BUILDING A WORLD OF DIFFERENCE

7 May 2014

# PRETREATMENT PROCESSES FOR POTABLE WATER TREATMENT PLANTS


## JEFF LINDGREN

ENGINEERING MANAGER
B&V - WATER


BLACK & VEATCH
Building a world of difference.

# AGENDA

- Conventional Pretreatment
  - Focus on Clarification (including Sedimentation)
- Theory/Goals of Clarification
- Review of High-Rate Clarification Technologies
- Comparison of Technologies
- Project Examples

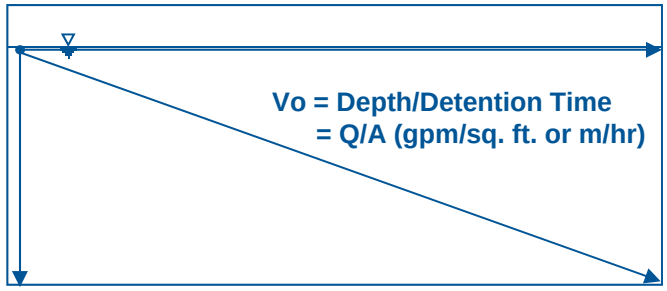
# CONVENTIONAL PRETREATMENT

- **Typically…….**
  - ***Rapid Mix*** → ***Flocculation*** → ***Sedimentation*** → Filtration
- **Advantages**
  - Simplicity
  - Widely used
  - Handle varying water quality
  - Familiarity (Regulatory, Operations)
- **Disadvantages**
  - Large Footprint
  - Higher cost, particularly with limited site
  - Wind/algae growth/solids removal

# THEORY/GOALS OF CLARIFICATION

# THEORY/GOALS OF CLARIFICATION

- **Clarification**
  - Part of pretreatment process
    - Multiple goals - turbidity/particles, Total Organic Carbon (TOC), etc.
  - Remove solids prior to filtration – maximize filtration processes
  - Sizing often defined in hydraulic loading rate (gpm/sf or m/hr) – translates to settling velocity
    - 0.5 gpm/sf = 1.2 m/h = 0.066 ft/min



# THEORY/GOALS OF CLARIFICATION

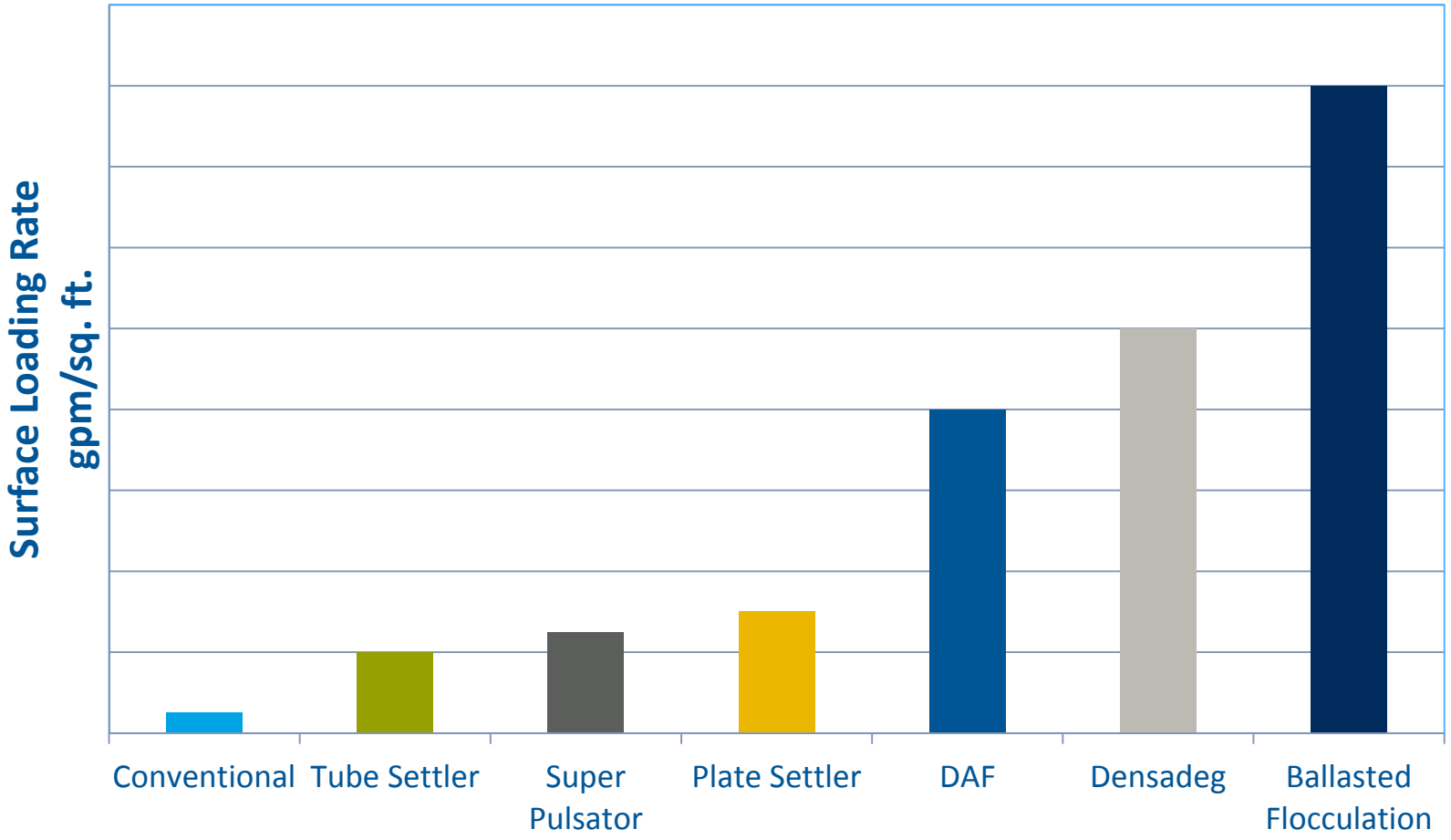
- **Why consider something besides conventional clarification?**
  - Limited real estate available
  - Cost advantages – often site specific
  - Raw water quality
    - Algae
    - Light floc
  - Regardless of clarification process chosen:
    - Coagulation/flocculation - conditioning of floc - is critical
    - Settled turbidity is not end goal

# REVIEW OF HIGH-RATE CLARIFICATION TECHNOLOGIES

# HIGH RATE CLARIFICATION OPTIONS

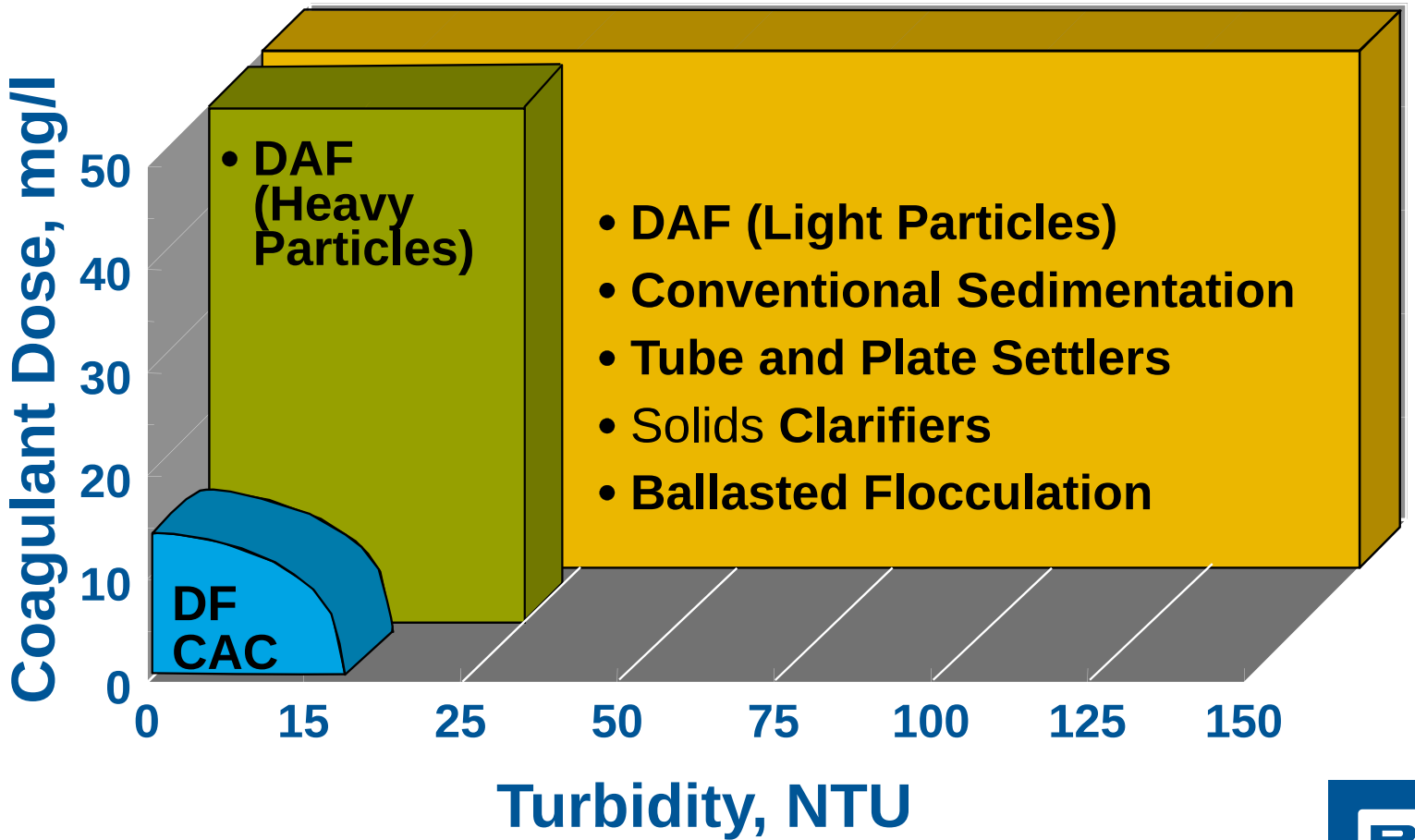
- **Plate and Tube Settlers**
- **Upflow Solids Clarifiers (Pulsator)**
- **Solids Contact Clarifiers (Densadeg)**
- **Ballasted Flocculation**
- **Dissolved Air Flotation (DAF)**
- **Others:**
  - Contact Adsorption Clarifiers
  - Direct Filtration

