MMSD
PARTNERS FOR A CLEANER ENVIRONMENT

FLYGT
a xylem brand

Minimizing Mixing Energy in Activated Sludge Selector Basins:

How Low Can You Go?

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WISCONSIN WASTEWATER OPERATORS' ASSOCIATION

WWOA Annual Conference 2017
October 17 - 20

South Shore Water Reclamation Facility

NACWA Platinum Award 20

Plan to Convert from Chemical P to Bio P by 2020

300 MGD Full Treatment Capacity

90 MGD Annual Average

Liquid Treatment Processes

-Preliminary/Primary/ Secondary/Disinfection
-Chemical P removal

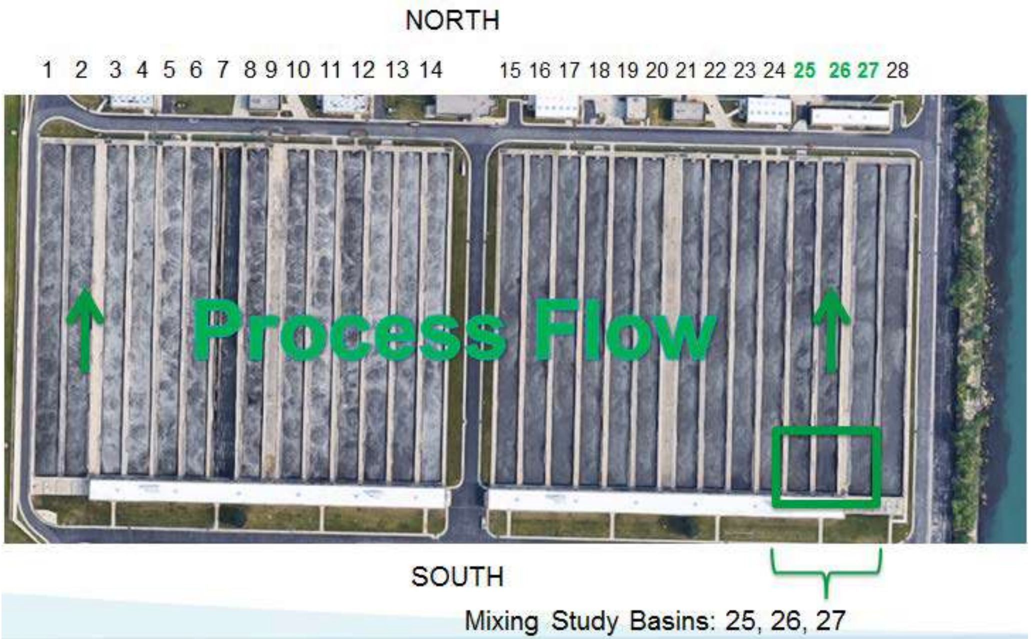
Solids Handling & Disposal

-Interplant pumping of solids
-GBTs and Plate and Frame
-Digesters Methane 1.3 MMCF

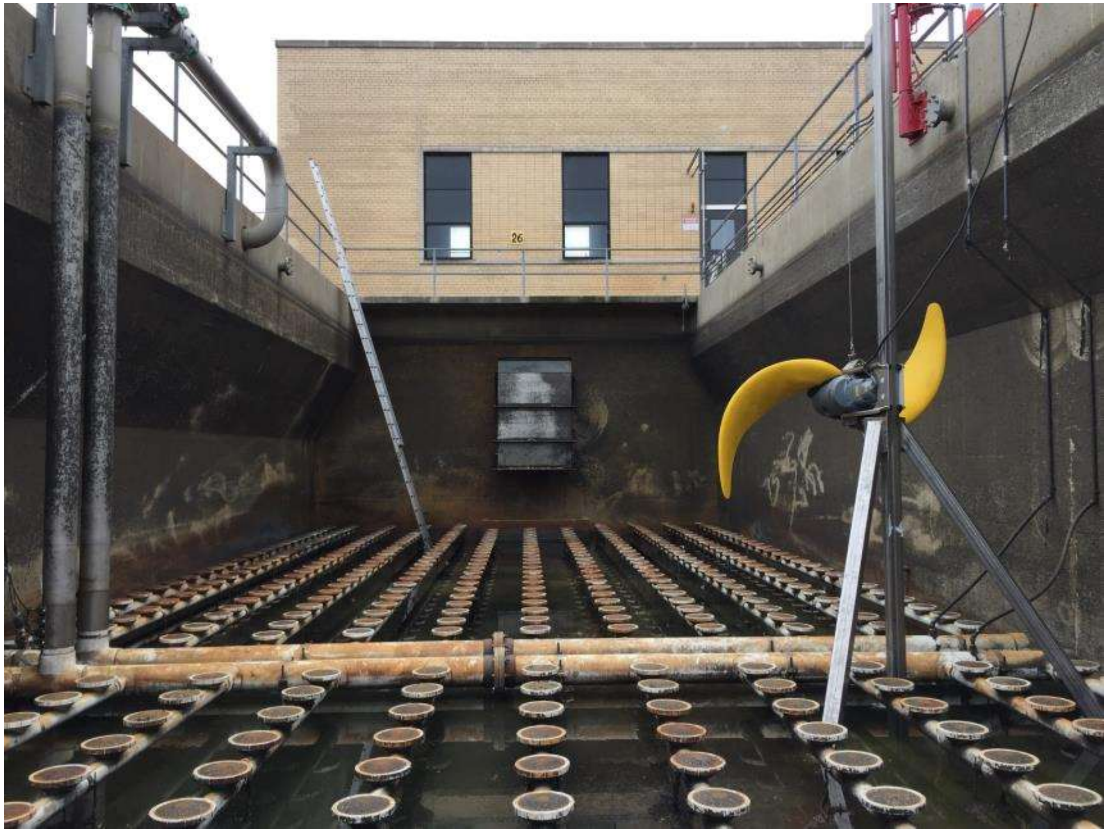
Study Comparing 3 Mixing Methods

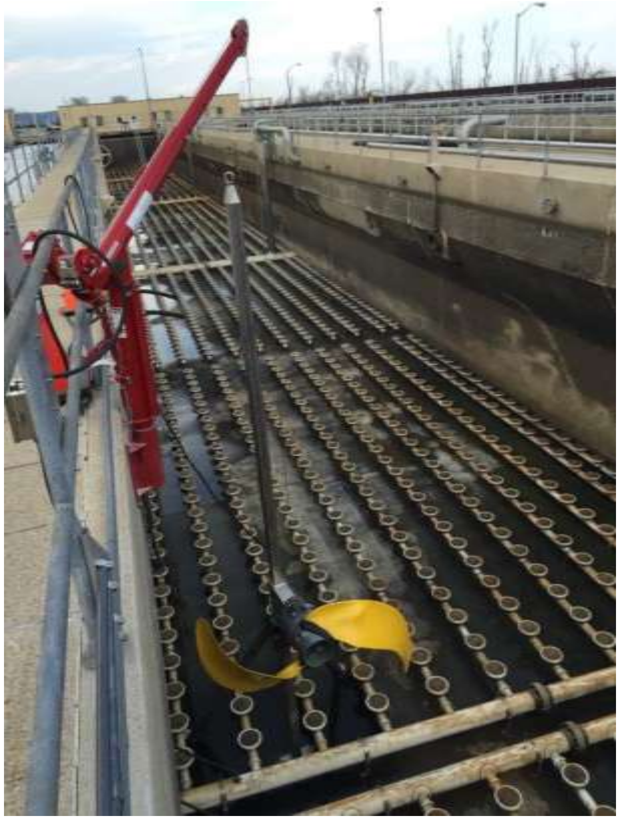
3 identical sized anoxic/anaerobic zones, 48 ft long x 30 ft wide x 15 ft deep

- Basin 25: Large Bubble Mixing System
- Basin 26: Submersible Horizontal Propeller Mixer with Adjustable Thrust
- Basin 27: Fine Bubble Diffused Air, turned down to mix and not aerate

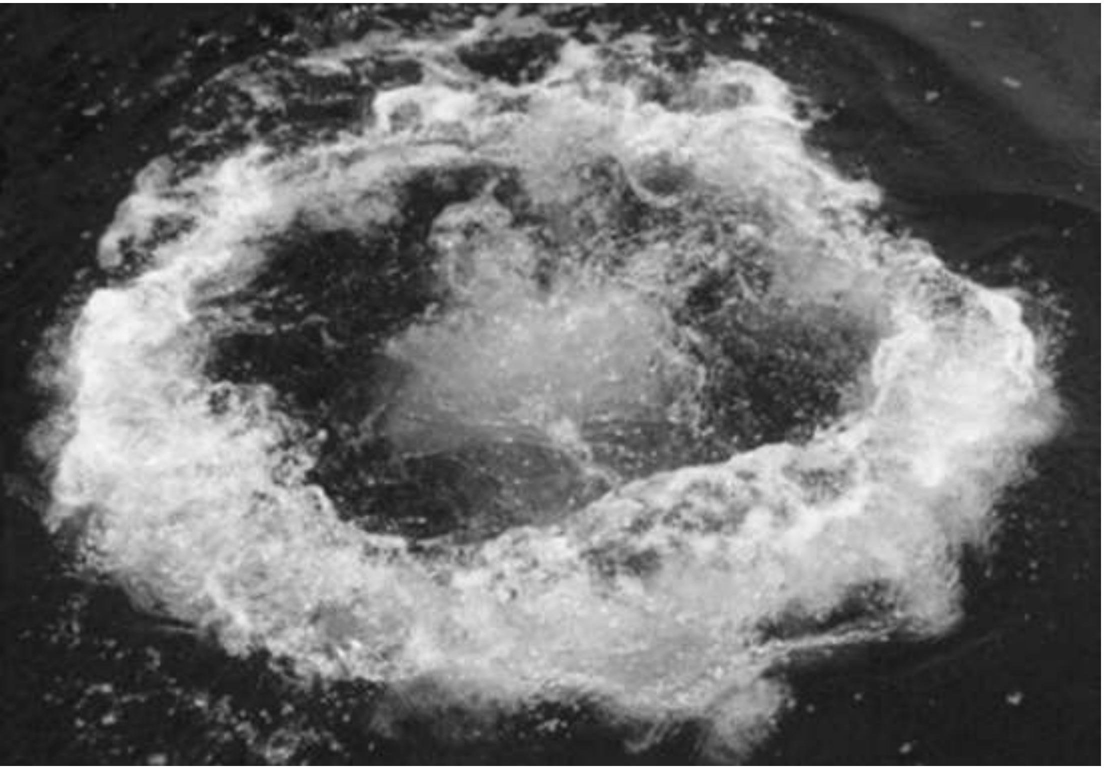


Submersible Horizontal Propeller Adjustable Speed (SHPAS) Mixer





Large Bubble Mixing



Reduced Air Flow Fine Bubble Mixing

Parameters Compared

- Quality of Mixing
- Conditions Favorable for BioP
- Energy Consumption

Quality Of Mixing

- Mixing Quality Index, MQI

$$MQI = \frac{1}{\text{STDEV of TSS Conc. along vertical and horizontal profile}}$$

