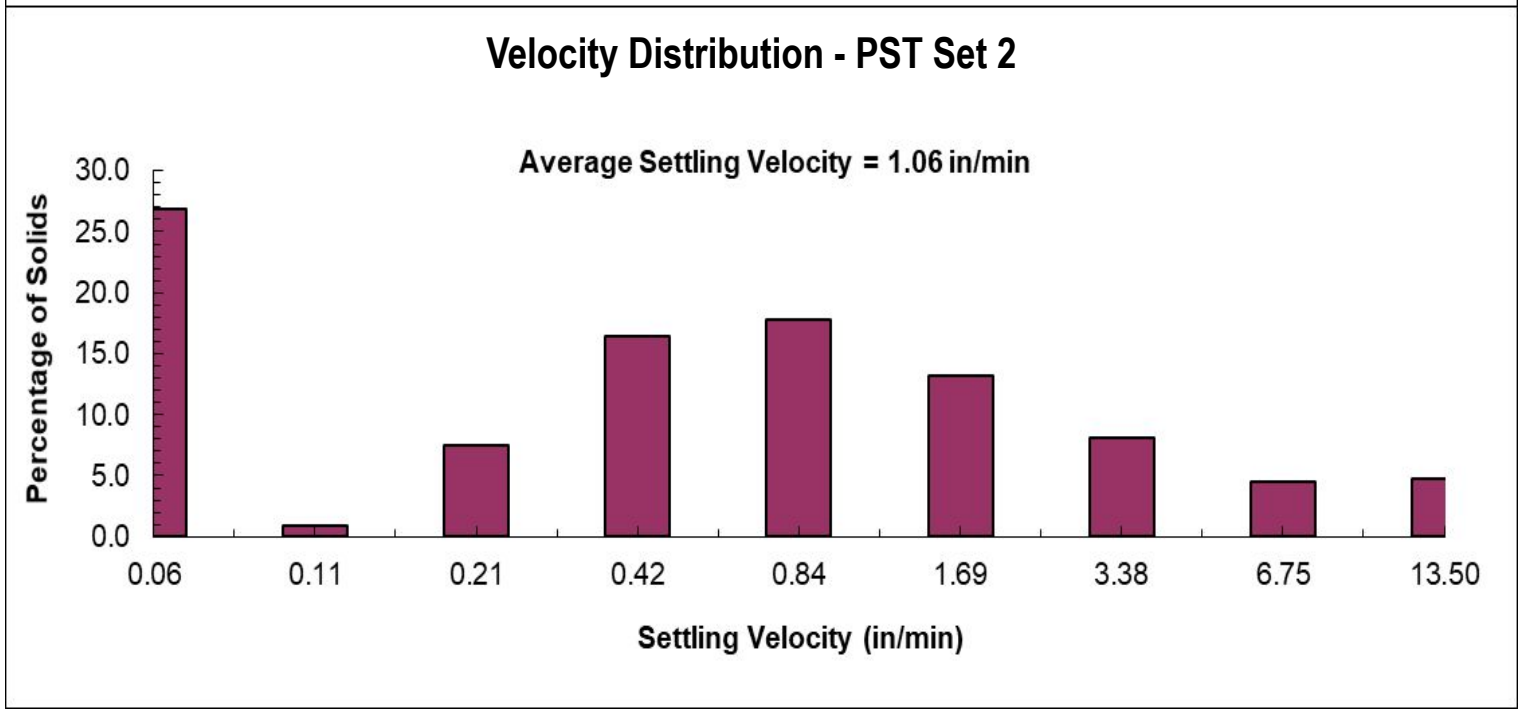




Field Sampling Results

- High percentage of non-settleable solids (0.06 in/min)
- Settling Velocity Distribution used to develop CFD model