# RELATIVE LOADING RATES

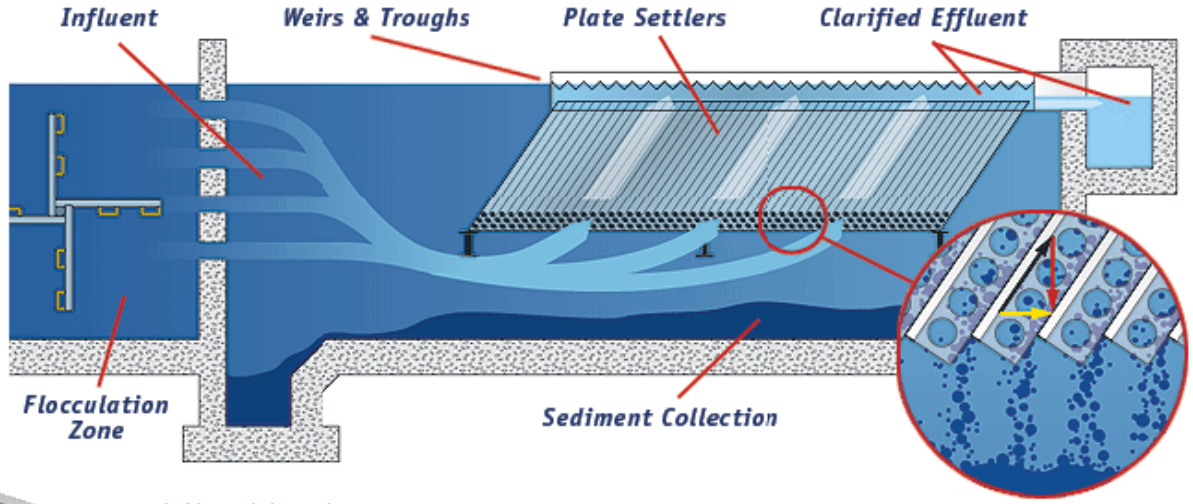


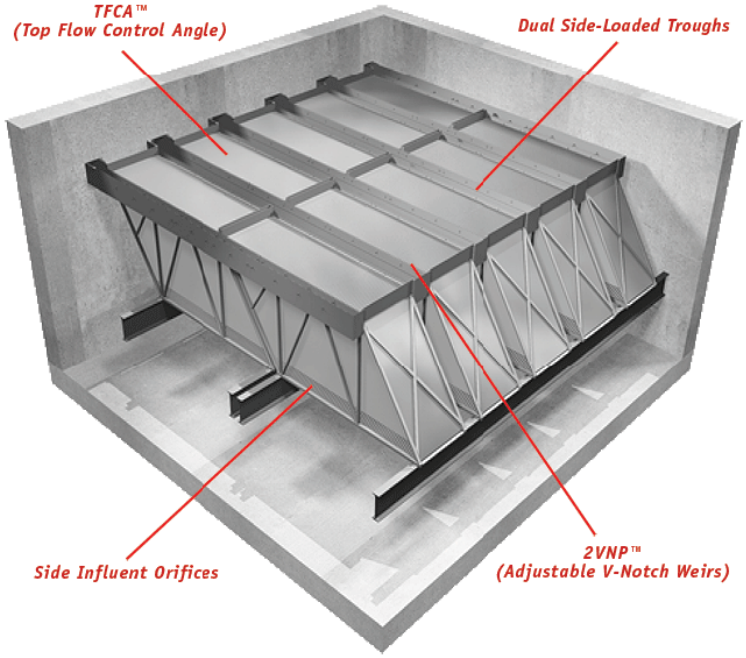

**Higher Loading Rate = More Capacity**

# CLARIFICATION TECHNOLOGIES CONDITIONS OF APPLICABILITY



# INCLINED PLATE SEDIMENTATION



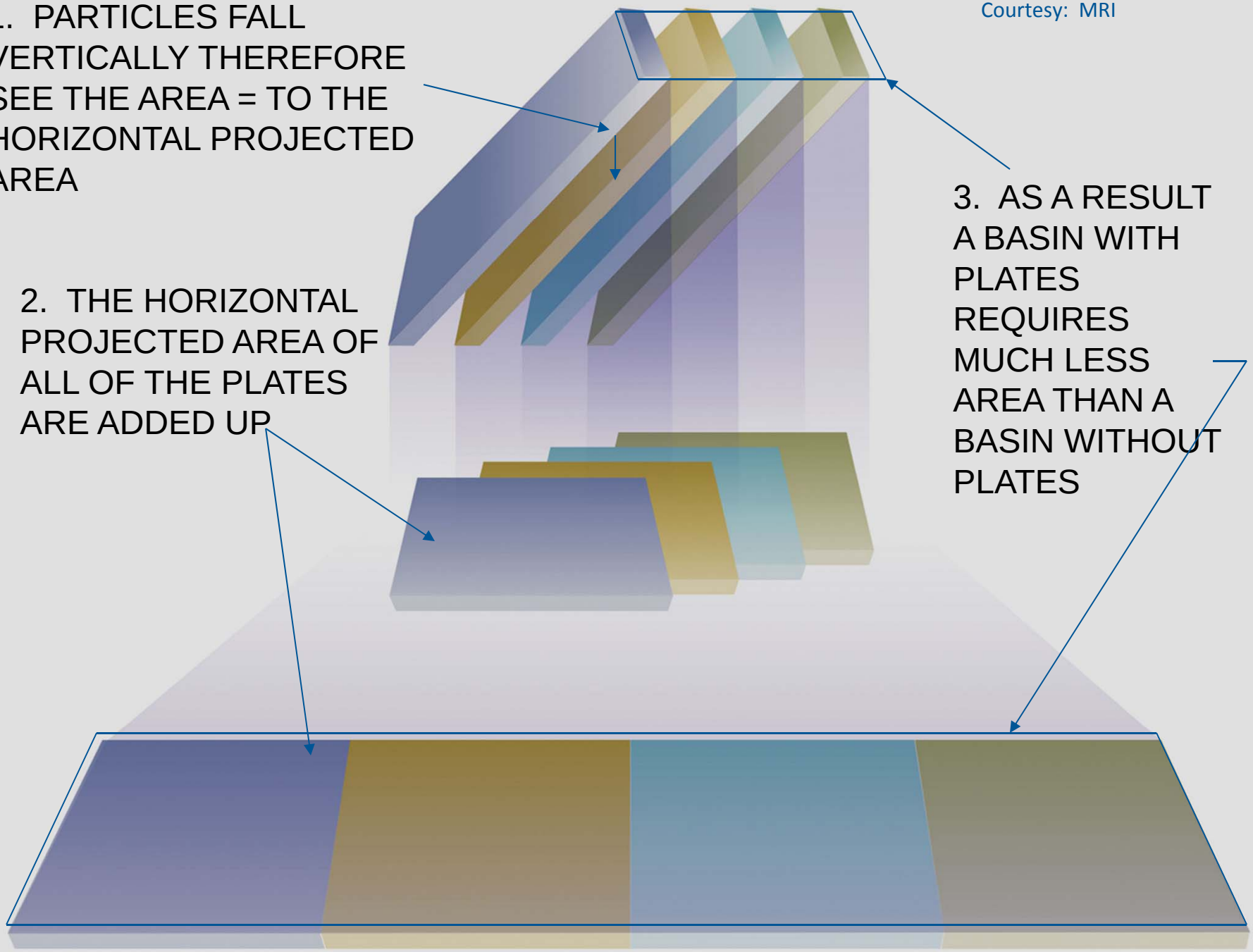




Courtesy: JMS

1. PARTICLES FALL VERTICALLY THEREFORE SEE THE AREA = TO THE HORIZONTAL PROJECTED AREA

2. THE HORIZONTAL PROJECTED AREA OF ALL OF THE PLATES ARE ADDED UP

3. AS A RESULT A BASIN WITH PLATES REQUIRES MUCH LESS AREA THAN A BASIN WITHOUT PLATES

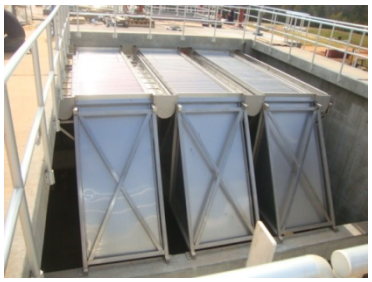


Courtesy: MRI

# INCLINED PLATE SEDIMENTATION

# INCLINED PLATE SEDIMENTATION

- **"Effective" surface loading rates - without plates**
  - Surface water with Alum or Ferric
    - 0.25-0.50 gpm/ft$^2$
  - Presedimentation
    - 0.75-1.50 gpm/ft$^2$



- **Equivalent surface loading rates - with plates:**

| TYPICAL APPLICATION RATES AND EFFICIENCIES | | |
|---|---|---|
| **Application Rate*** | **Efficiency**** | **Equiv. Surface Loading Rate***** |
| 0.25 | 90% | 6.35 |
| 0.30 | 80% | 6.75 |
| 0.30 | 90% | 7.59 |
| 0.35 | 80% | 7.82 |
| 0.35 | 90% | 8.88 |
| 0.40 | 80% | 8.98 |

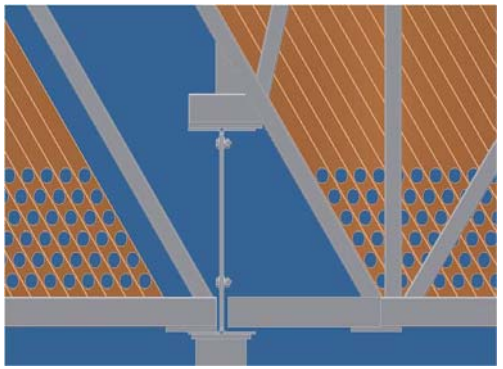
* gpm/sf of effective projected horizontal surface area

** % of total projected horizontal surface area used in the design

*** gpm/sf within the actual plate settler "plan view" surface area

Courtesy: JMS

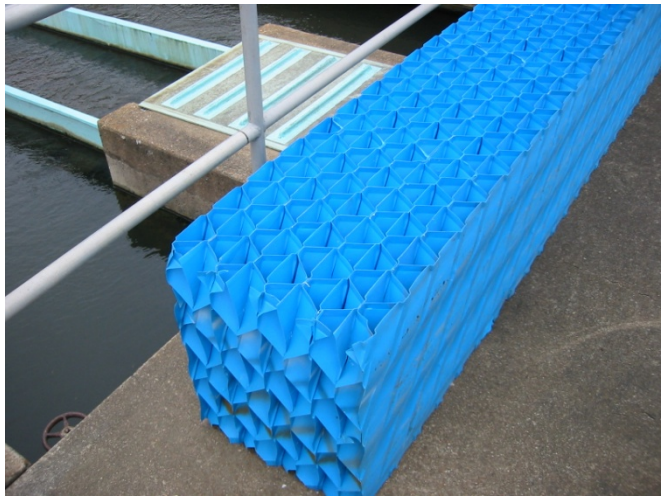
# INCLINED PLATE SEDIMENTATION

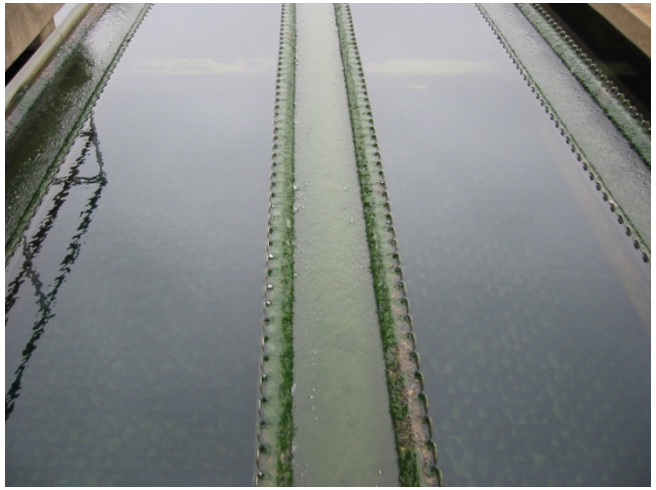


- **Advantages**
  - Small footprint area / easily covered
  - Widely used
  - Potential $ savings vs. conventional
- **Disadvantages**
  - Deeper basin required
  - Not always amenable to retrofits in existing basins
  - Obstruct access and view of sludge collection equipment
- **Considerations**
  - Consistency of floc size
  - Sludge withdrawal
  - Retrofits – space beneath plates

# TUBE SETTLERS

- Similar concept to plate settlers
- Shorter length can often more easily fit in existing basins
- Less $ than plates
- Less control of flow as compared to plates
- Where large solids volume, can be susceptible to re-entrainment of solids
- Longevity

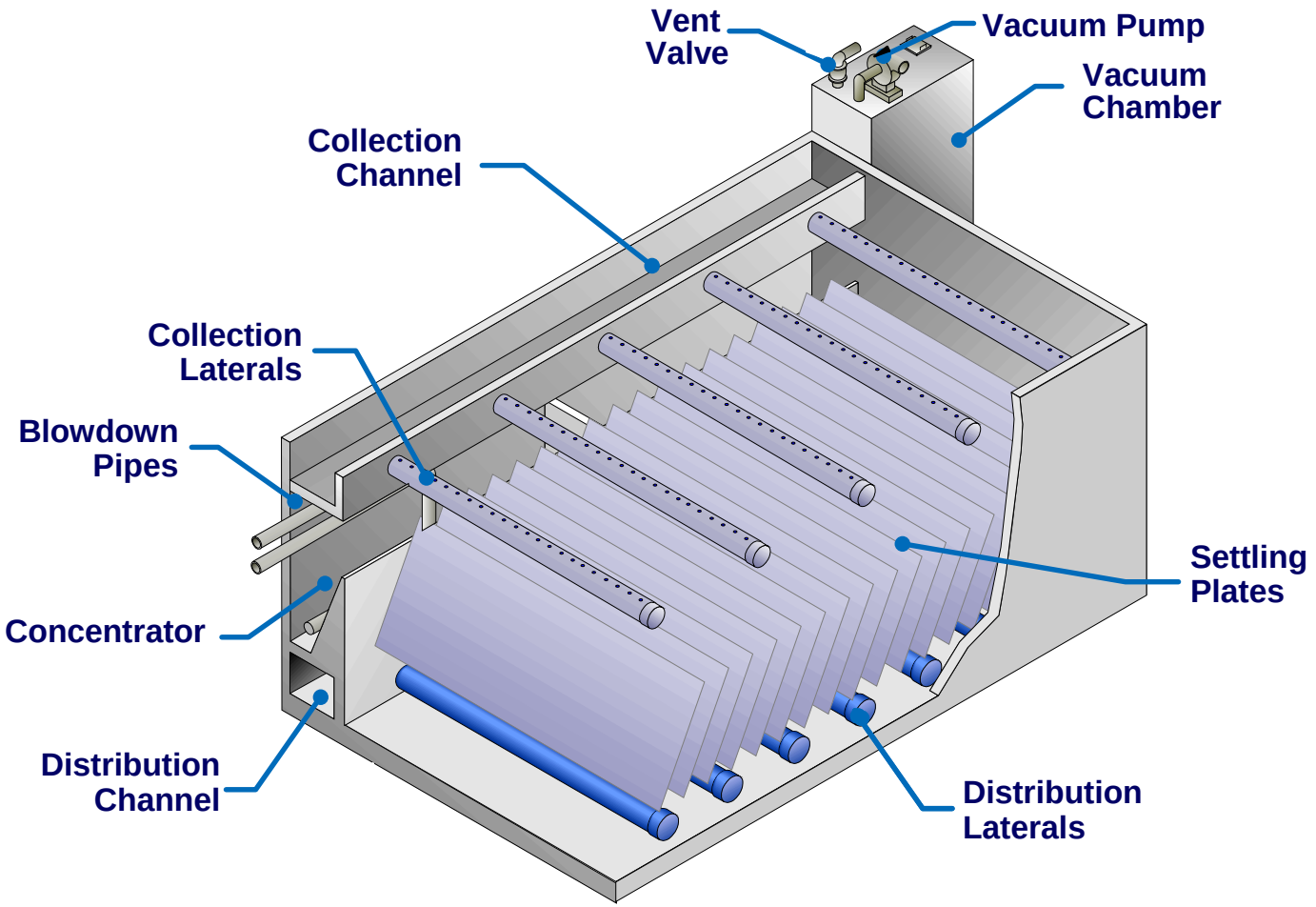




# UPFLOW SOLIDS CLARIFIER (IDI SUPERPULSATOR)

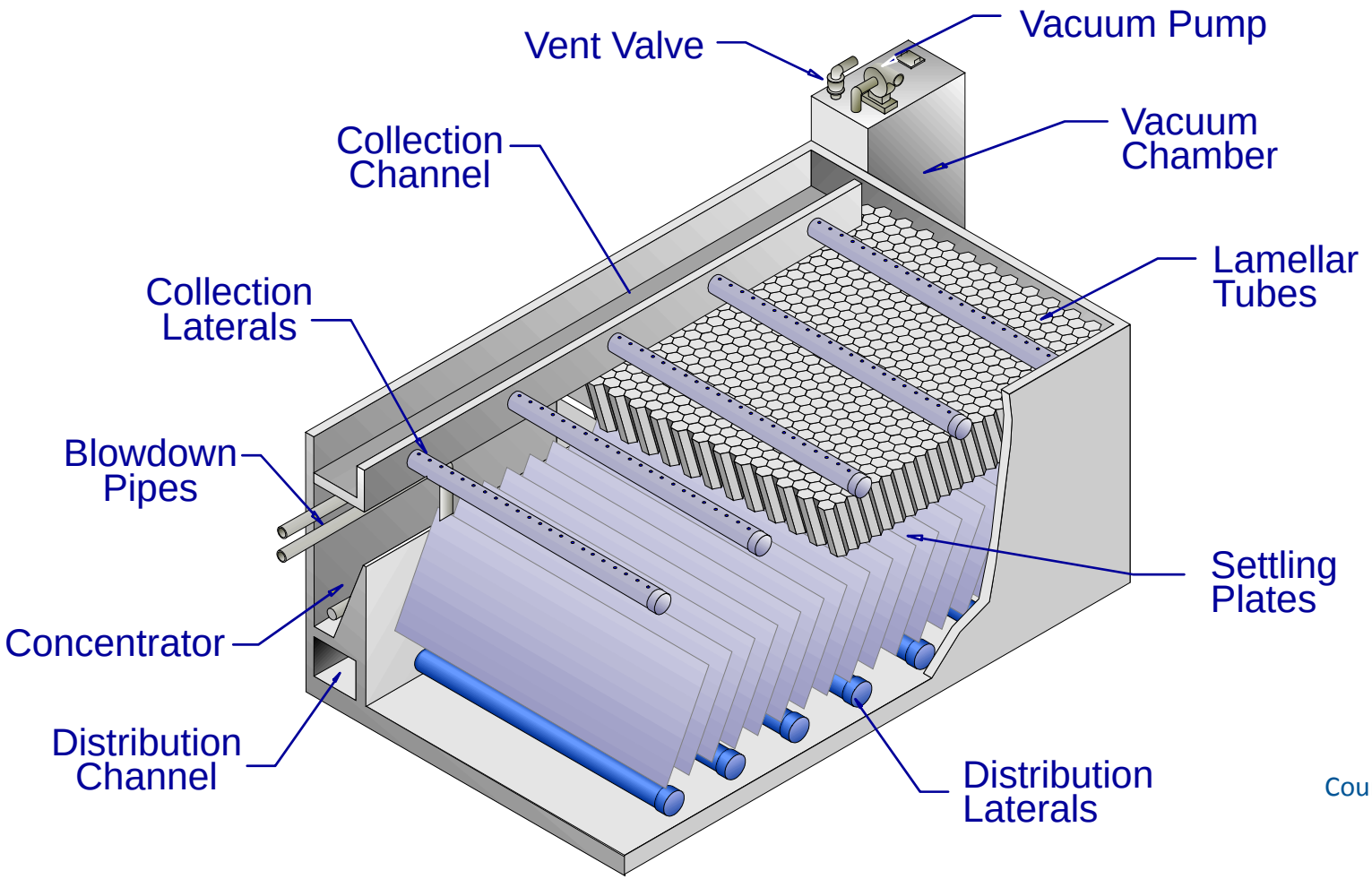
- Sludge blanket clarifier (2 – 4 gpm/ft$^2$)
- Flocculation and sedimentation in one basin
- Pulsed flow through the basin - created by vacuum pump
- Inclined plates with and without tube settlers
- 20+ Years of installed experience – over 150 US installations