- The higher the MQI, the better the Mixing

You can use this method for the following:

- Evaluate the performance of the same mixer at varying speed
- Evaluate minimum mixing energy required by a mixer to maintain a homogeneous solution
- Compare the performance of different type of mixers

We call this method as Arora Mixing Evaluation Method

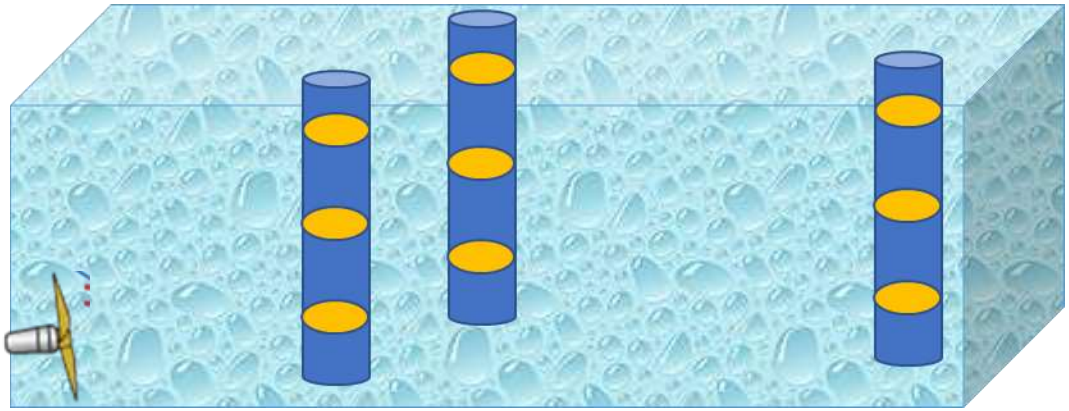
MQI Determination

- Sampling Location Selection: (0.3Y, 0.6Y and 0.9Y Depths)

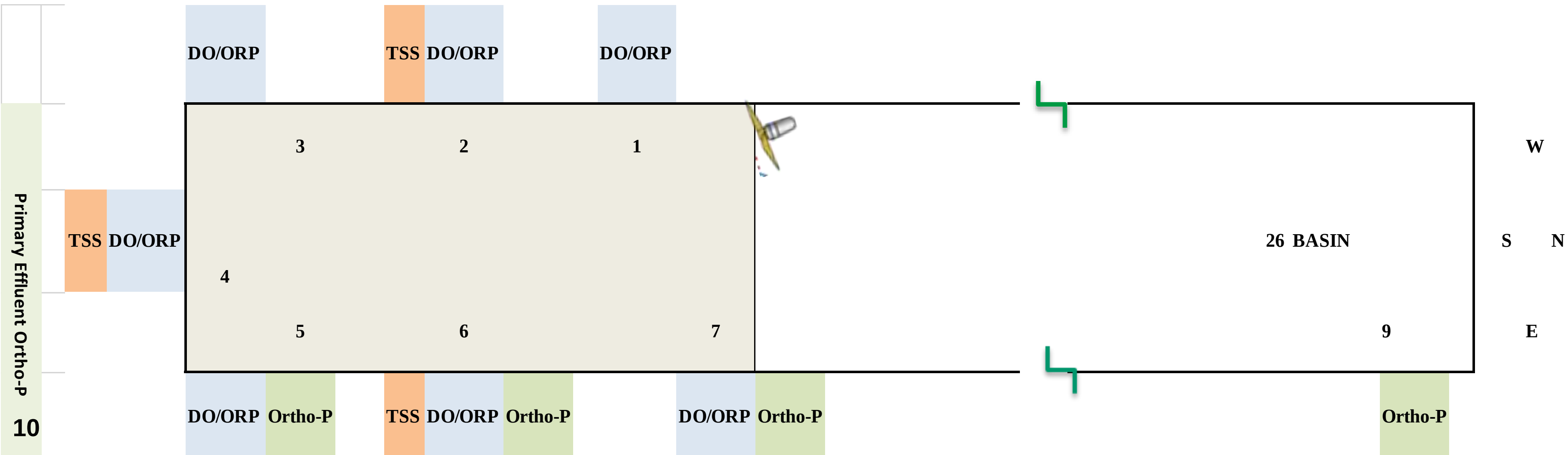
- Sample Collection:
  - Sludge judge pour off MLSS from predetermined depths
  - Hand held TSS Analyzer

- Concentration Measurement:
  - Handheld TSS Meter
    (like a Royce Meter Model 711)
  - Laboratory Tests

- Data Evaluation:
  - Stdev of 9 or more TSS conc
  - MQI = 1/Stdev
  - Calculate the MQI for 5 times
  - Determine Average MQI