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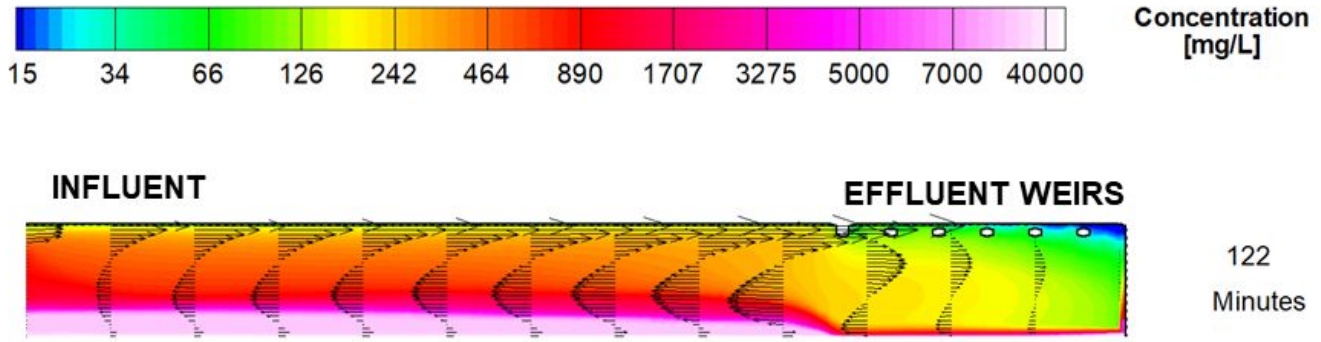
CFD Modeling

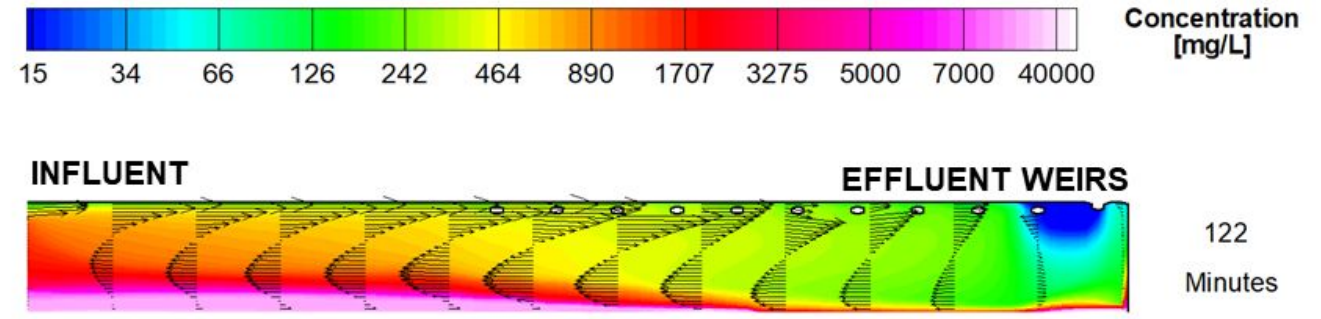
CFD Modeling: Existing Conditions

- HACM Model and 2DR used
- Assumptions:
  - 280 mgd influent flow
  - Equal split between PST Sets