# Superpulsator® Clarifier



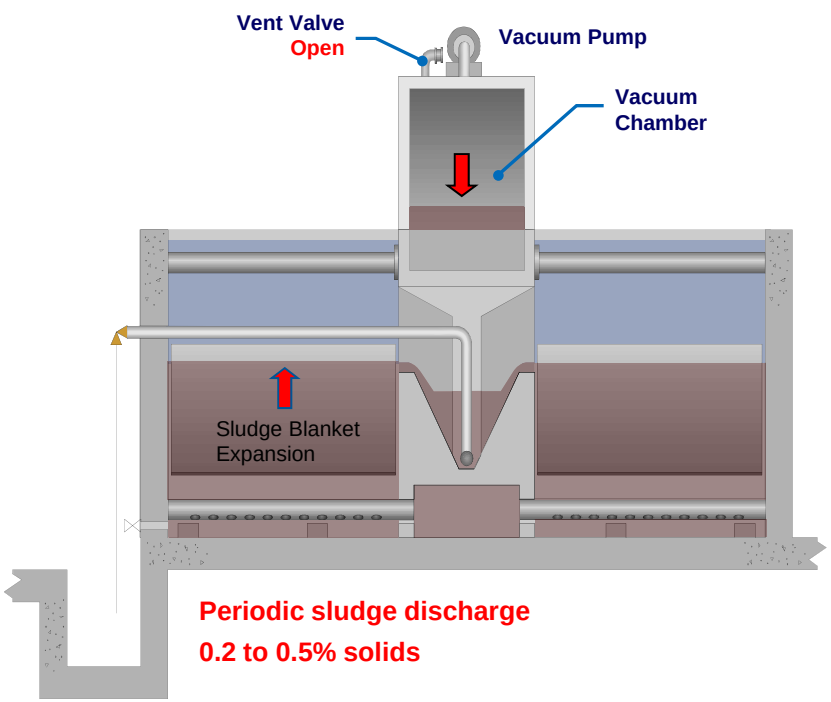

Courtesy: IDI

# Superpulsator® Type U Clarifier

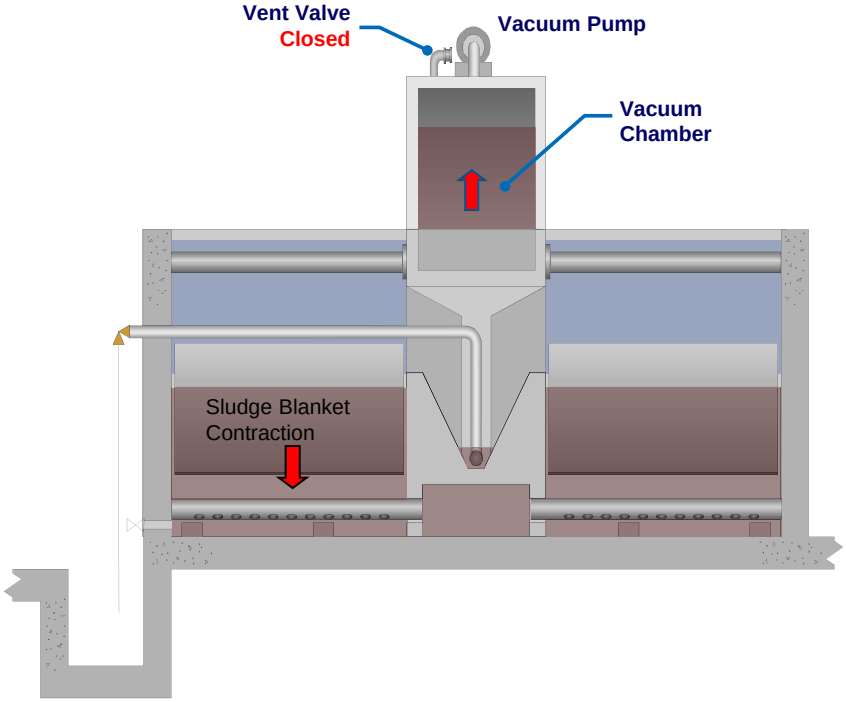



Courtesy: IDI

# VENTING AND PULSING



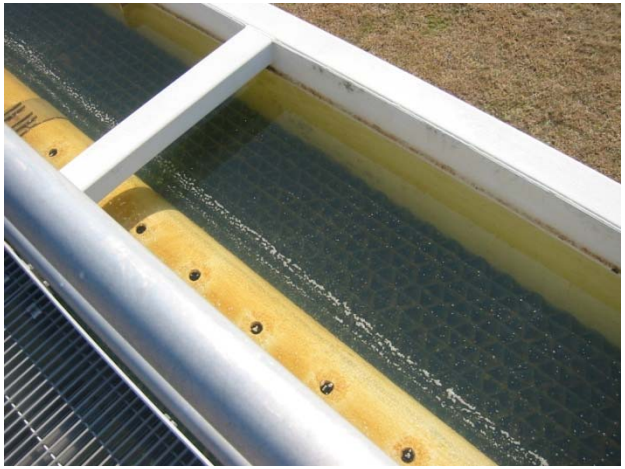

*Venting: 8 to 12 seconds*

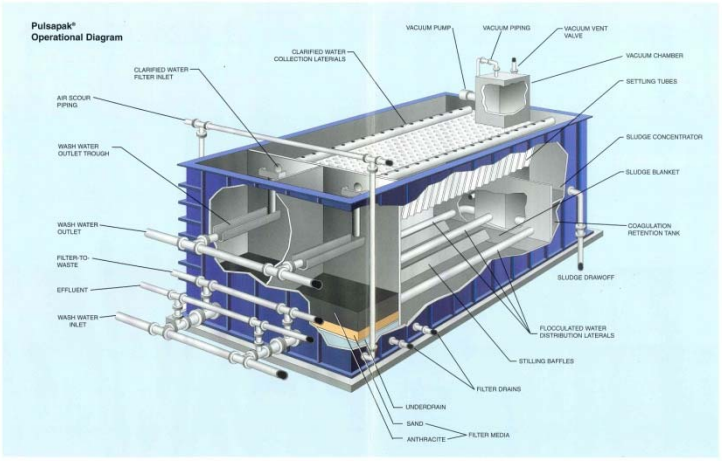



*Pulling a Vacuum: 40 to 50 seconds*

Courtesy: IDI

# UPFLOW SOLIDS CLARIFIER (IDI SUPERPULSATOR)

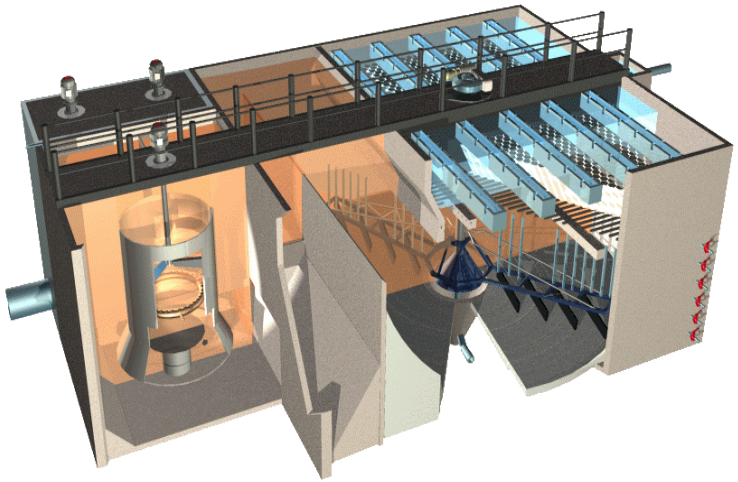


# UPFLOW SOLIDS CLARIFIER (IDI SUPERPULSATOR)

- **Advantages**
  - No moving parts below surface
  - Ability to incorporate PAC in sludge blanket (T&O/TOC)
  - Potential $ savings vs conventional
  - Capable of high flocculation efficiency
  - Proven performance / state acceptance
- **Disadvantages**
  - Heavy solids can settle and require periodic removal
  - Can be difficult to control when flow rate or water quality change
- **Considerations**
  - Settling velocity of solids - homogeneous and controlled
  - Susceptible to upset with temperature change
  - Need to manage blowdown

# SOLIDS CONTACT CLARIFIER (IDI DENSADEG)

- High rate solids contact clarifier (8 – 12 gpm/ft$^2$ as compared to 0.75 – 1.5 for traditional SCUs)
- Mixing, solids recirculation, clarification/ thickening
- Versatile – clarification, softening, residuals handling
- Water and wastewater applications
- 20 Years of installed experience – over 50 US installations and 150 installations worldwide



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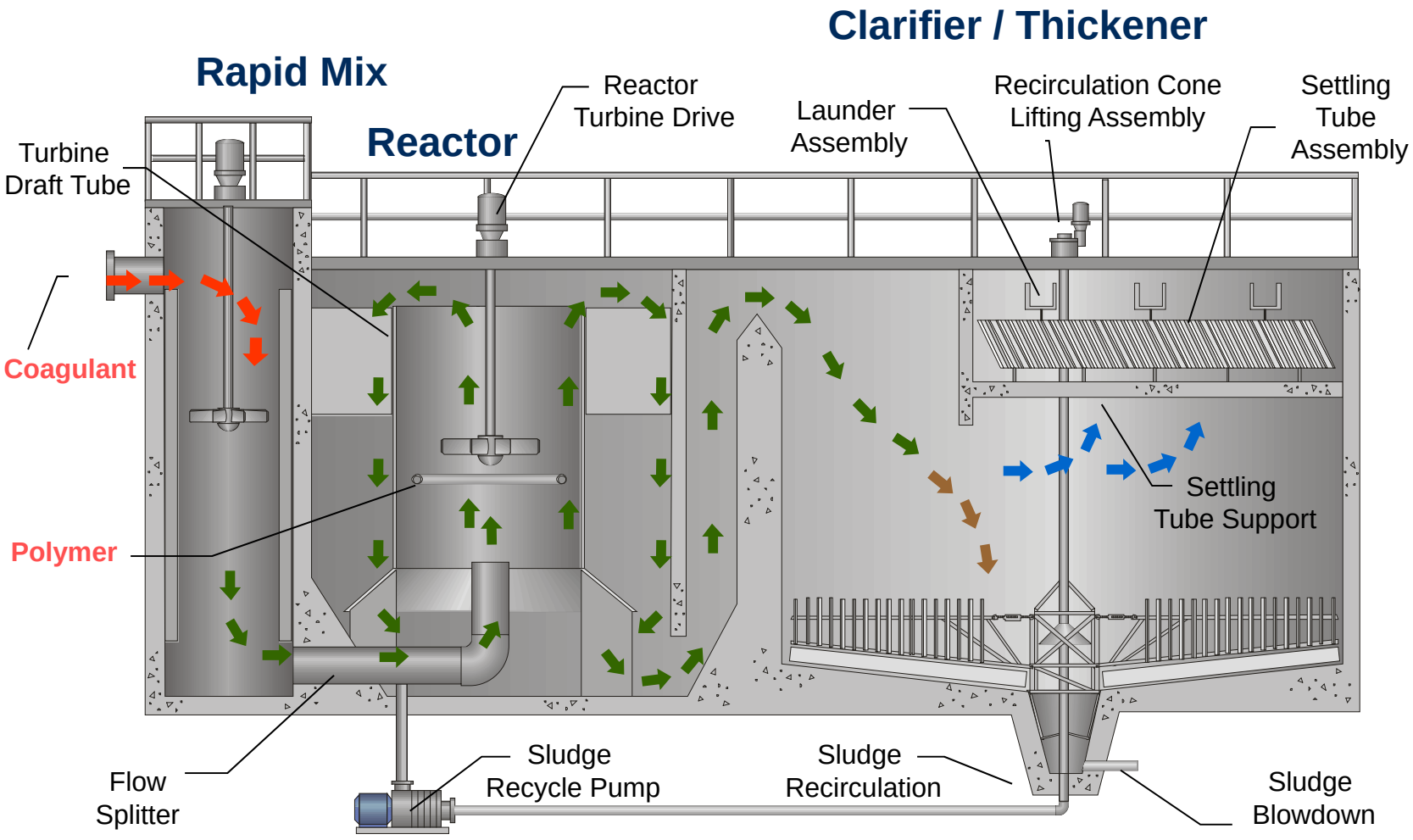