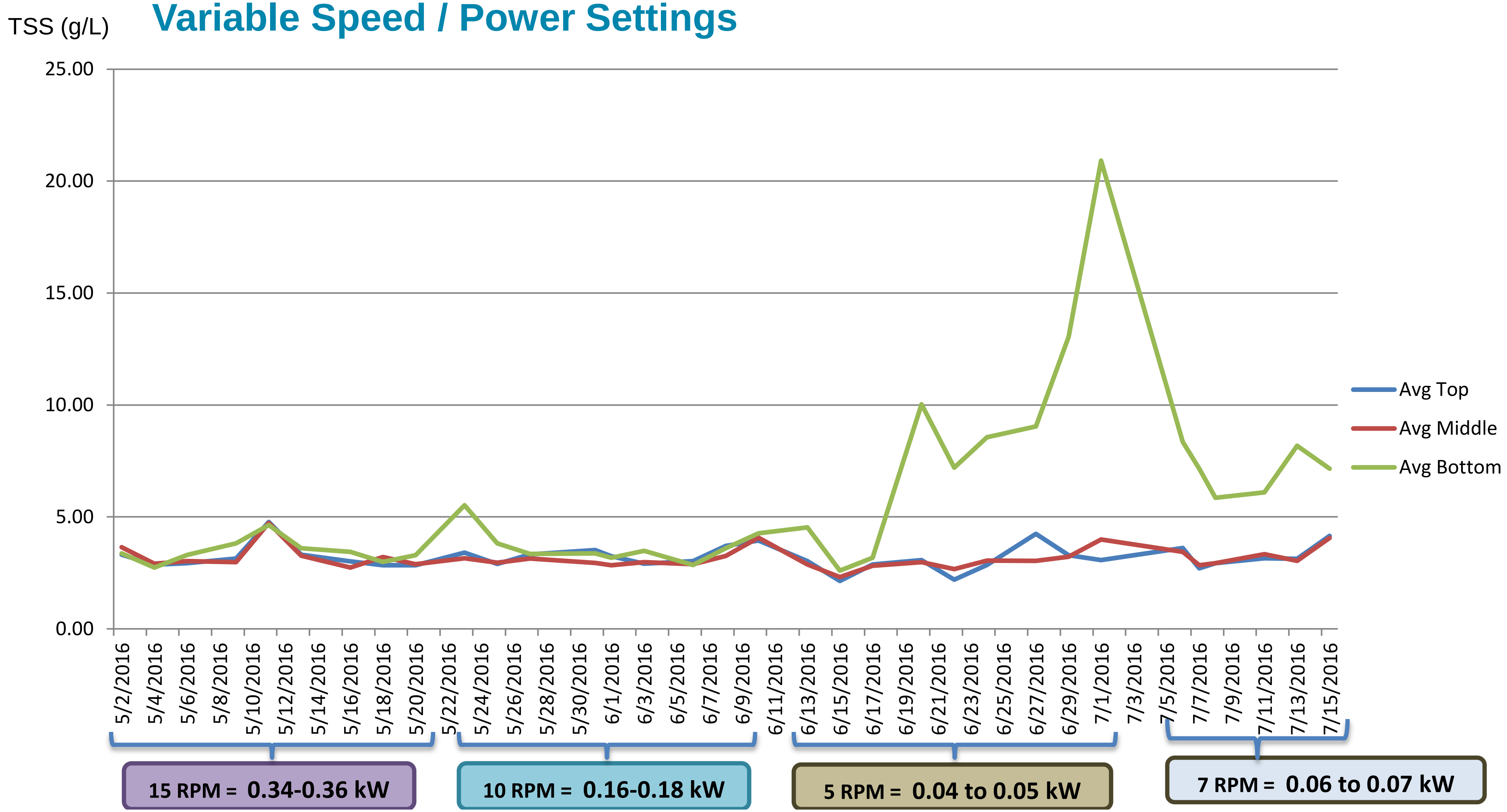
Sampling Locations



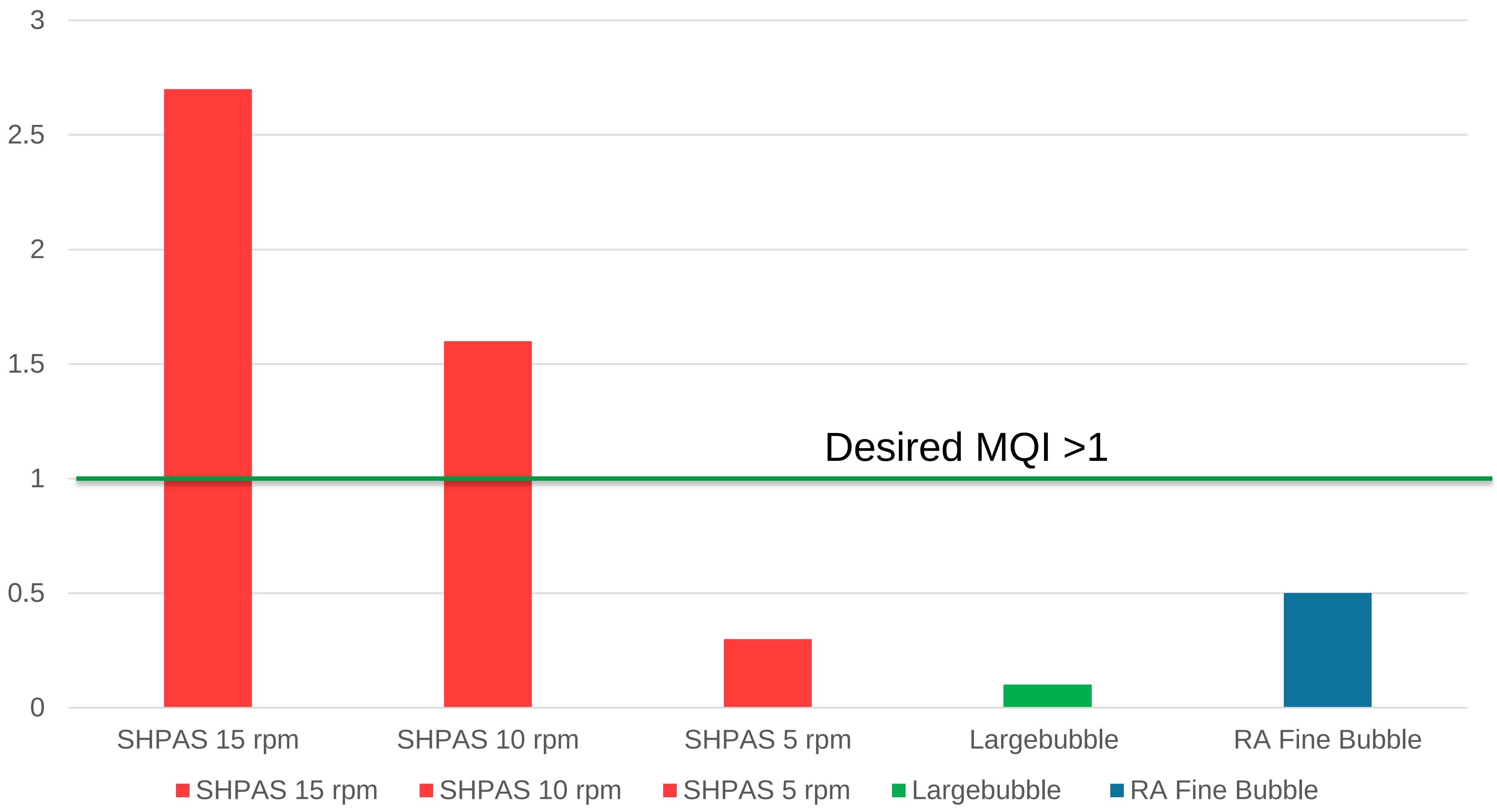
Standard Deviation of TSS

Submersible Horizontal Adjustable Thrust Propeller Mixer - Average TSS of Locations #2,4,6