PST Set 1 Existing Conditions

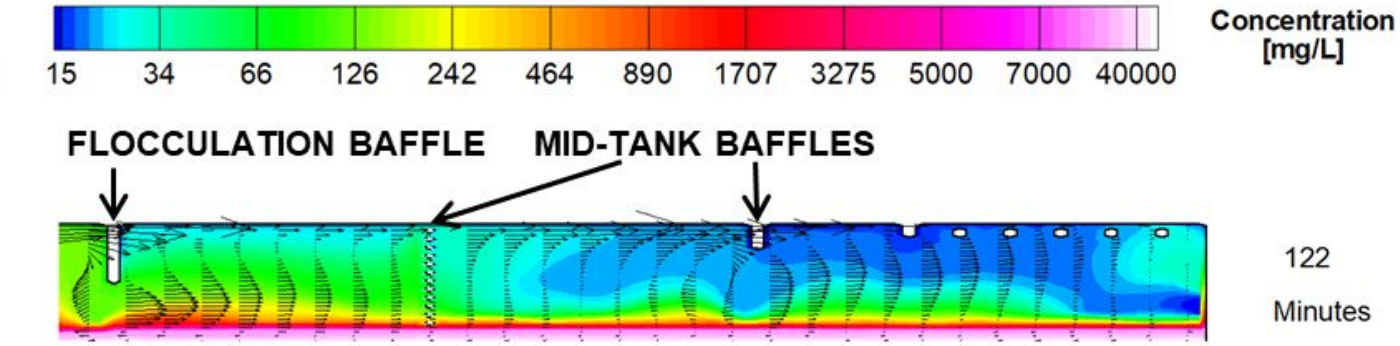
	PST Set 1	PST Set 2
Flow per Bay (mgd)	4.0	5.5
Effluent Suspended Solids (mg/L)	45	80



PST Set 2 Existing Conditions

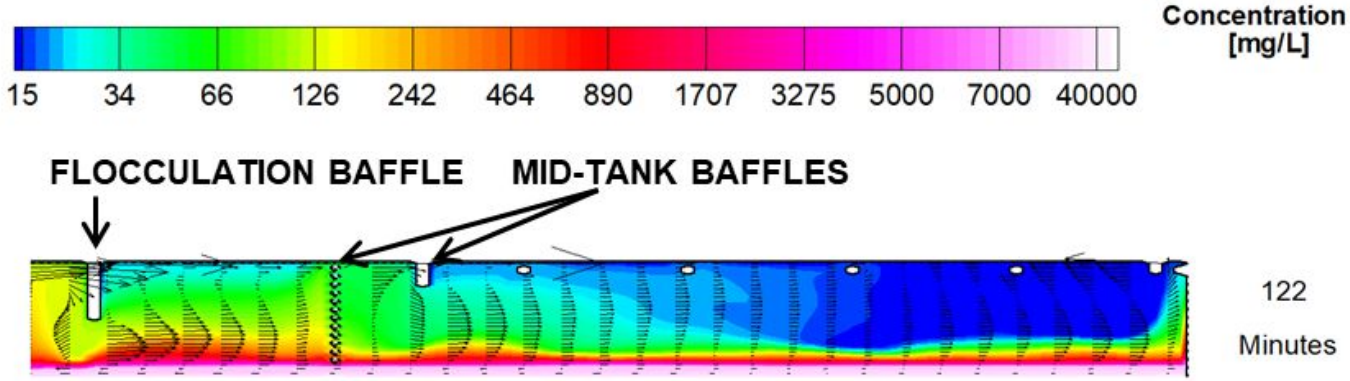
CFD Modeling: with Structural Modifications

- Model with similar conditions adding baffles
- Increase in solids capture at increased flow



PST Set 1 Proposed Modifications

	PST Set 1	PST Set 2
Flow per Bay (mgd)	4.0	5.5
Effluent Suspended Solids (mg/L)	25	25
Improved Removal	40%	65%



PST Set 2 Proposed Modifications

Conclusions & Optimization Recommendations

- Average NSS concentration low compared to a typical PST effluent presenting potential for improving performance.
- Average FNSS lower than NSS indicating that improving flocculation in the PST would yield higher TSS removal efficiencies.
- CFD modeling indicated addition of flocculation, mid-tank and sludge protector baffles has potential to improve performance.
- **It was recommended that PWD considers the addition of these baffles to both sets of PSTs. Planning for demonstration testing is ongoing.**

07

Next Steps

Next Steps

- Due to budgetary and contractual constraints, PWD delayed further implementation of baffling at NE WPCP

- Currently planning for a demonstration test (single PST from each set) of baffles in the coming years

Questions?

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