# DESIGN CRITERIA

**REACTOR RETENTION:**

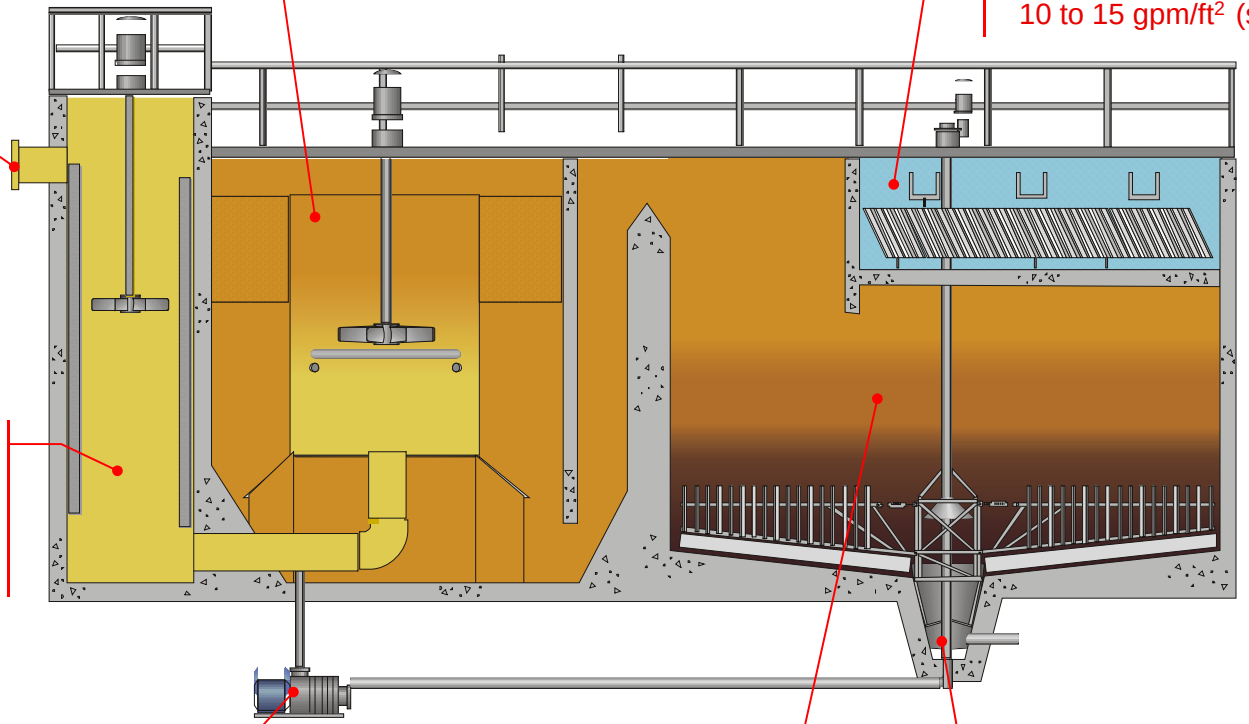
8-10 min

**LOADING RATE:**

8 to 10 gpm/ft$^2$ (clarification)
10 to 15 gpm/ft$^2$ (softening)

**CAPACITY per UNIT:**

1 to 22 MGD (concrete)
0.15 to 14 MGD (steel)



**RAPID MIX RETENTION:**

2 to 3 min (clarification)

**SLUDGE RECYCLE:**

3% to 6%

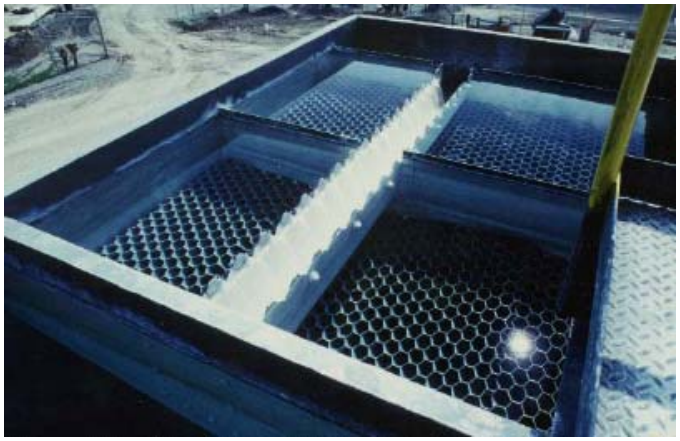
**CLARIFIER RETENTION:**

23 to 28 min

**SLUDGE BLOWDOWN:**

2% to 4% (clarification)
5% to 20% (softening)

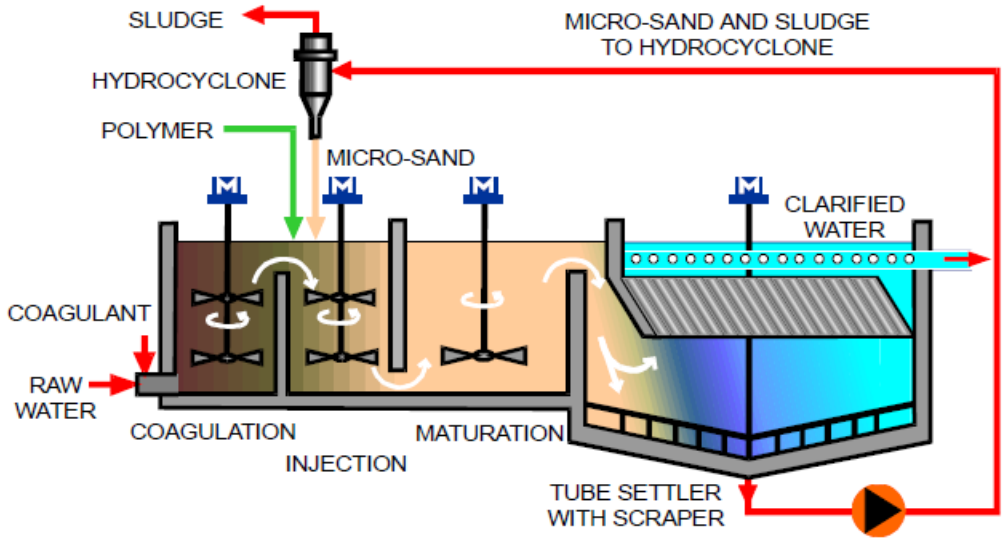
# SOLIDS CONTACT CLARIFIER (IDI DENSADEG)



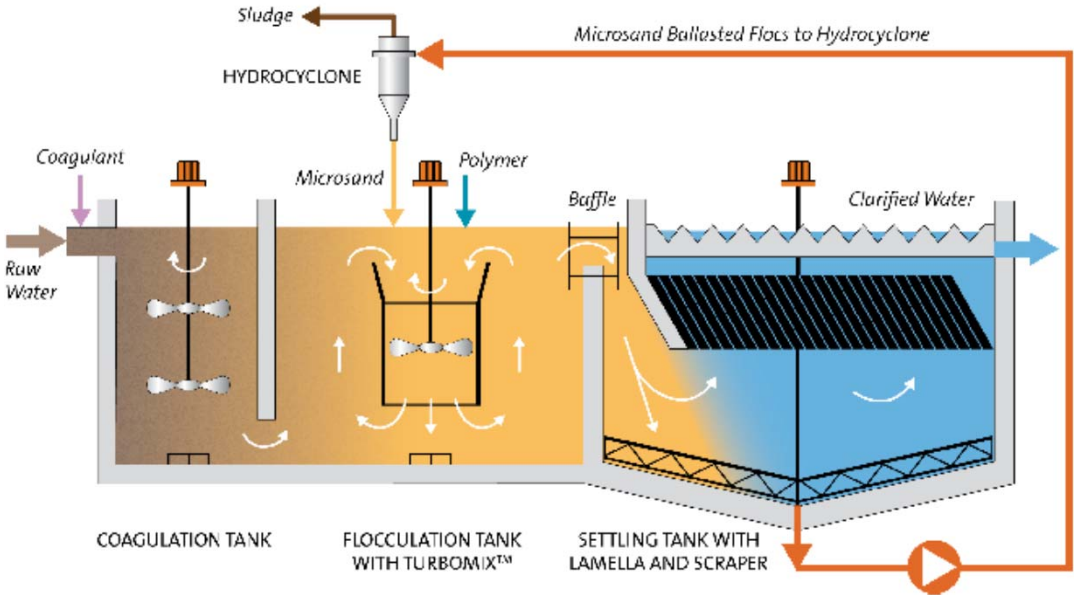
# SOLIDS CONTACT CLARIFIER (IDI DENSADEG)

- **Advantages**
  - Small footprint area
  - Ability to incorporate PAC
  - Potential $ savings vs. conventional
- **Disadvantages**
  - Pilot testing requirements
  - Lot of steel internals – maintenance
  - Needs sludge inventory – longer startup times
- **Considerations**
  - Needs polymer – effect on “filterability”
  - Need to manage blowdown
  - Susceptible to upset with temperature change

# BALLASTED FLOCCULATION - ACTIFLO




Kruger Actiflo
Traditional




Kruger Actiflo
Turbo

# BALLASTED FLOCCULATION

- **High rate ballasted flocculation clarifier (15-30 gpm/sq.ft)**
- **Use of microsand to "ballast" flocs – makes particles sink faster**
  - 50 - 100 micron effective size (smaller sand tends to work better)
- **Use of hydrocyclones - microsand recovery from the sludge**
  - Dilute solids
- **15 Years of installed experience – over 120 US installations**

# BALLASTED FLOCCULATION

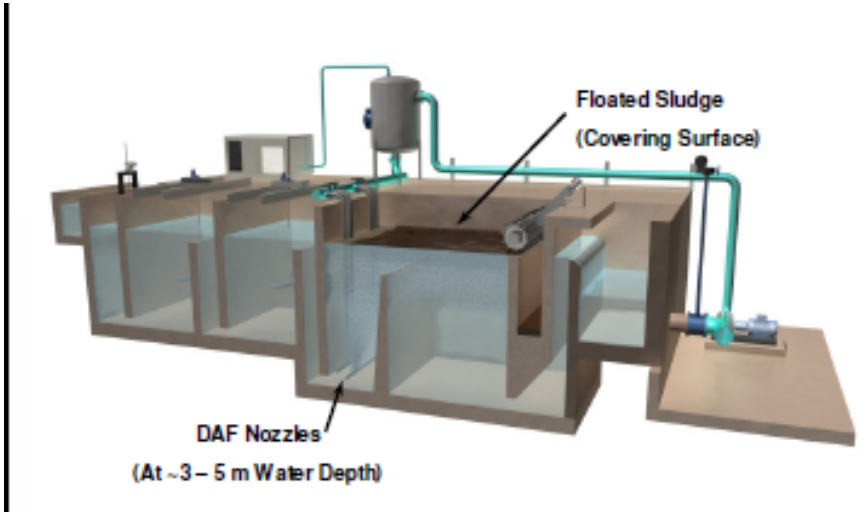
# BALLASTED FLOCCULATION

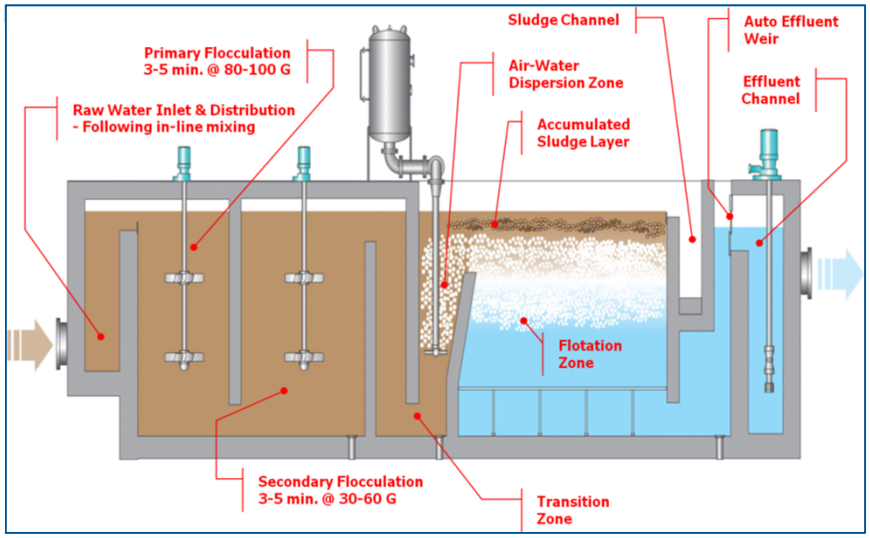
| | |
|---|---|
| Coagulation (Flash Mix) | 1 - 2 minutes |
| Injection (Flash Mix) | 1 - 2 minutes |
| Maturation (Flocculation) | 4 - 6 minutes |
| Settling (20 gpm/sf): | 2 minutes |
| Total Detention Time | 8 - 12 minutes |

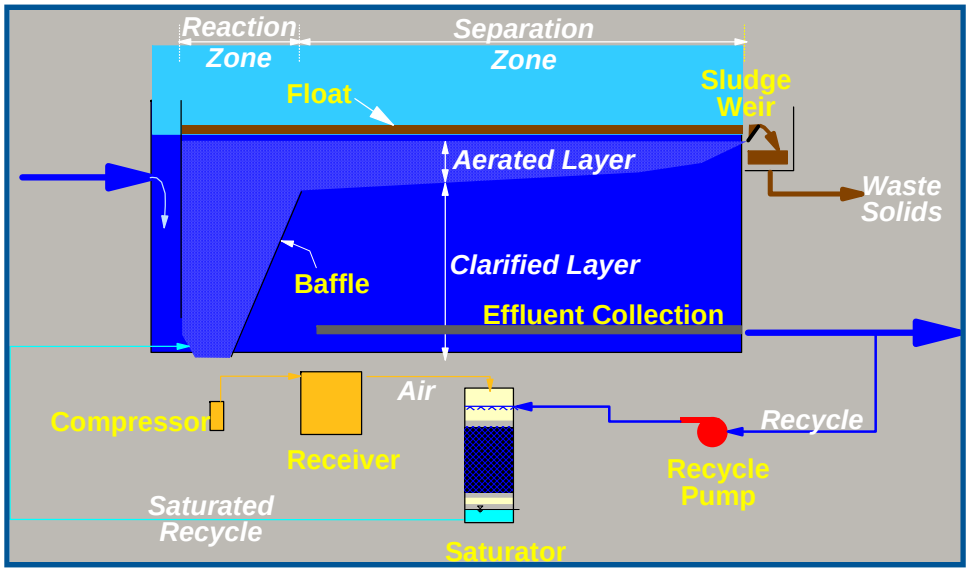
# BALLASTED FLOCCULATION

- **Advantages**
  - Small “footprint” area
  - Quick response to adjustments
  - Potential $ savings vs. conventional
- **Disadvantages**
  - Higher power consumption
  - Pilot testing requirements
  - Low solids content in sludge
  - More process elements to control and optimize
- **Considerations**
  - Needs polymer – effect on “filterability”
  - Sand is consumed (loss) - ~ 8 lbs/MG
  - Sand pumps/piping need special design

# DISSOLVED AIR FLOTATION



# DISSOLVED AIR FLOTATION

- **Float solids instead of settle**
- **Primarily for low turbidity/low solids applications**
- **Excellent for algae removal (algae likes to float) and waters with "thermal variation"**
- **Options**
  - Conventional (2-5 gpm/ft$^2$)
  - Stacked DAF – Filtration (4-6 gpm/ft$^2$)
  - High Rate DAF (6-20 gpm/ft$^2$)

# DISSOLVED AIR FLOTATION

# DAF DESIGN PARAMETERS

- **Recycle stream pressure: 60 - 90 psi**
- **Flocculation time: 5 - 20 minutes**
- **Flotation zone detention time**
  - 5 - 15 Minutes
  - Surface Loading Rate: 2 - 6 gpm/ft$^2$
  - High rate: 6 – 20 gpm/ft$^2$