Variable Speed / Power Settings



Mixing Quality Index – 3 mixers



Conditions Favorable for BioP

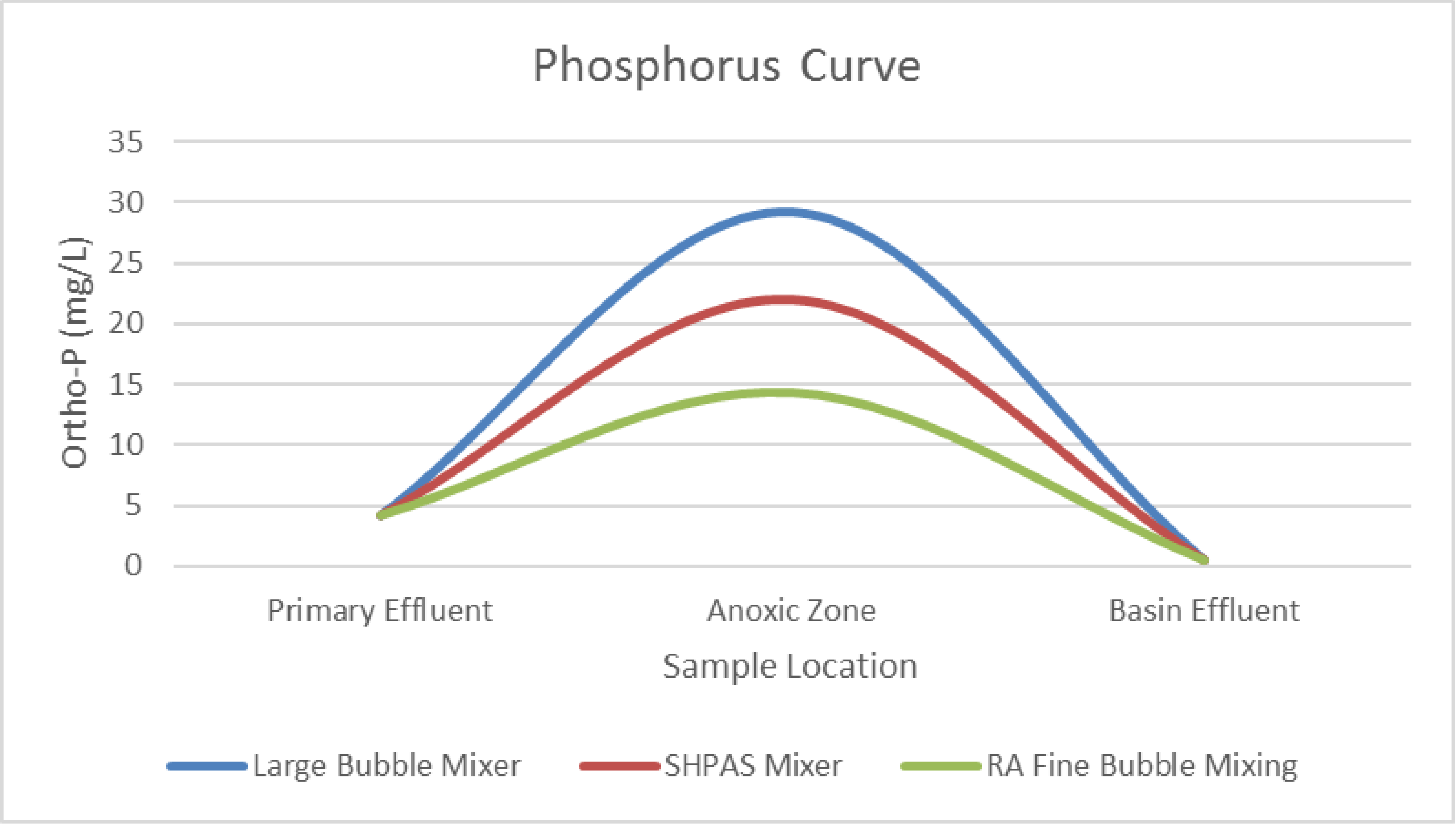
- Phosphorus Profile

    -P in Anoxic zone Vs Primary Eff

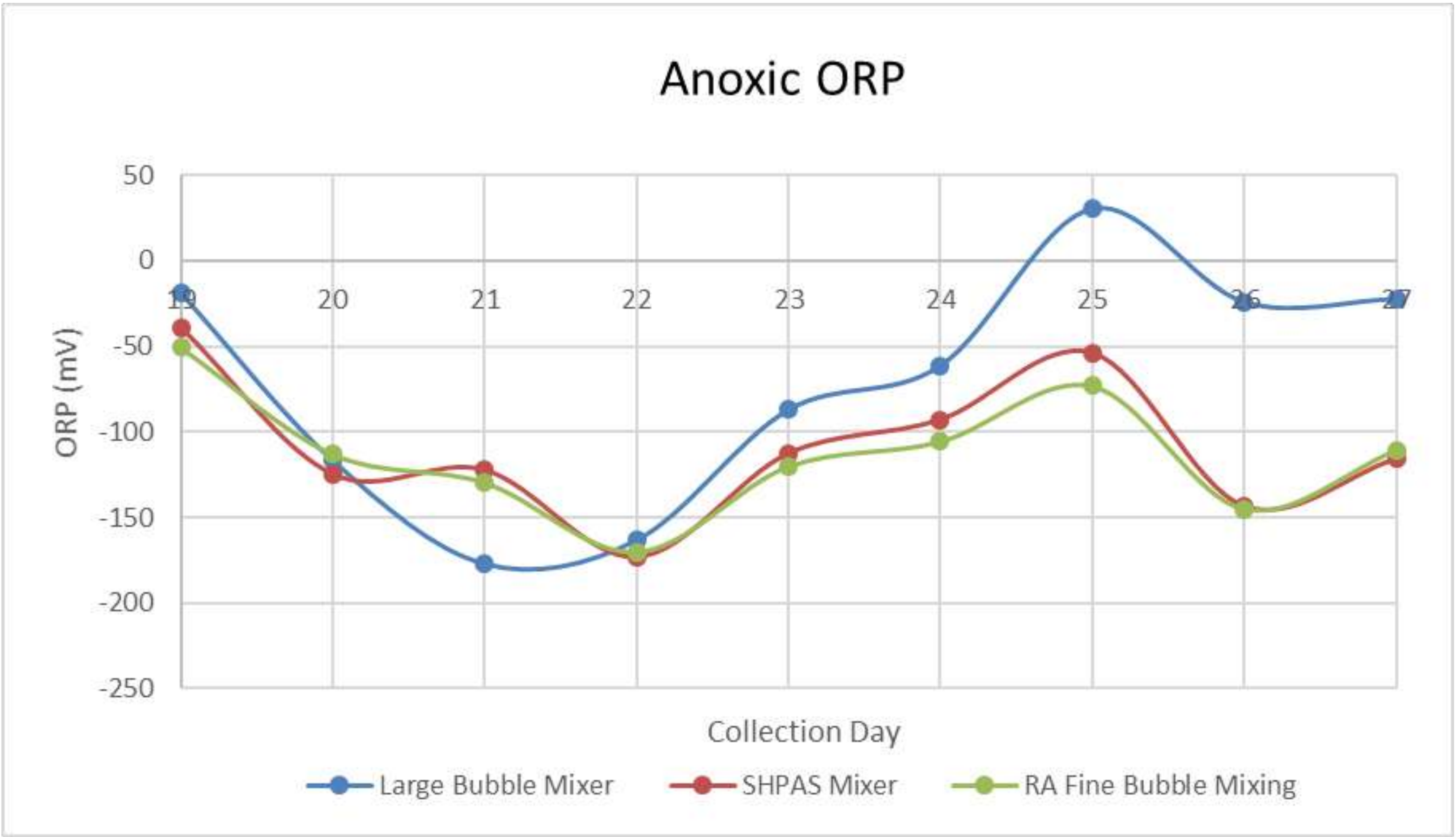
- Anoxic ORP

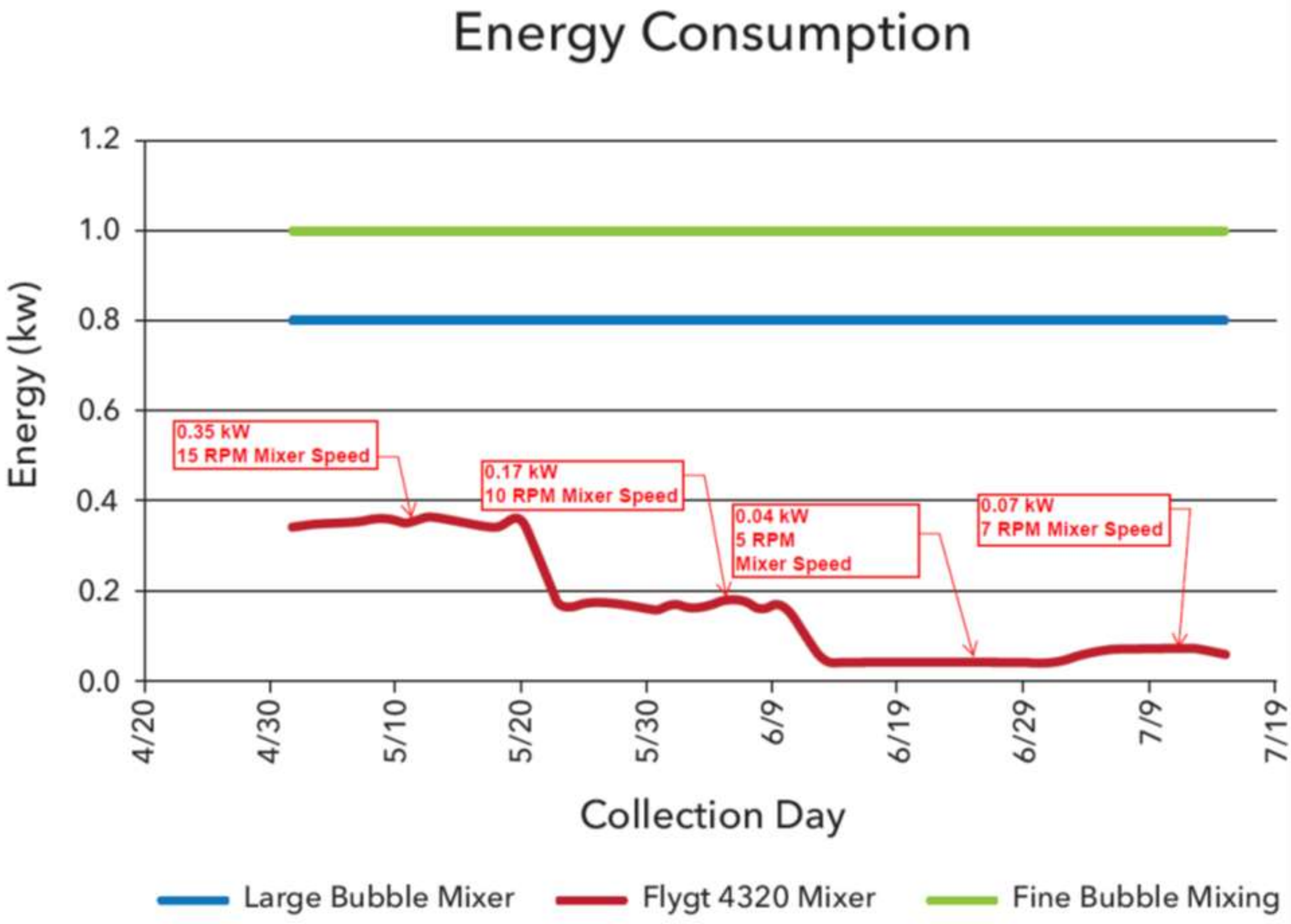
- Anoxic DO

Conditions Favorable for BioP



Conditions Favorable for BioP




Energy Consumption
Energy (kw)
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.35 kW
15 RPM Mixer Speed
0.17 kW
10 RPM Mixer Speed
0.04 kW
5 RPM
Mixer Speed
0.07 kW
7 RPM Mixer Speed
4/20
4/30
5/10
5/20
5/30
6/9
6/19
6/29
7/9
7/19
Collection Day
Large Bubble Mixer
Flygt 4320 Mixer
Fine Bubble Mixing

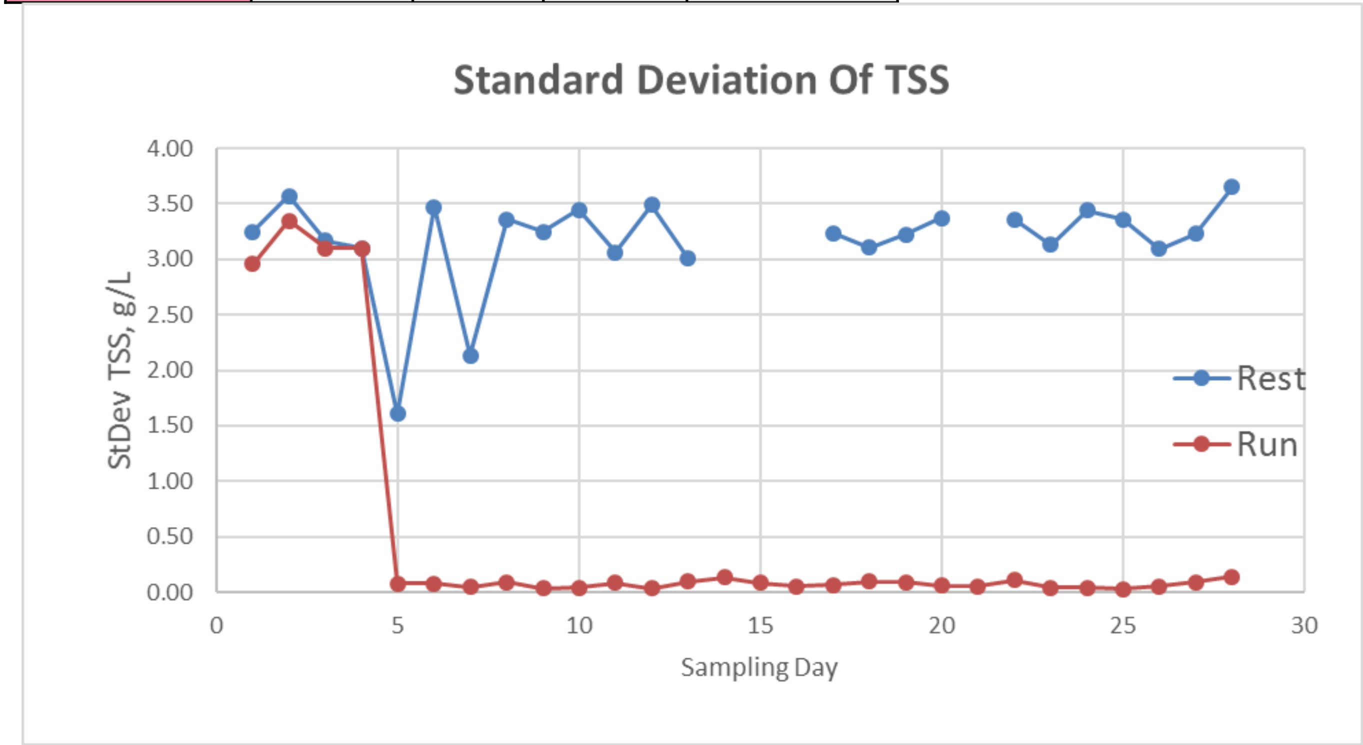
Samples and Results Evaluation

Test	Location (s)	Vertical Profile	Total Samples	Results Evaluation
1) Total Suspended Solids, TSS	2, 4, 6	Every 5 feet	9	MQI >1
2) Oxidation Reduction Potential, ORP	2, 3, 4, 5, 6, 7	1 foot from surface	6	Average < -100
3) Dissolved Oxygen, DO	2, 3, 4, 5, 6, 7	1 foot from surface	6	Average < 0.1 mg/L
4) Phosphorus	5, 6, 7, 9, 10	Scoop from top	5	$\frac{\text{Ave.Ortho P Location 5, 6, 7}}{\text{Ortho P Location 10}} > 2$

Next Steps:
Rest Run Cycles of the Mixer

Mixer Settings

Days	1 to 3	4	5 to 19	20 to 30
Rest Hours	11.75	11	11	11.5
Run Hour/s	0.25	1	1	0.5
RPM	15	15	30	30



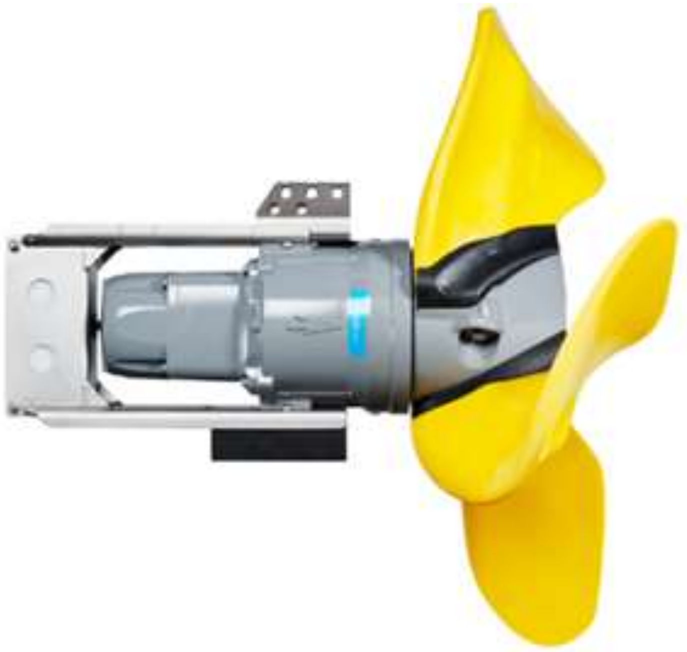
Goals of BNR Mixing

Applicable to any type of mixer

- Prevent settling
- Prevent short-circuiting of inflows
- Promote robust contact between microbes and wastewater.
- Minimize energy consumption
- Maximize process flexibility

Experience and Expertise

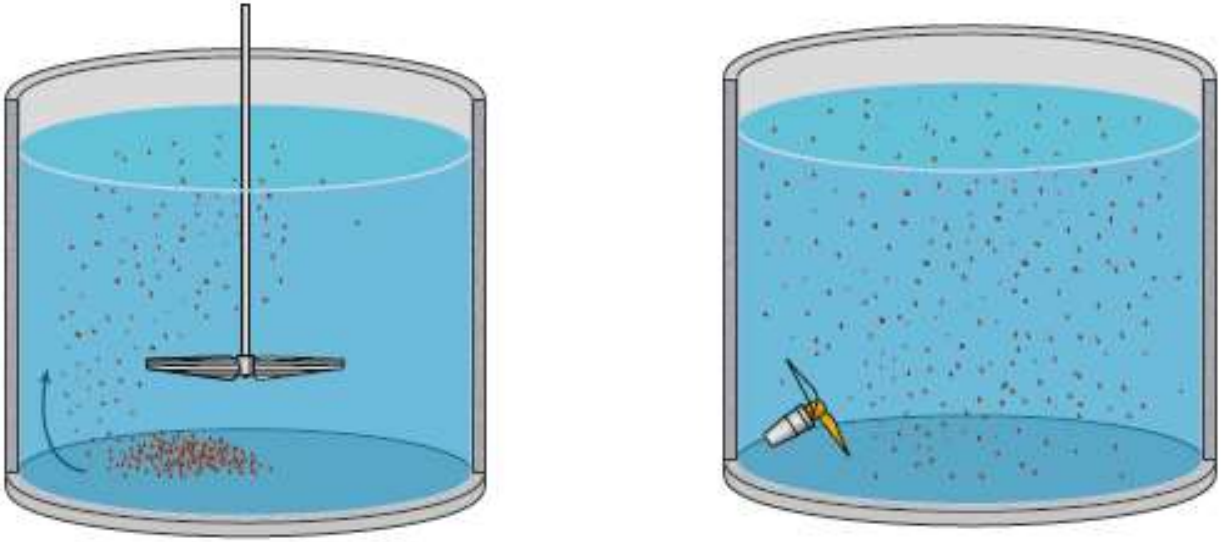
- Flygt invented the submersible mixer
- Wrote the book
- Pioneered mixing in BNR



Preventing Settling:

<u>Maintaining a Homogeneous Suspension</u>

- ✓ **Re-suspending solids off bottom or drawing down solids from surface crust**
- ✓ **Keeping solids in a homogeneous suspension**
- ✓ **Leveraging full tank volume**

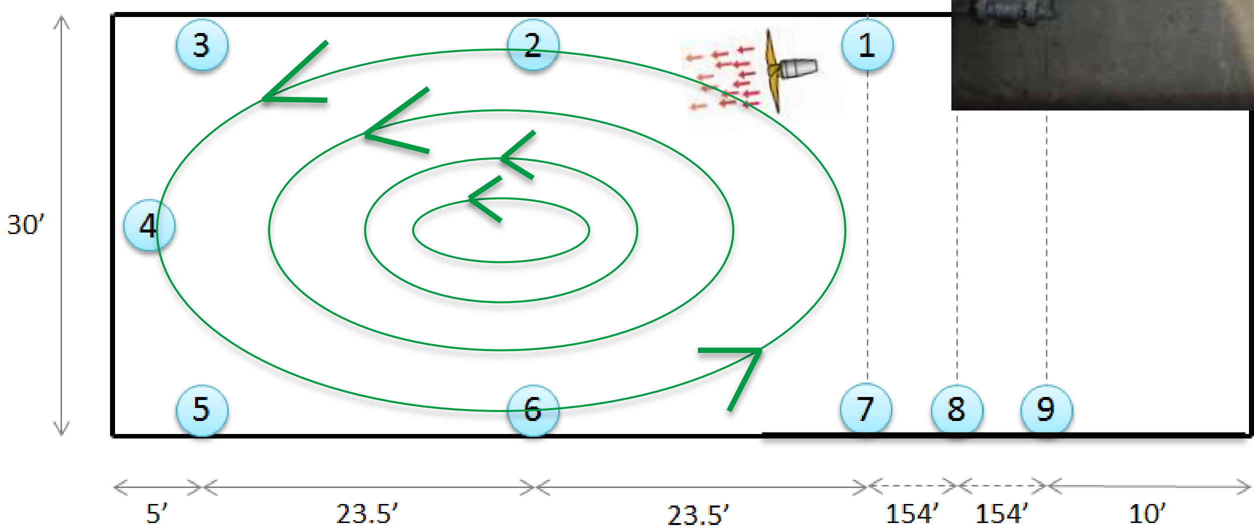


Prevent Settling

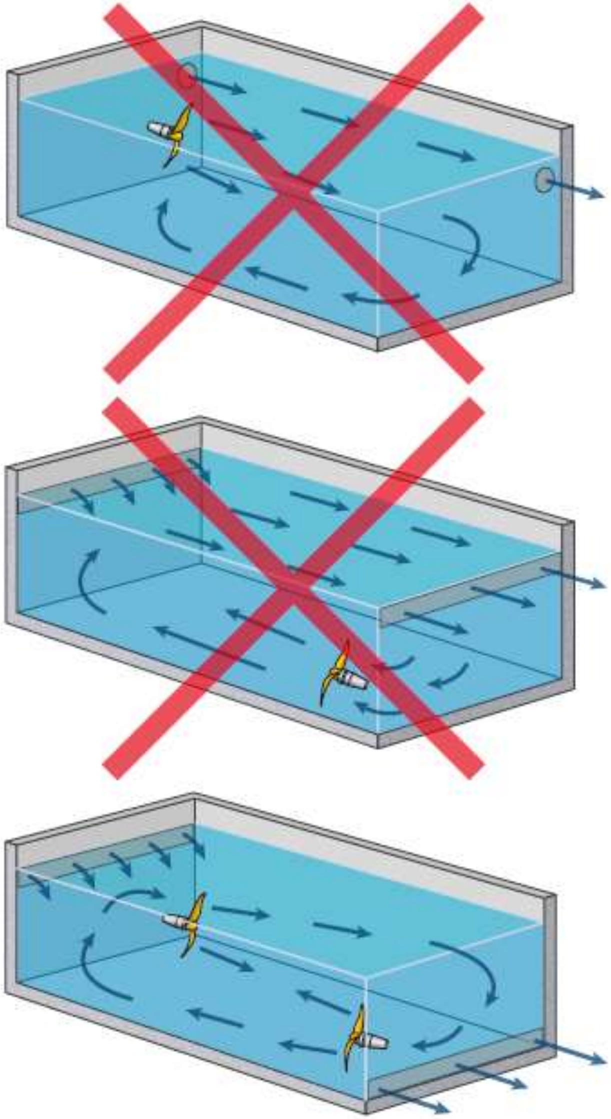
Measuring TSS Profile

9 readings over an array of points

Top-view of sampling locations:

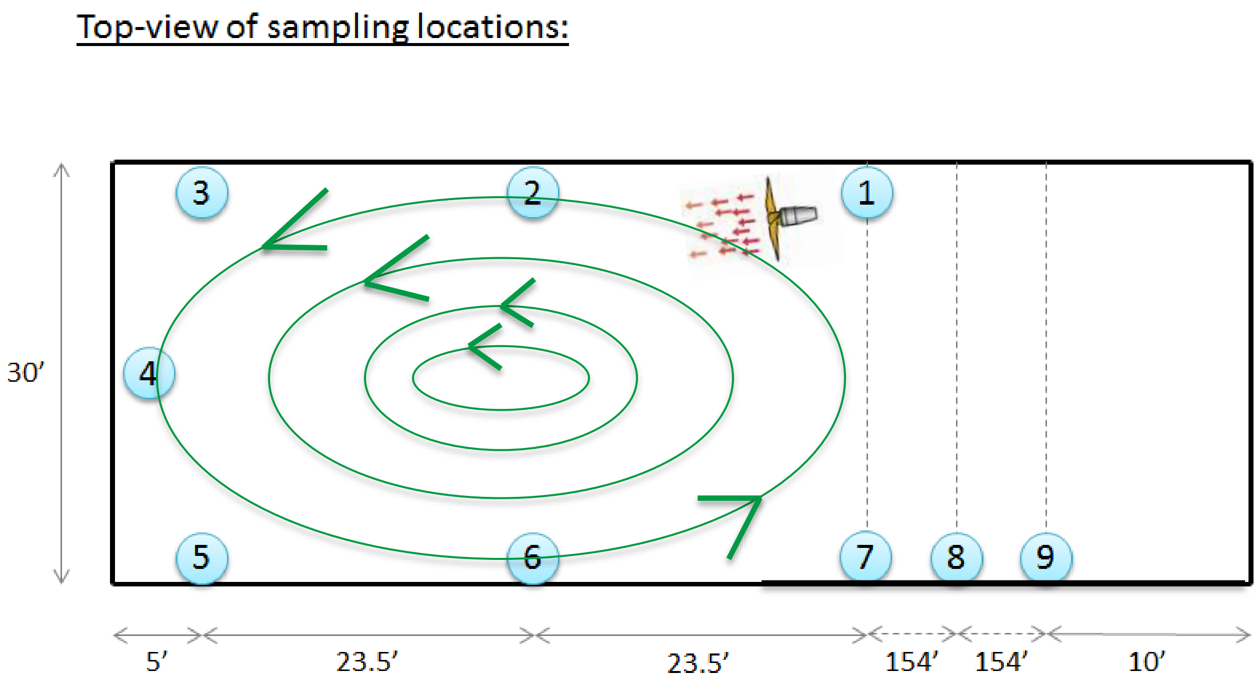


Prevent Short Circuiting:



Prevent Short Circuiting

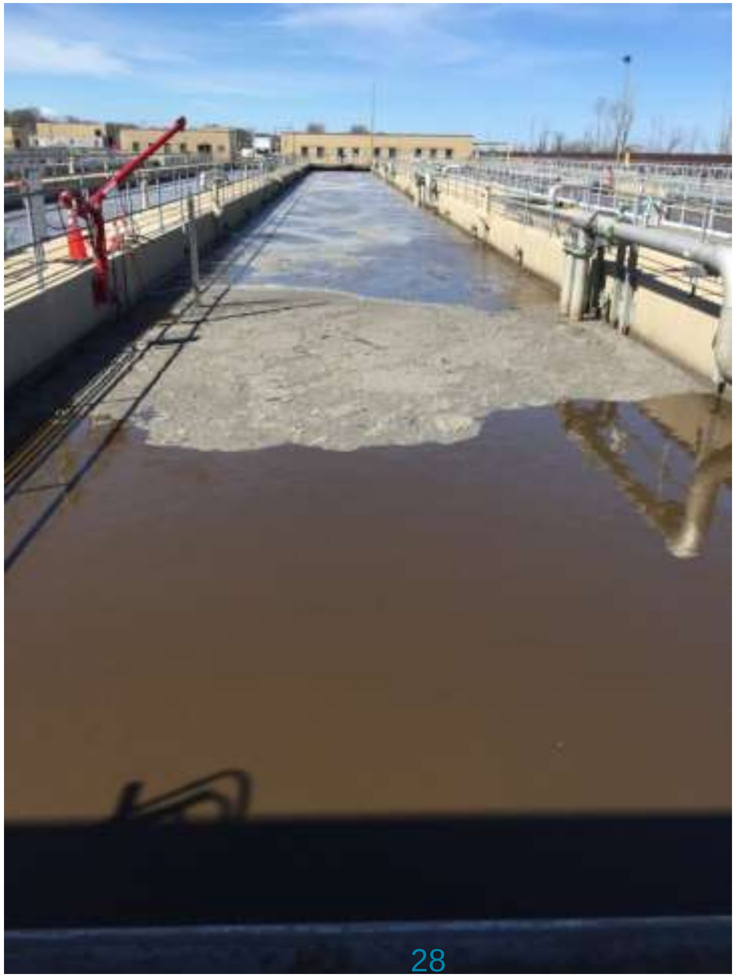
Prevent Short Circuiting: Bulk Flow Loop