# DISSOLVED AIR FLOTATION

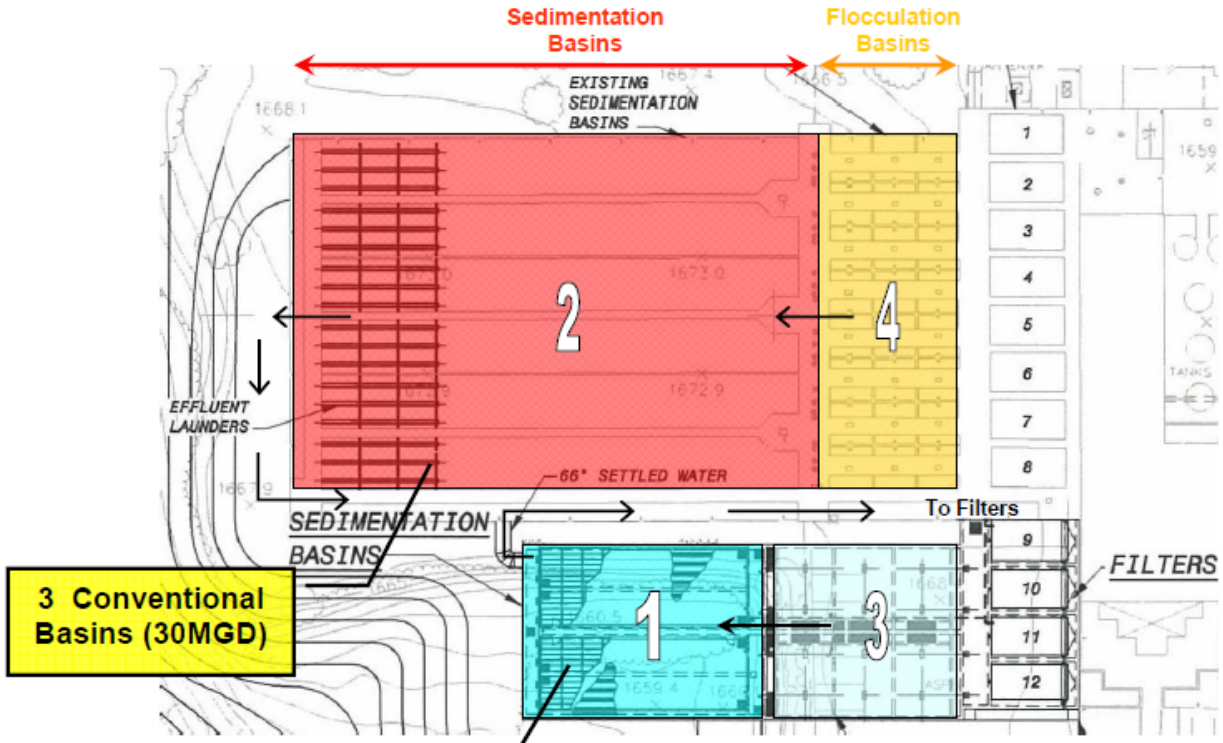
- **Advantages**
  - Small footprint area
  - Generally not polymer dependent (less likely to reduce filter runs)
  - Ideal for light solids
  - High sludge solids concentration (2 - 5%) w/mechanical scraping
- **Disadvantages**
  - High power costs
  - Pilot testing requirements
- **Considerations**
  - Definition of loading rates (basin area, recycle)
  - Raw water DO
  - Sludge transport w/mechanical scraping
  - Heavy solids can create difficulties

# COMPARISON OF TECHNOLOGIES

# COMPARISON OF ALTERNATIVE CLARIFICATION PROCESSES

- **Each case needs to be evaluated on its own individual circumstances**
  - Water quality
  - Treatment goals
  - Regulations
  - Existing infrastructure/personnel
  - Space availability
  - Cost sensitivity
- **So let's look at some examples**
  - No space limitations
  - Warm weather/water

# SPACE/VOLUME RELATES TO CONCRETE



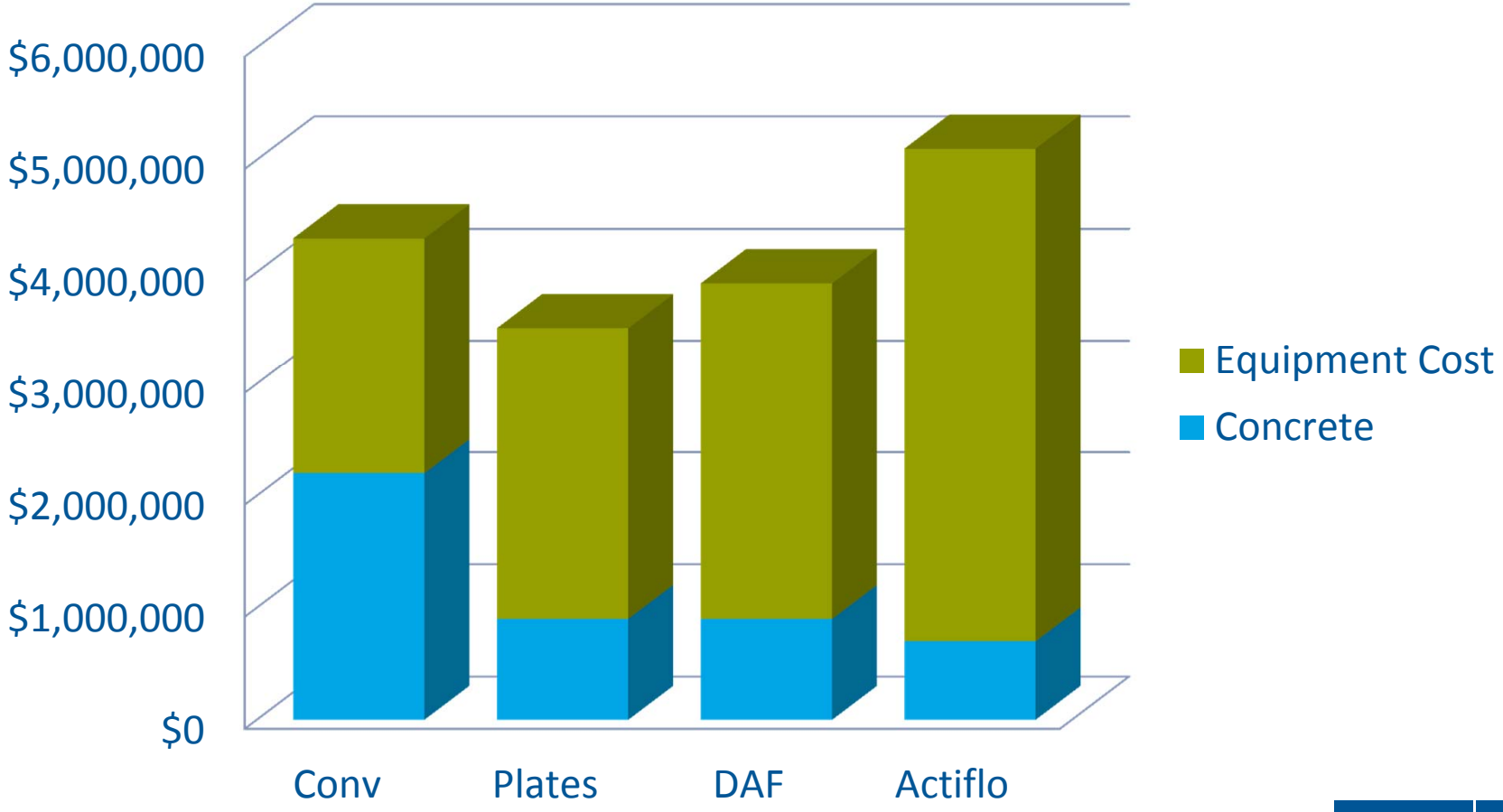

Conventional
31,500 sq ft

Plates
9,600 sq ft

DAF
6,000 sq ft

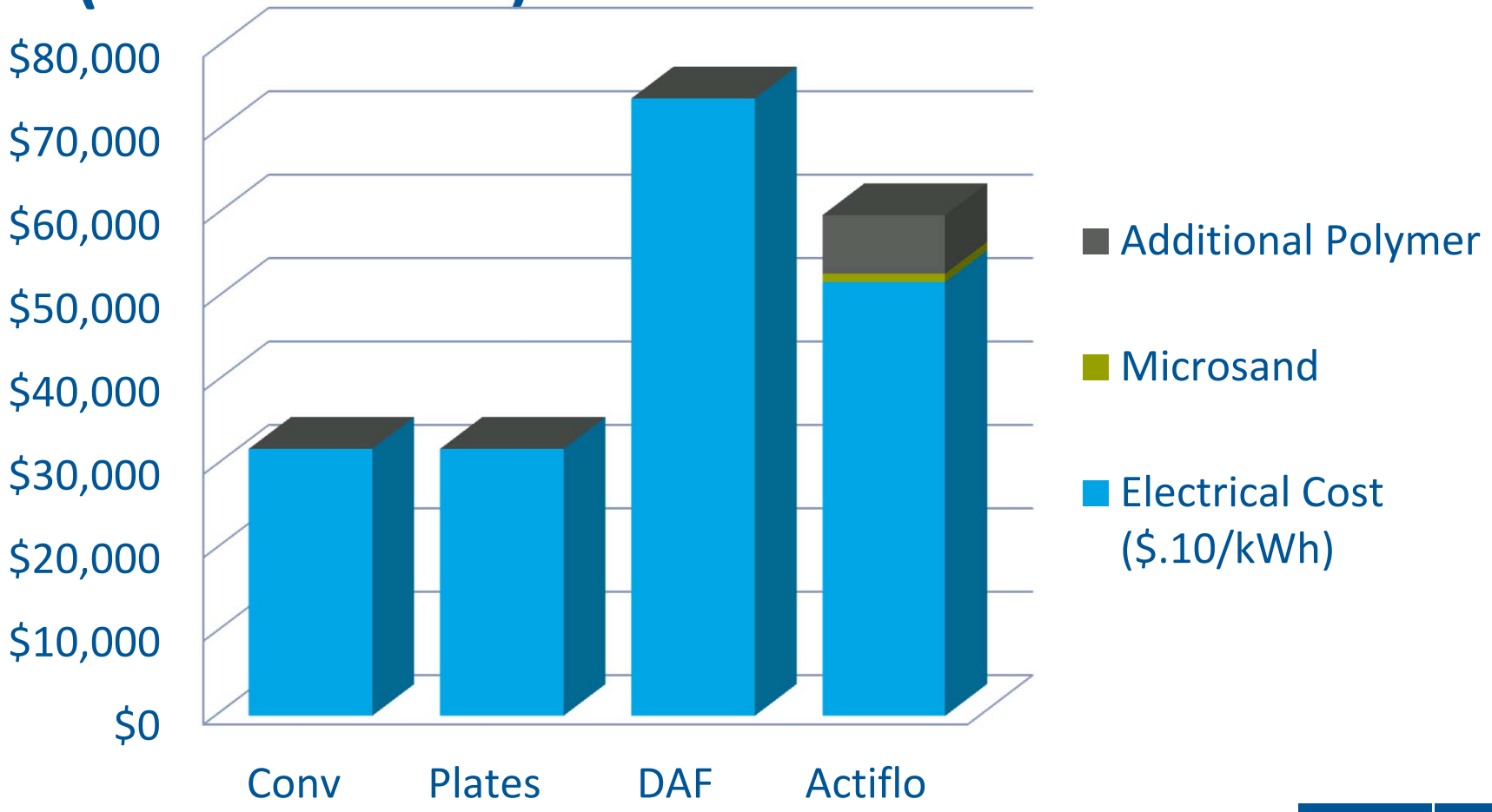
Actiflo
4,000 sq ft

# EVALUATION OF DIFFERENTIAL CAPITAL COSTS (24 MGD WTP)




**Concrete matters but equipment does too**

# EVALUATION OF OPERATING COSTS, EXCLUDING LABOR (24 MGD WTP)




**Power is a major variable to consider**

# COMPARISON OF TECHNOLOGIES - SUMMARY

- **Many choices for high rate sedimentation**
- **Available for new plants, retrofits**
- **Selection is site specific based on**
  - Water source
  - Existing facilities
  - Space availability
  - Enhanced coagulation needs/DBP reduction
  - Weather
  - Cost
- **Pilot testing may be needed**
  - Include filtration
- **Effective coagulation still critical**

# PROJECT EXAMPLES

# EWEB

## Hayden Bridge Water Treatment Plant

# EWEB Contact Basin No. 2 (of 3)

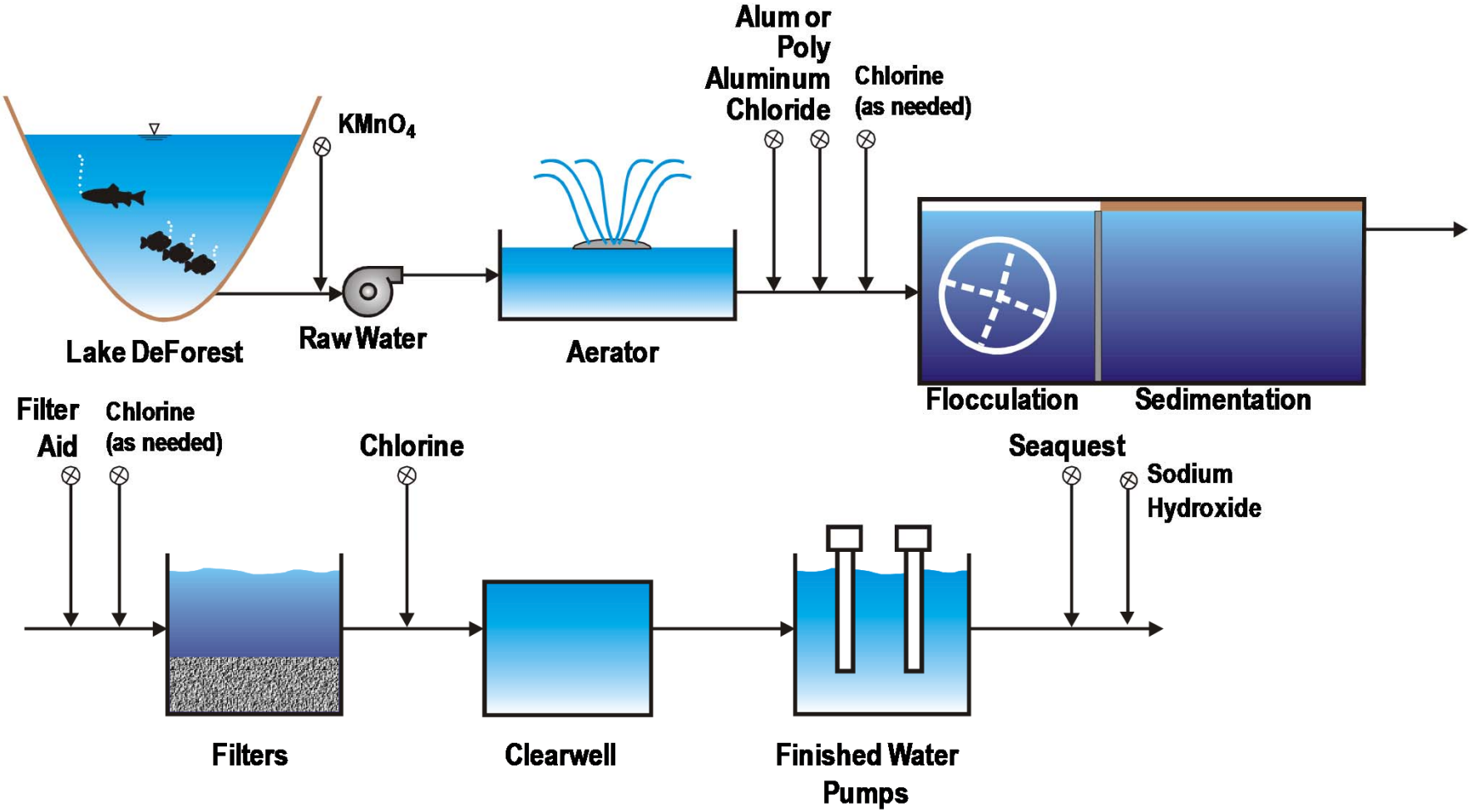
## EWEB Contact Basin No. 3 (of 3)