Promote robust contact between microbes and wastewater

Maximize Process Flexibility

Scum is periodically cleaned by temporarily turning up the mixer speed



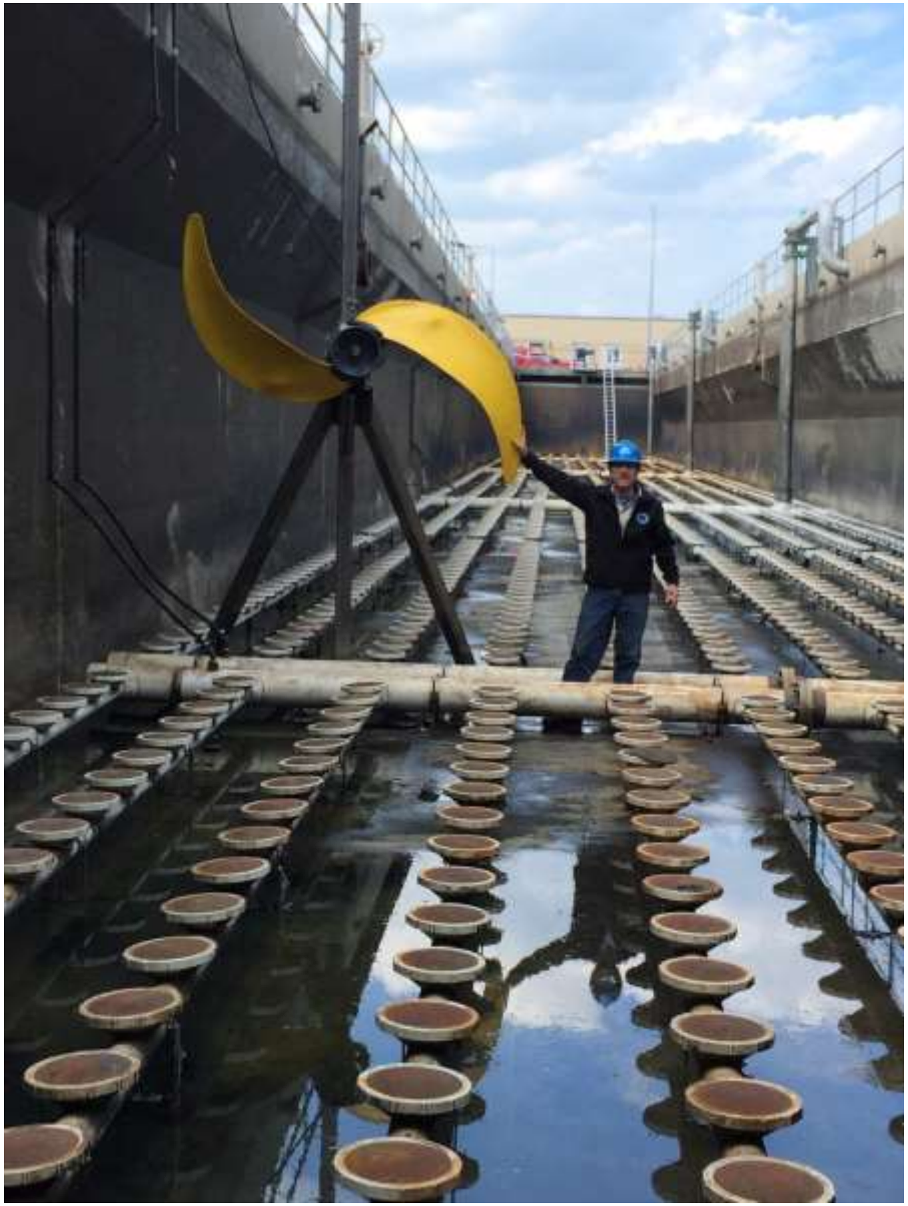
Goals of BNR Mixing

- Prevent settling
- Prevent short-circuiting of inflows
- Promote robust contact between microbes and wastewater.
- ***Minimize energy consumption***
- Maximize process flexibility

Minimize Mixing Energy

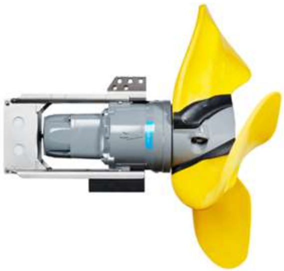
How was good mixing achieved with low mixing energy?

1. ***The mixer itself***
2. ***Smart mixer positioning***



Minimize Mixing Energy

How was good mixing achieved with low mixing energy?



1. The mixer

- **Low speed, High thrust-to-power ratio**
    - Large Diameter Low Speed Mixers have ***the highest published ISO 21630 thrust-to-power ratio*** of any submersible mixer
    - 5 times more effective than high-speed submersibles
- **Adjustable thrust via integrated VFD**
    - Enables operator to turn the mixing energy up or down to suit tank dimensions and process needs
- **Self-cleaning propeller does not collect debris**

Minimize Mixing Energy

How was good mixing achieved with low mixing energy?

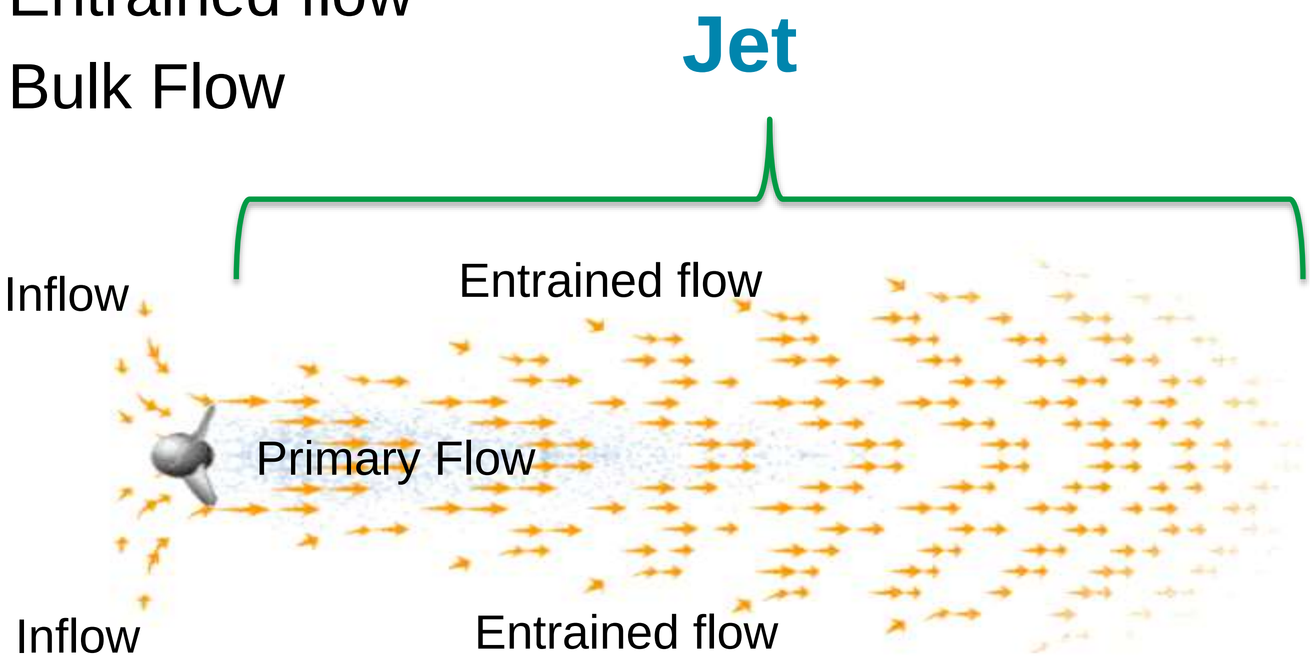
2. Smart Mixer Position

- Engineered to takes full advantage of the mixer jet within the basin geometry
- Minimizes hydro-mechanical losses

Smart Mixer Positioning
Creating Mixing and Bulk Flow

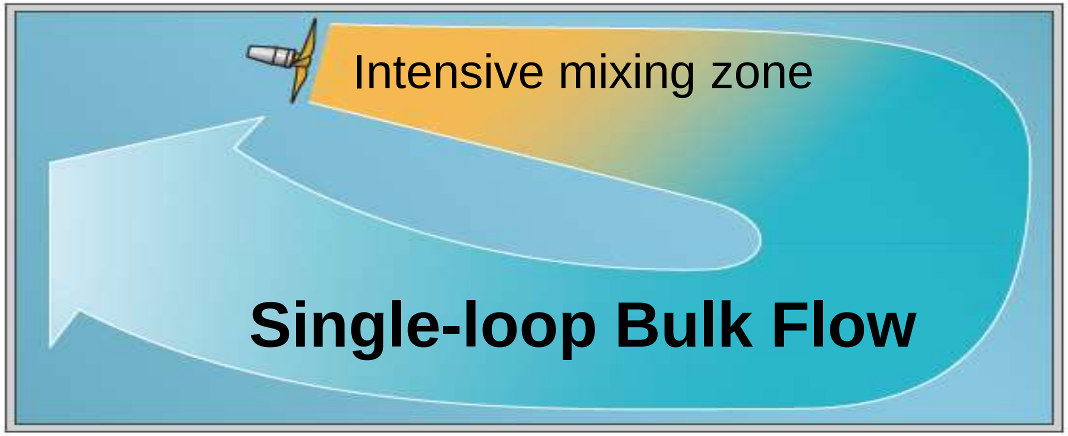
Many flows, one source

1. Inflow
2. Primary flow
3. Entrained flow
4. Bulk Flow

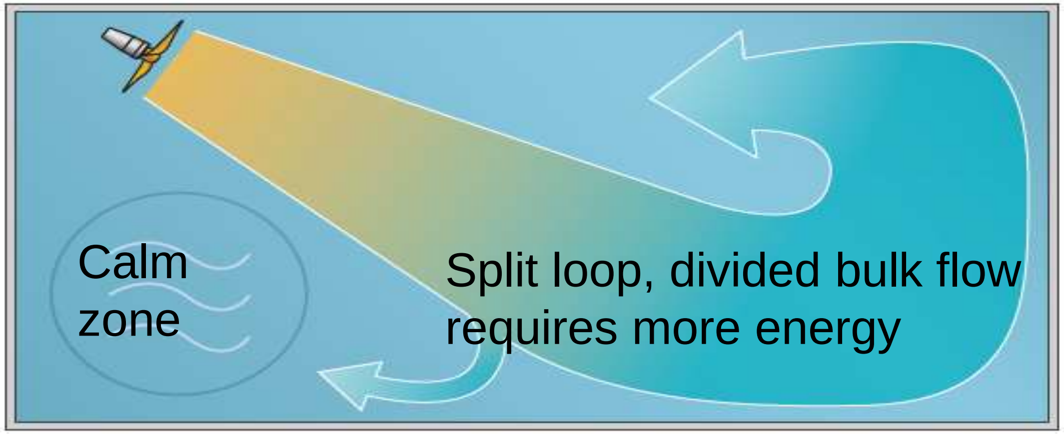


Smart Mixer Positioning
Creating Mixing and Bulk Flow

Good mixer positioning

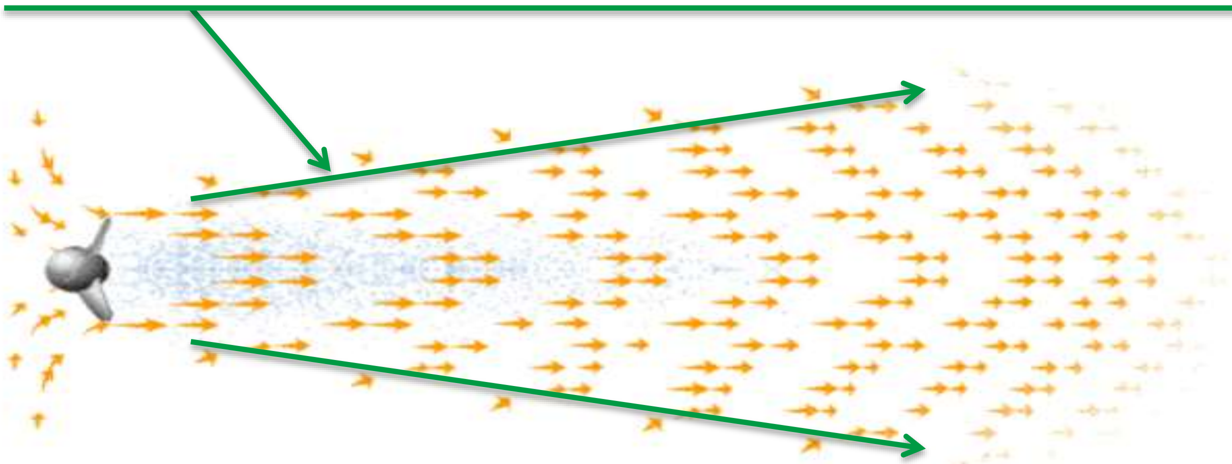


Not as good



Smart Mixer Positioning
Mixer Jet

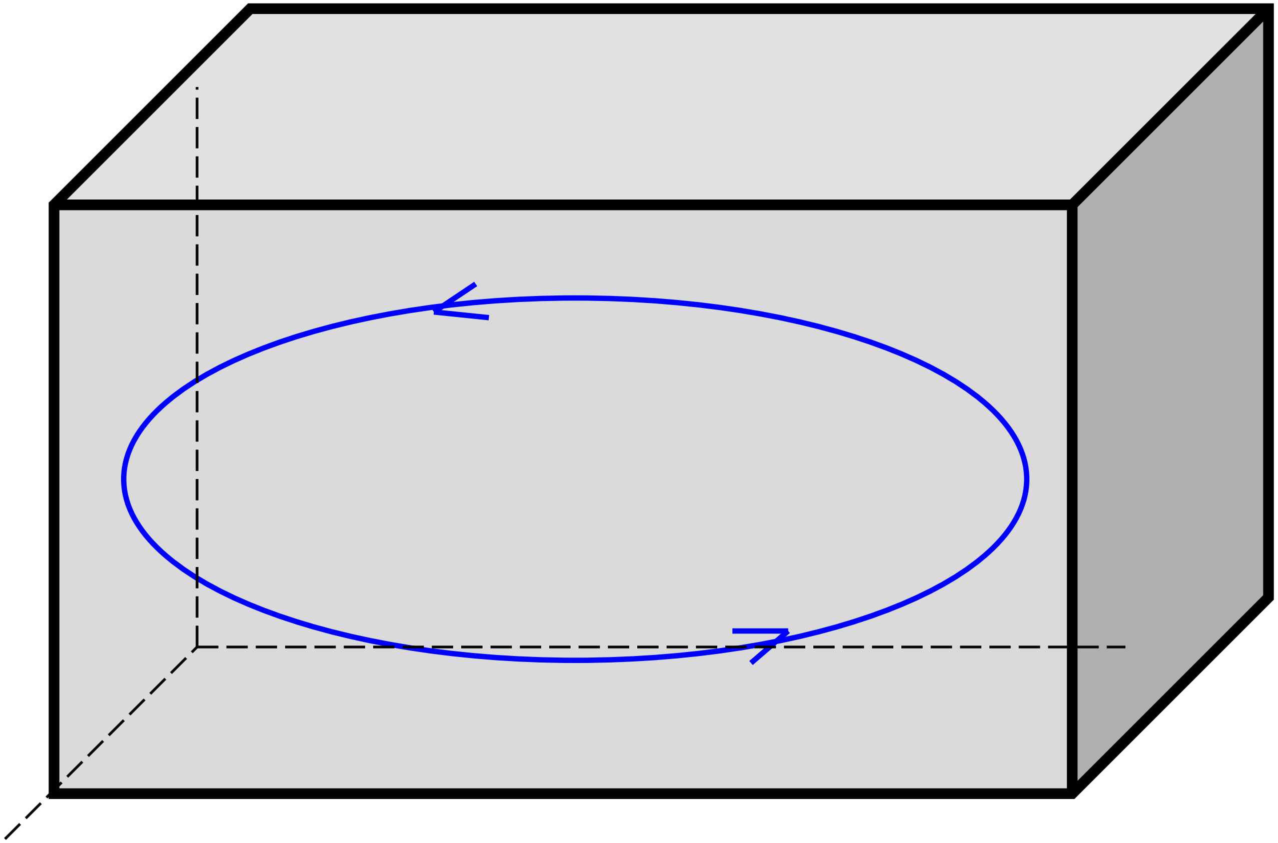
- Jet drives both primary flow and bulk flow
- Jet brings the surrounding liquid into motion
  - The surrounding low-velocity liquid is entrained
  - Majority of the mixing is not in the prop-area
  - Intensive mixing happens along the jet border



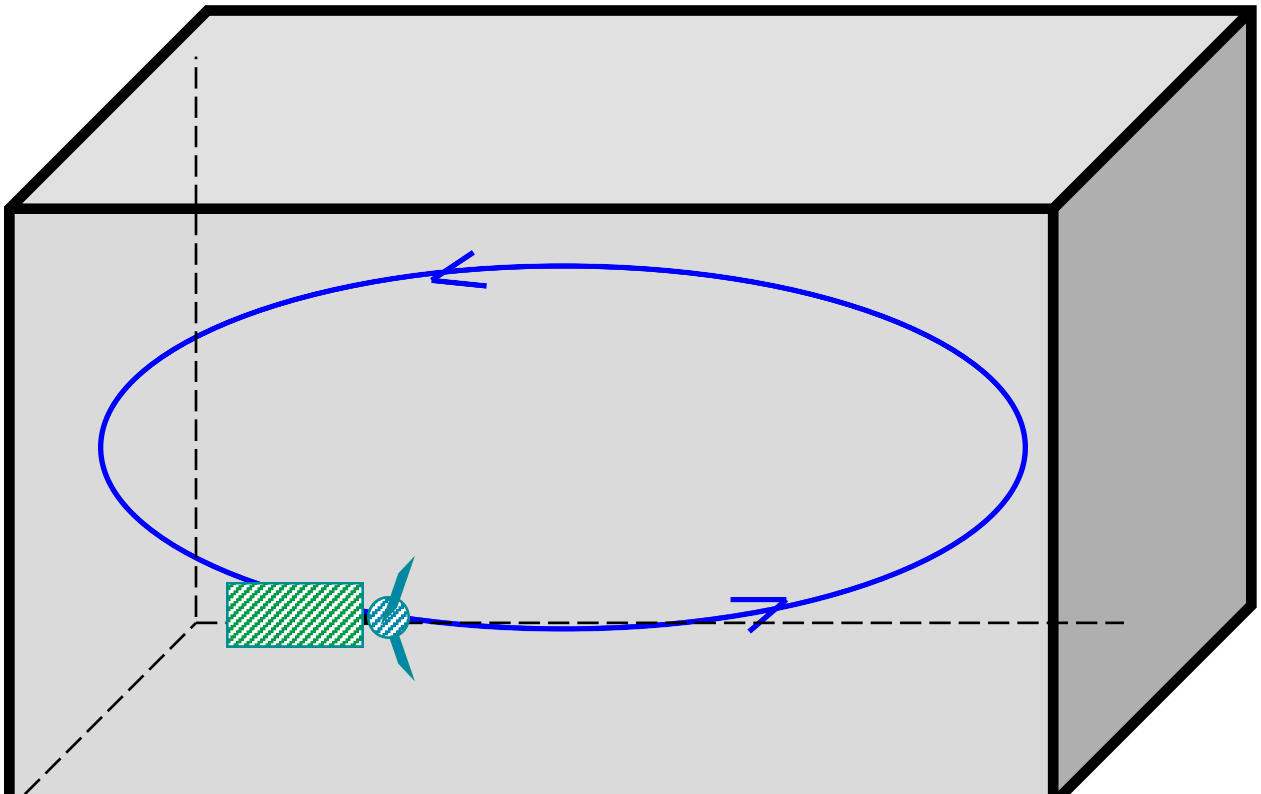
Smart Mixer Positioning for a bulk flow loop

1. Determine the most efficient bulk flow loop
2. Locate the mixer along the streamlines of the loop
3. Position for a long jet path
4. Smooth Jet deflection
5. Steer clear of obstacles