# UNITED WATER

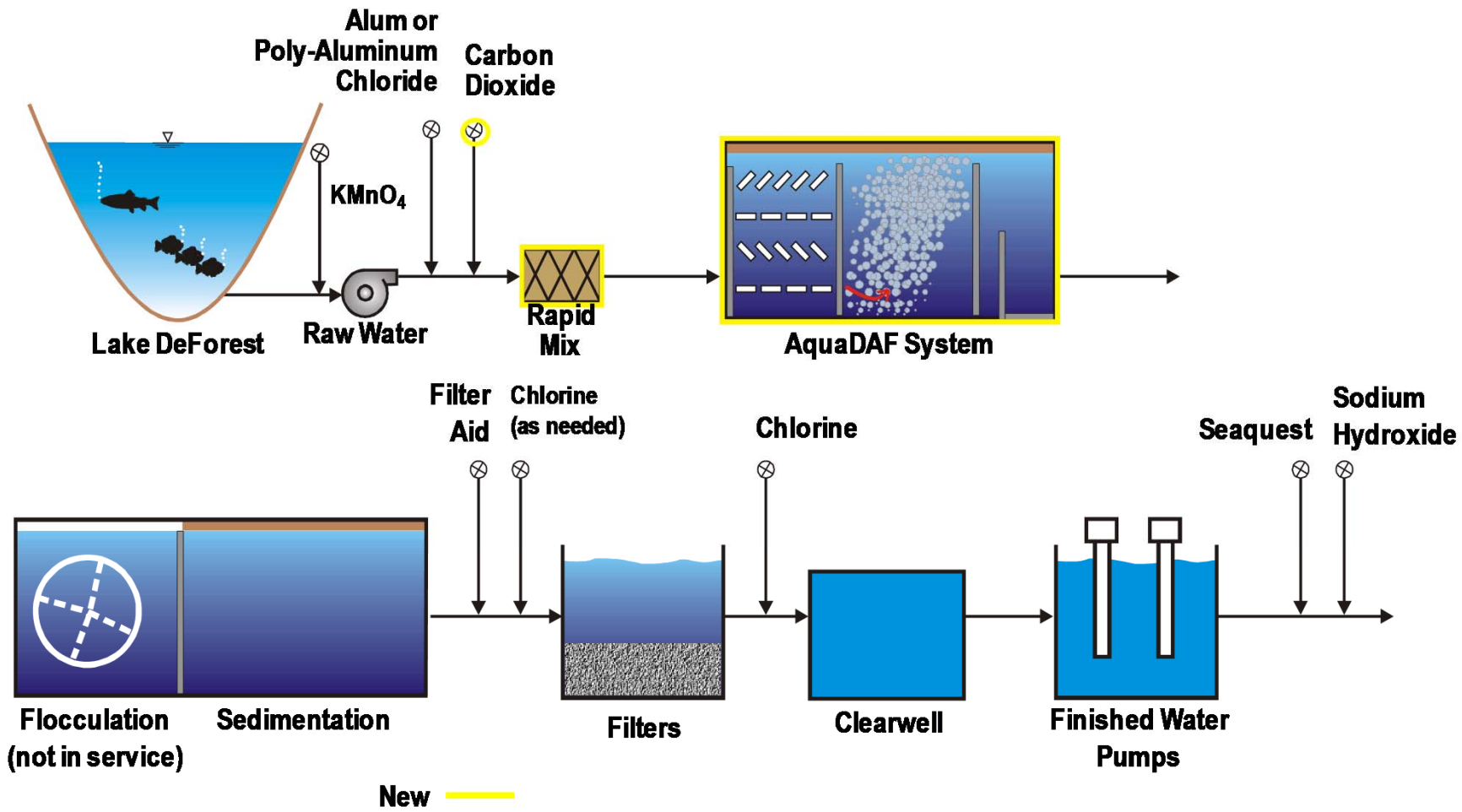
**20 mgd Lake DeForest WTP Retrofit**

**Clarkstown, New York**

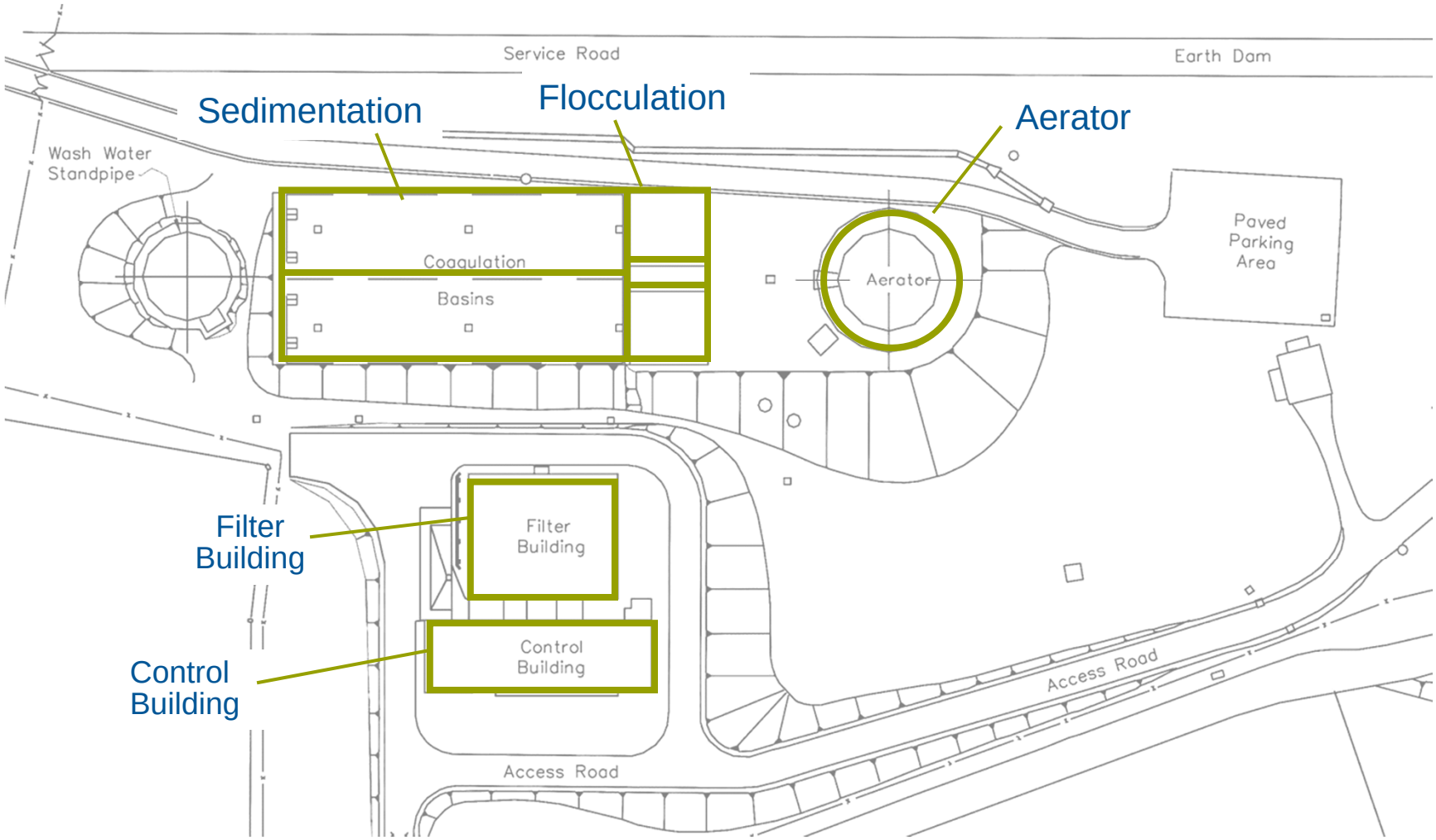
# INITIAL PROCESS FLOW DIAGRAM



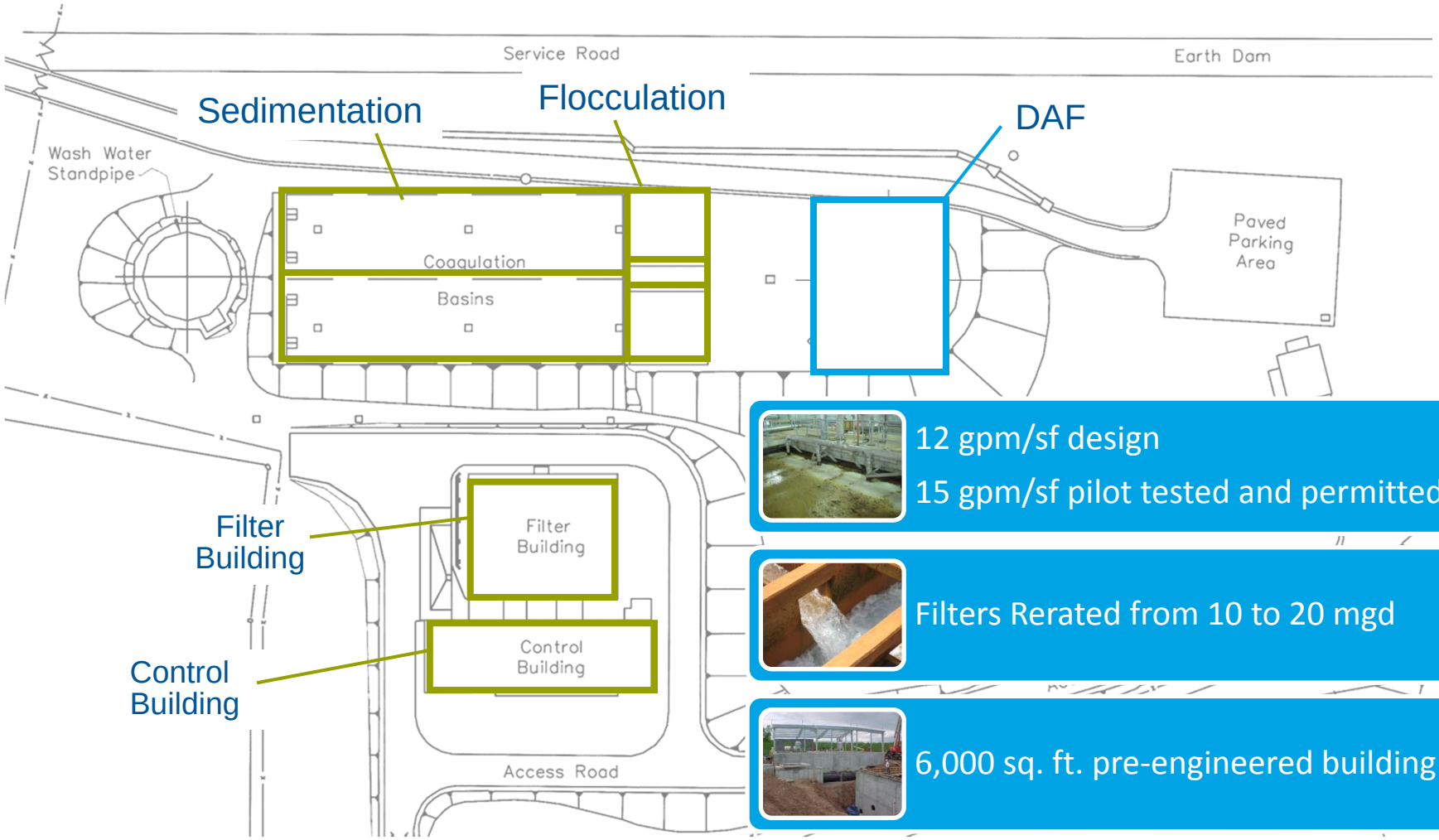
# REVISED PROCESS FLOW DIAGRAM



# ORIGINAL SITE PLAN – 10 MGD



# REVISED SITE PLAN – 20 MGD






12 gpm/sf design

15 gpm/sf pilot tested and permitted



Filters Rerated from 10 to 20 mgd



6,000 sq. ft. pre-engineered building

# BALLASTED FLOCCULATION PRETREATMENT AT THE CHANDLER, AZ PECOS WTP

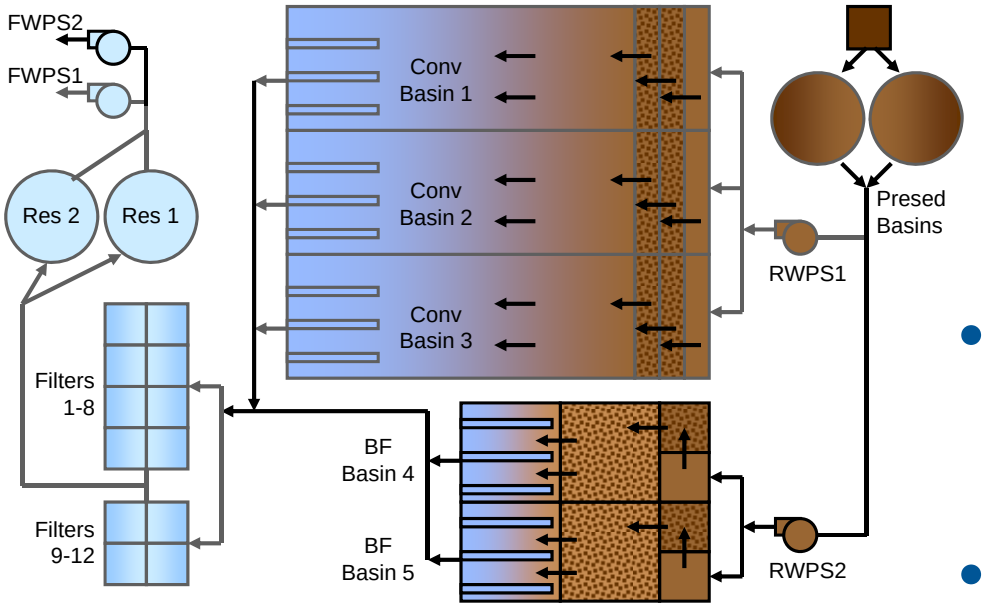

## VICTORIA SHARP

CITY OF CHANDLER
CHANDLER PECOS WTP SUPERINTENDENT


BLACK & VEATCH
Building a world of difference.®

# PROJECT OVERVIEW

# A HYBRID PLANT




- Kept existing 30 mgd of conventional pretreatment.
- Added 30 mgd of new ballasted flocculation pretreatment.
- Operate both in parallel upstream of anthracite monomedia filters.