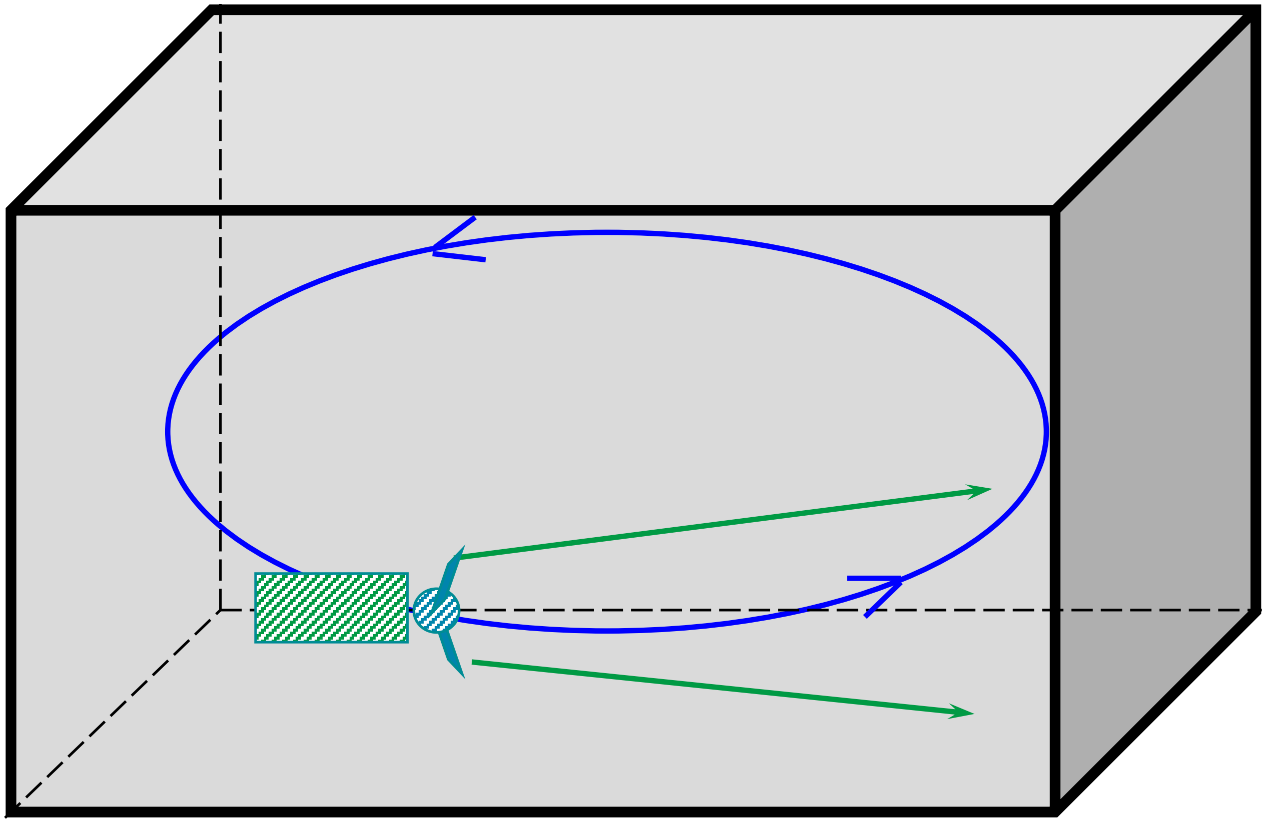
Smart Mixer Positioning
1. Determine the most natural, efficient bulk flow loop



Smart Mixer Positioning
2. Locate the mixer along the streamline of the loop



Smart Mixer Positioning
3. Position for a long jet path



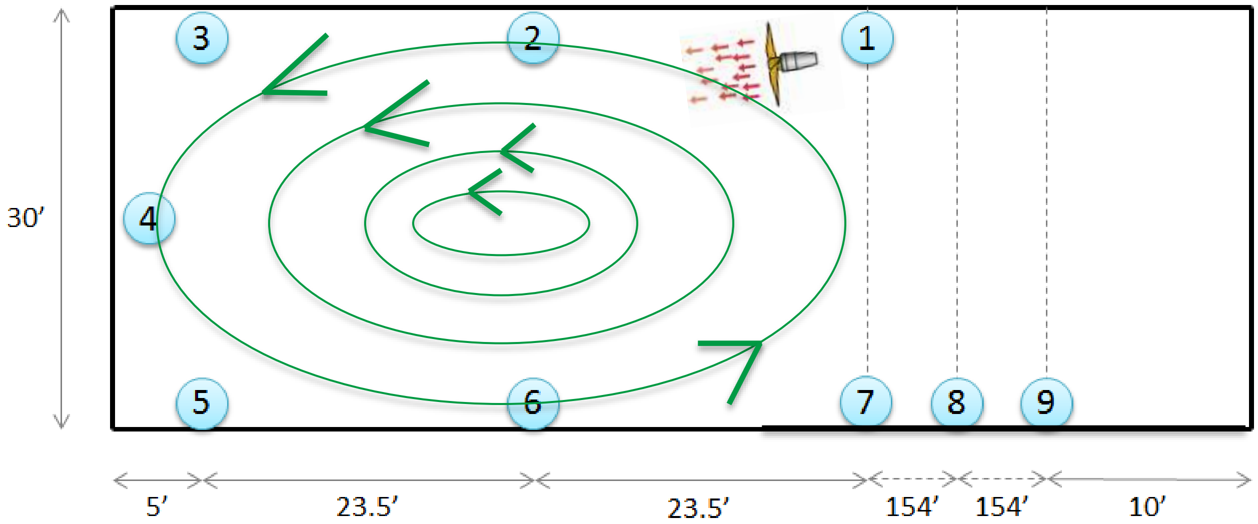
Long jet paths entrain more flow and develop stronger bulk flow

Smart Mixer Positioning

For this zone geometry, the mixer positioned in the corner of the mixing zone. creates the most efficient bulk flow loop with the least hydro-mechanical losses as it flows in a race-track shaped loop.

Smart Mixer Positioning
Bulk Flow Loop

Top-view of sampling locations:



Minimize Mixing Energy

Related reading:

Paper presented at WEFTEC 2015

How Oversized Mixers Became an Industry Standard

Carollo Engineers and authors form
City of Boulder, CO
and Seattle, WA

“Limited published data suggests that power levels much below the traditional design criteria… are able to maintain adequate mixing...”

Minimizing Mixing Energy

WEF Short-course Webcast

Mixing Activated Sludge

Fundamentals and Recent Advances in Low-Energy Mixing

- **WEF members are able to view the recording at no cost on WEFCOM, and non-members can purchase the webcast for $40 through the WEF Knowledge Center.**
- Activated sludge mixing is important for today's resource recovery engineers, managers, consultants and operators. With new regulations and discharge permits, many facilities need to upgrade their activated sludge processes to reduce both effluent-nutrients and energy requirements. For these upgrades, mixing is needed in a range of biological processes/basins like pre-anoxic, anaerobic, fermentation, anoxic, oxic, swing-zones, and centrate-holding basins. This WEF MRRDC webcast will cover fundamentals of mixing with a focus on activated sludge. It will also cover recent advances in mixing activated sludge with record-low energy (**in the range of 0.28 – 0.73 w/m3)** and broad flexibility using horizontal submersible propeller mixers. It will also cover the impact these advances are expected to have on design practices.

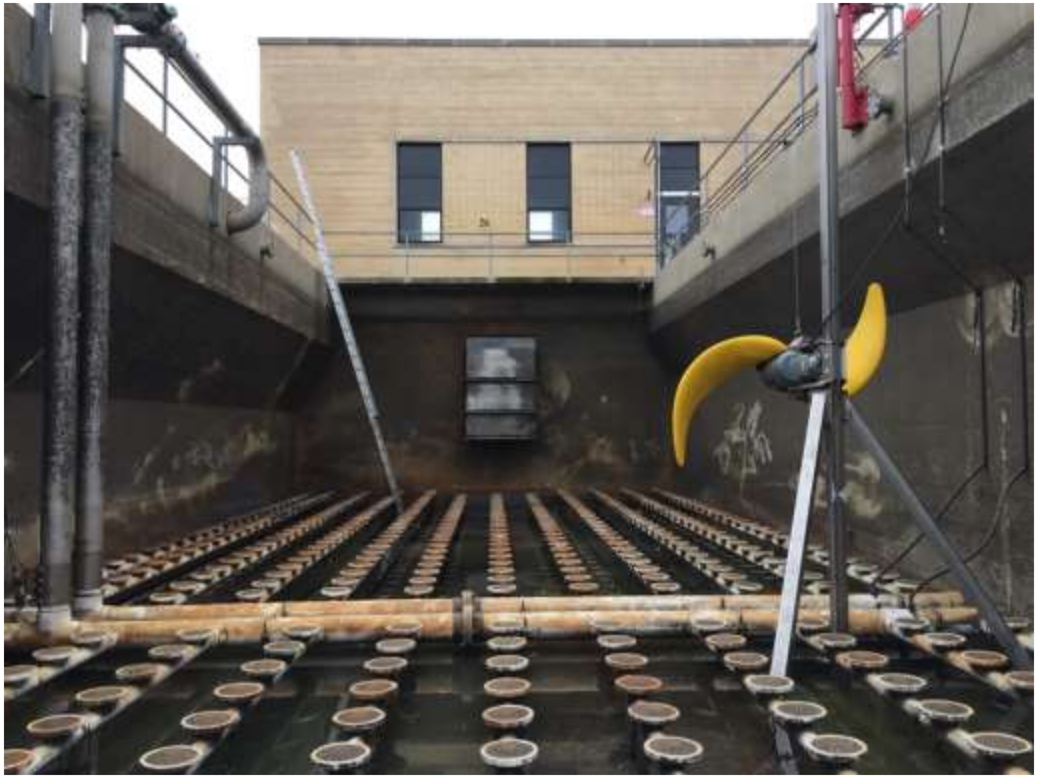
Conclusions and Implications for Future Standards

Conclusion from study
Energy Consumption: How low can you go?

Mixing Energy:
Lowest by far with SHPAS mixer speed set to 10 RPM
- 0.17 kW
- 170 Watts

Zone Size:
- 48 feet long
- 30 feet wide
- 15 feet deep
- 21,600 cubic feet

Power/Volume
- 0.28 W/cubic meter
- 7.87 W/1000 cubic feet
- 0.011 HP/1000 cubic feet



Conclusion:

Mixing energy as low as
0.28 Watts/cubic meter
can sufficiently mix activated sludge using Submersible Horizontal Propeller Adjustable Speed (SHPAS) Mixing with smart mixer positioning.

Implications for Future Standards

- **Expect revisions to published guidelines to reflect new findings**
- **Updated MOPs** relating to mixing:
  - MOP 8, MOP 34, and MOP-37
- **Meanwhile, check with trusted suppliers for selections and system designs**
- **Look forward to lower energy mixing in activated sludge!**

Questions?