# WHY BALLASTED FLOCCULATION?

- Resulted in longer filter runs.
- Less tendency for turbidity breakthrough.
- Much smaller footprint than conventional basins.
- Shorter detention times allowing changes in water quality to be apparent quicker.
- Positive feed back from the operations and maintenance group during a tour of the Passaic Valley Water Commission plant in New Jersey.

# OPERATIONAL OBSERVATIONS

- Handles turbidity changes well.
- Changes in water quality show up in 20 minutes, rather than hours in a conventional basin.
- Uses more chemicals.
- Less sand is needed than was original assumed by operations.

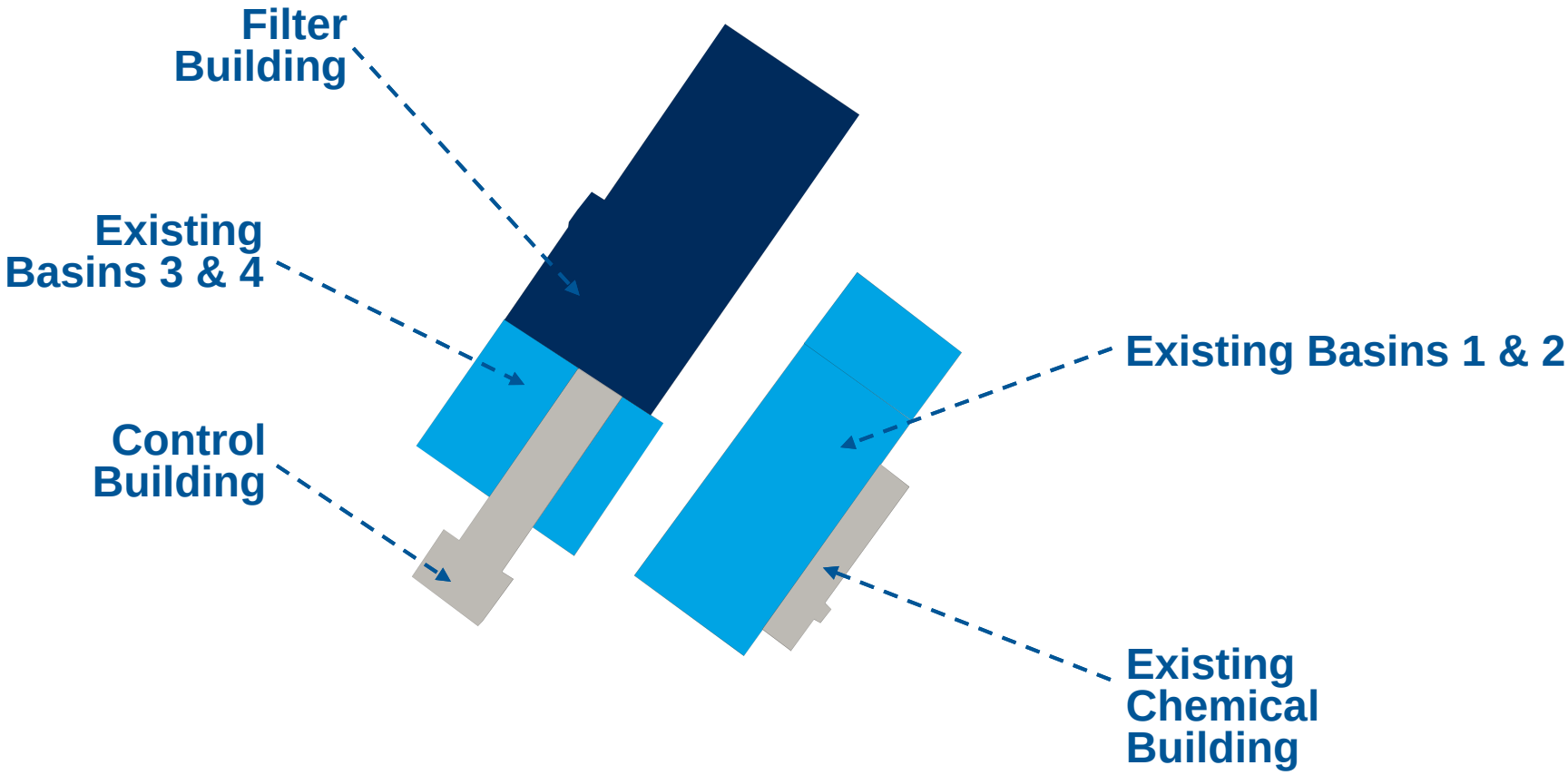

30 mgd BF Basins
30 mgd Conventional Basins

# PASSAIC VALLEY WATER COMMISSION

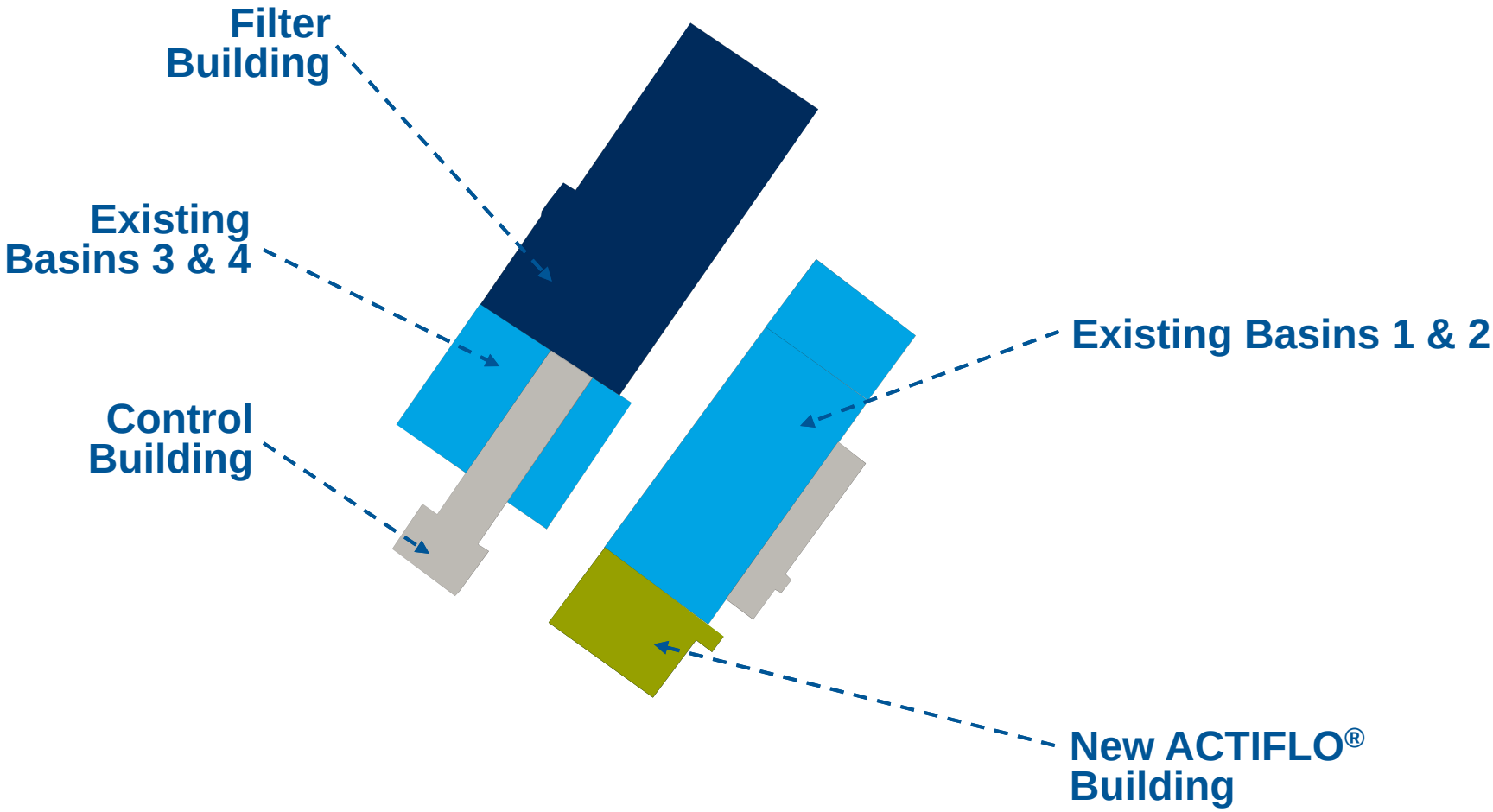
## 110 mgd Little Falls WTP Retrofit

## Clifton, New Jersey

# LITTLE FALLS WTP – PROCESS SEQUENCE

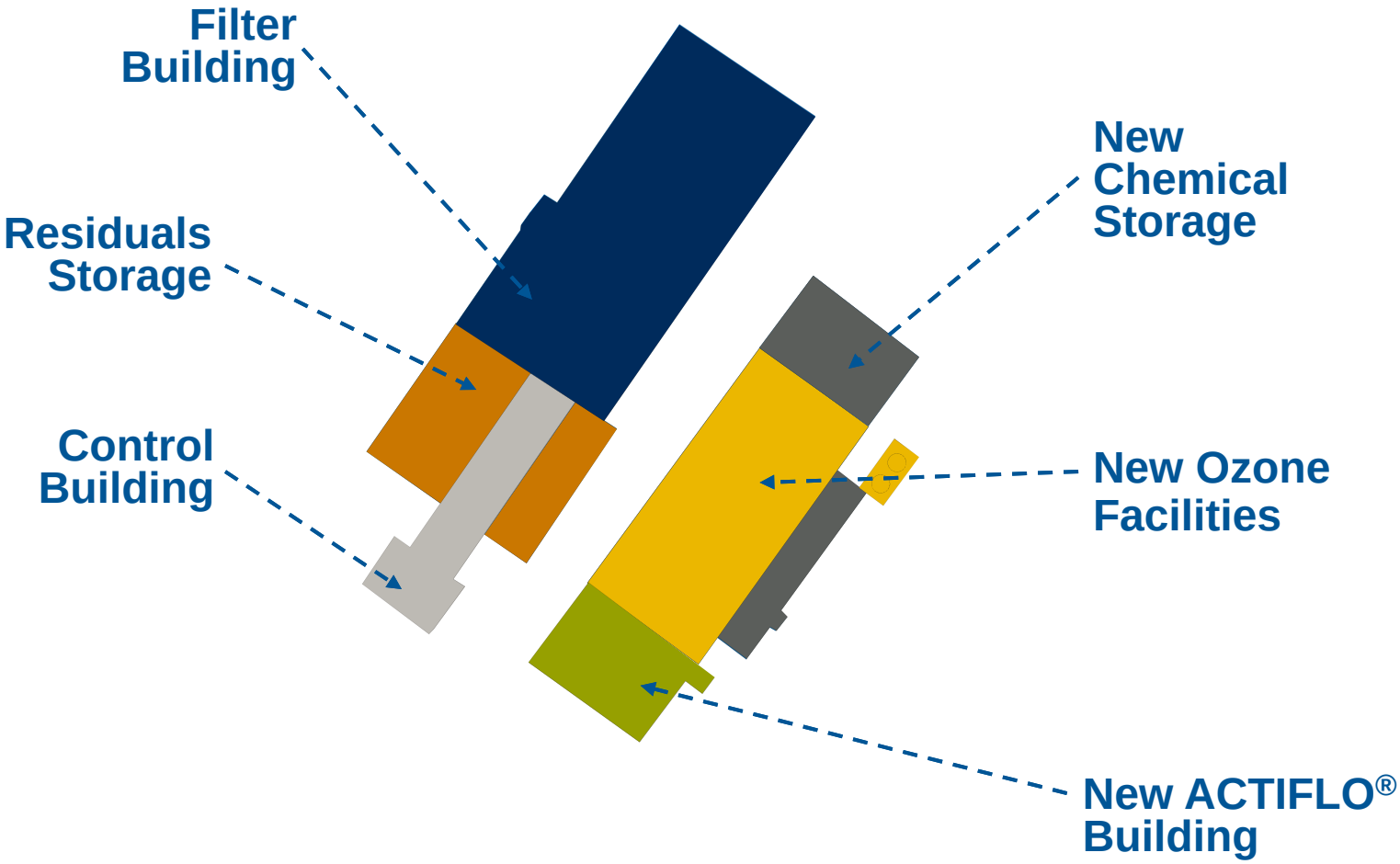


# LITTLE FALLS WTP – PROCESS SEQUENCE



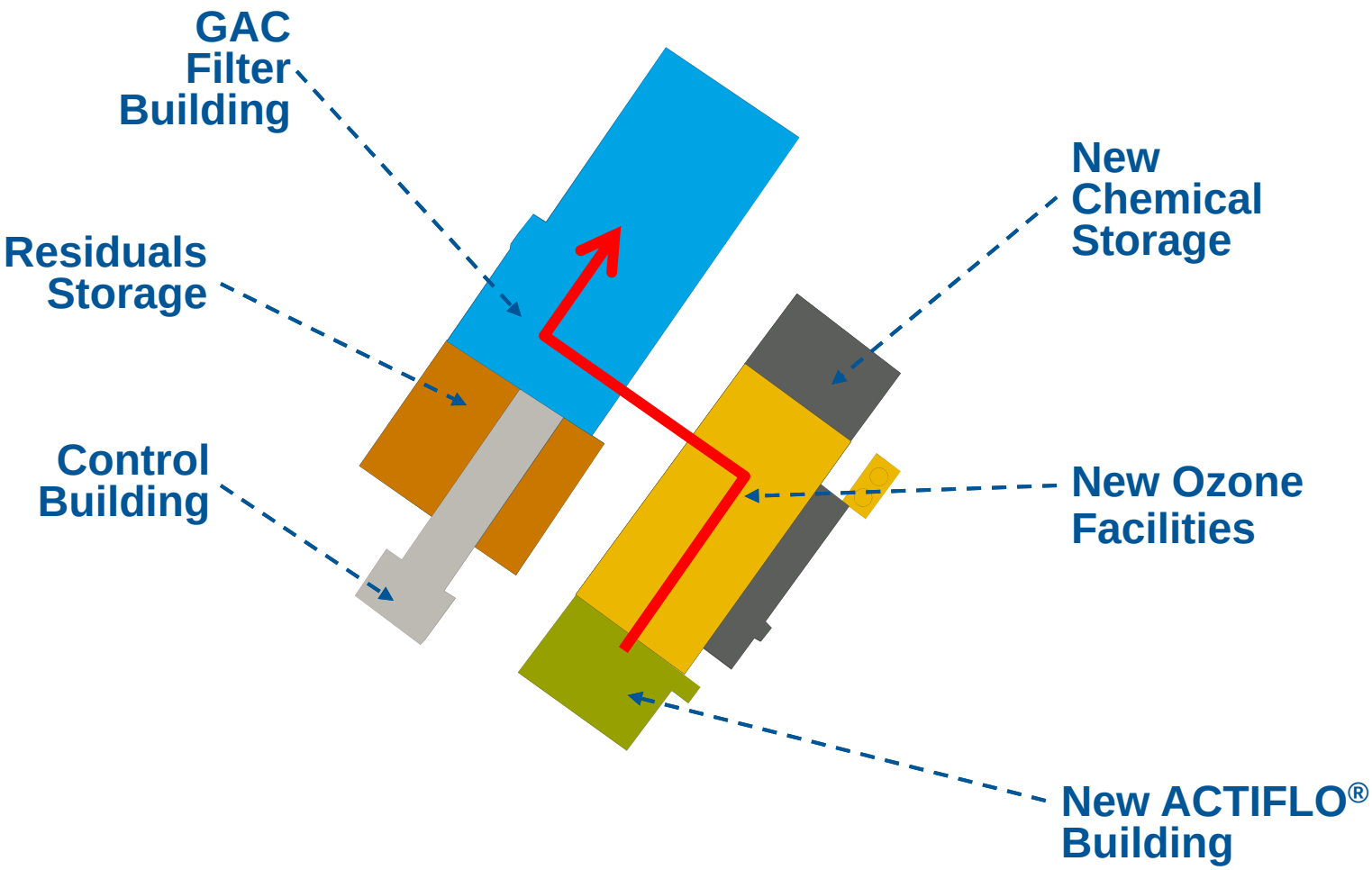

**Four Trains at 40 gpm/sf**

# LITTLE FALLS WTP – PROCESS SEQUENCE




**3,600 ppd Ozone – 3.5 mg/L dose**

# LITTLE FALLS WTP – PROCESS SEQUENCE




**Converted from anthracite/sand to 42" GAC**

# CALIFORNIA WATER SERVICE COMPANY
# NE BAKERSFIELD, CA WTP PRETREATMENT

# PROJECT DESCRIPTION

**CAPACITY: 22 MGD**

**START UP: JUNE 2003**

**RAW WATER SOURCE – KERN RIVER**

**PREOXIDATION & COAGULATION**

**TWO STAGE FLOCCULATION**

**HIGH RATE SEDIMENTATION**

**MEMBRANE FILTRATION**

# SOURCE DESCRIPTION

## KERN RIVER

## NORMAL CONDITIONS
TURBIDITY: 3 TO 6 NTU
TOC: 2.5 – 3.0
COLOR: 50 – 100

## EXTREME CONDITIONS
TURBIDITY: 16000 NTU
TOC: 6+
COLOR: 500+

# PROCESS DESCRIPTION

## RAPID MIX

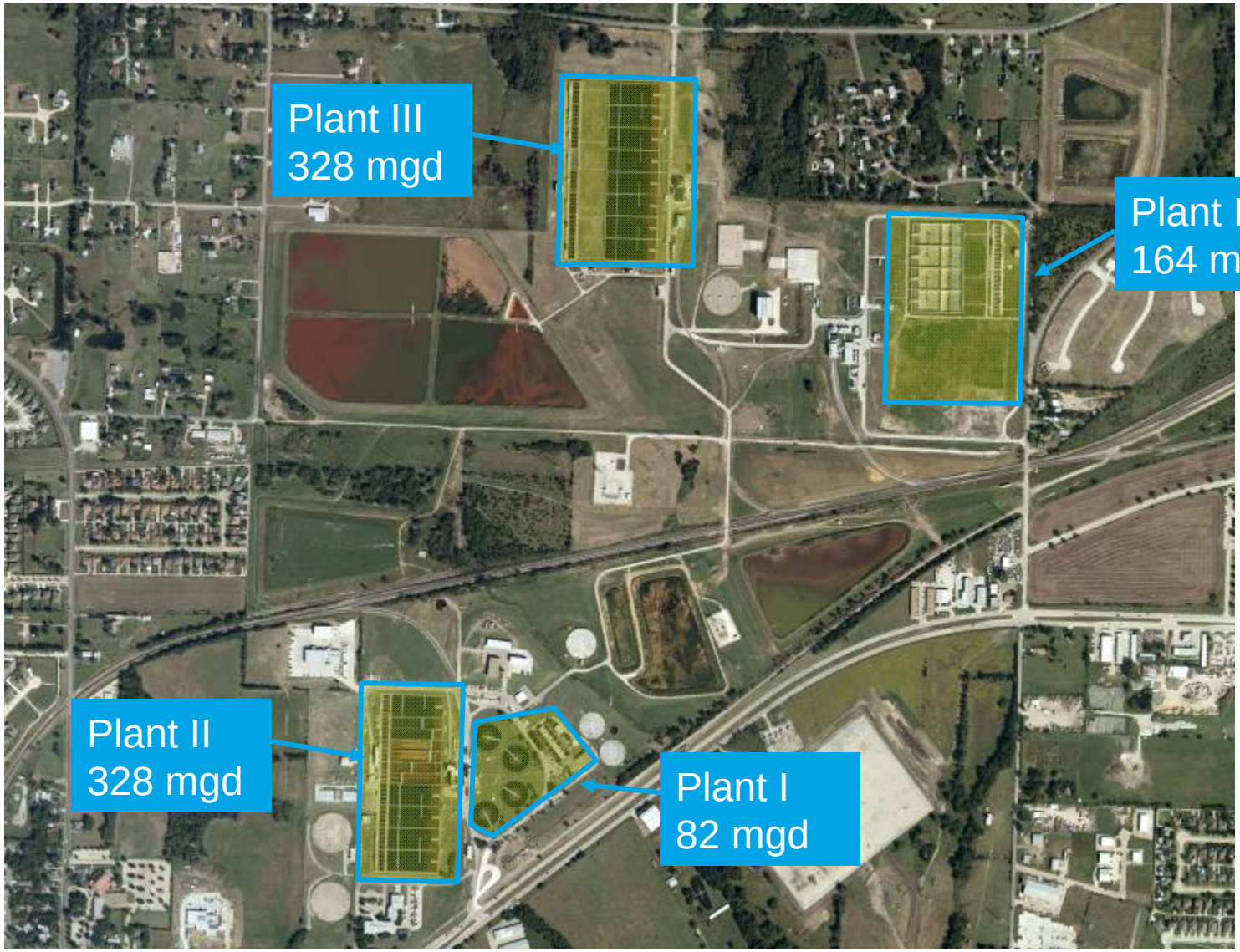
## TWO STAGE FLOCCULATION

## HIGH RATE CLARIFICATION
- PARKSON PLATE SETTLERS
- 0.32 GPM / SQ FT LOADING RATE
- TRACK GUIDED SLUDGE REMOVAL SYSTEM

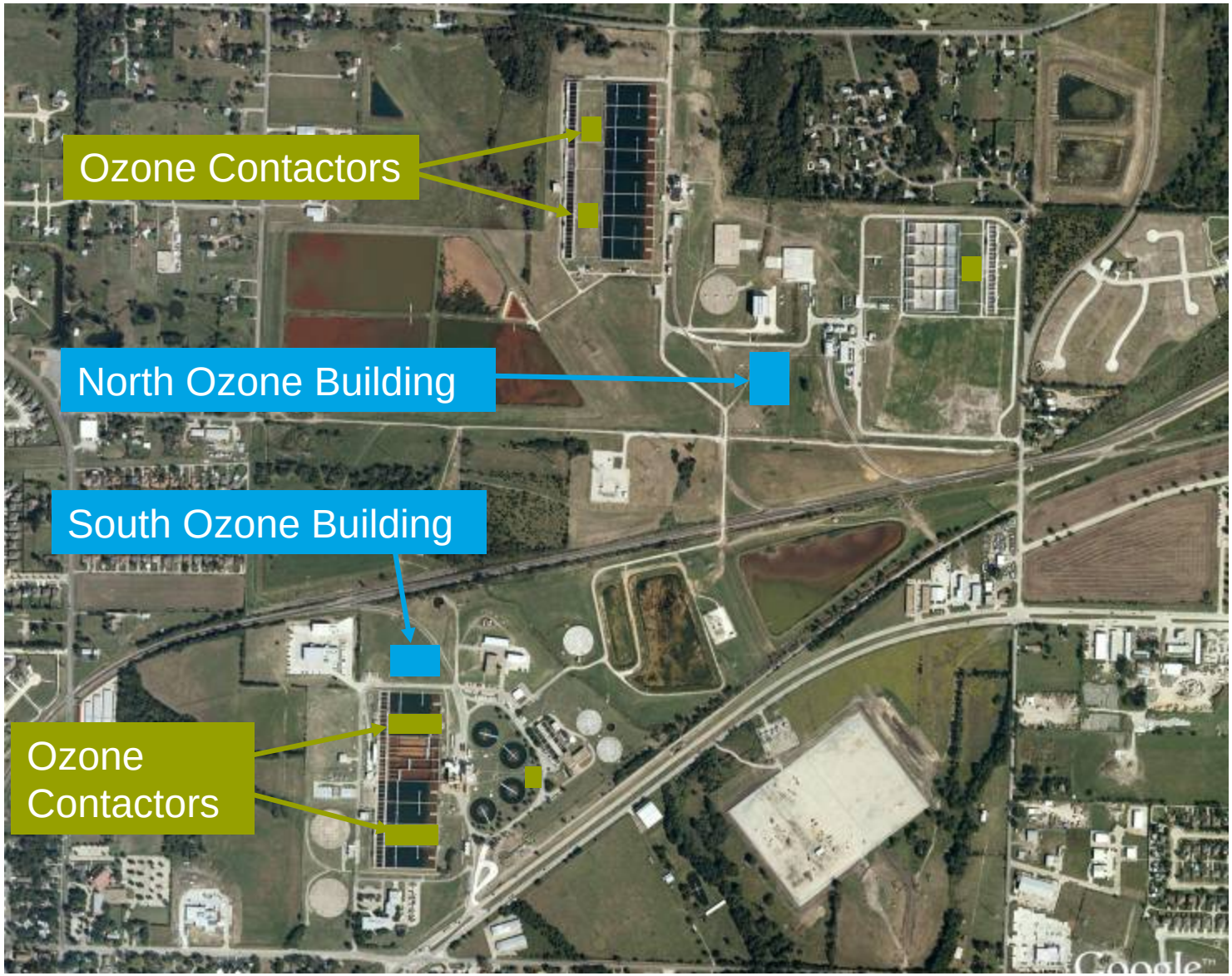
# NORTH TEXAS MUNICIPAL WATER DISTRICT

## 900 mgd Wylie WTP Retrofit

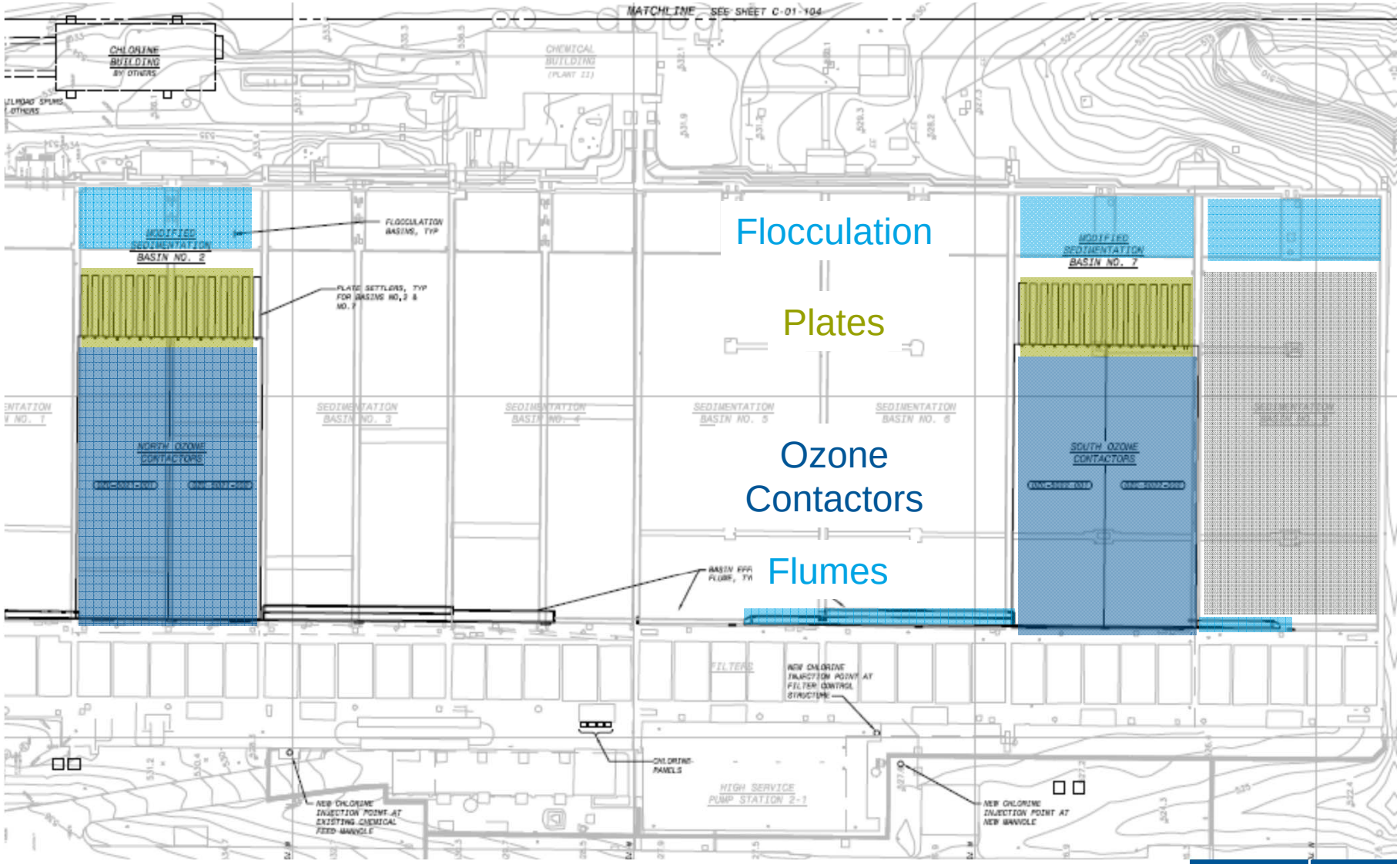
# NTMWD – WYLIE WTP



# INTEGRATING OZONATION



# REPLACED TWO OF EIGHT BASINS WITH PLATES




**Two basins of 41 mgd each – 0.4 gpm/sf**

# QUESTIONS?

# CONTACT INFO

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**Engineering Manager**

**Black & Veatch**
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**Lake Oswego, OR 97035**

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