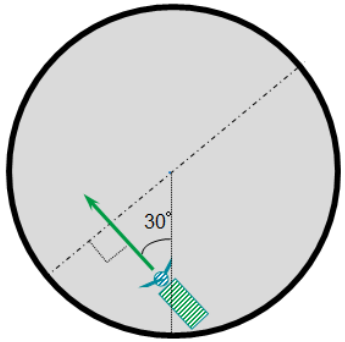
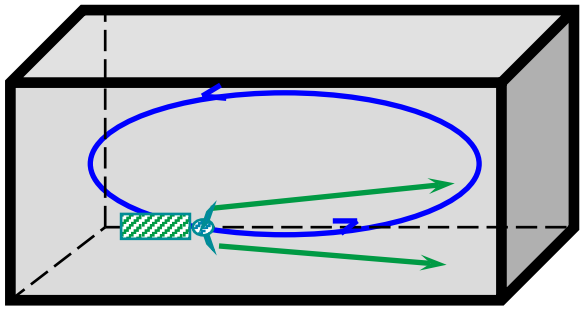
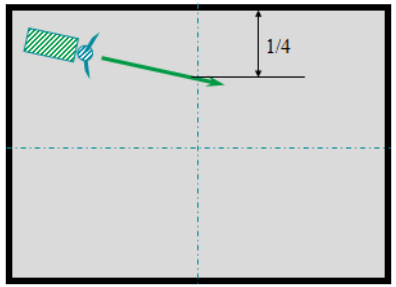
Mixing Guidelines for Biological Nutrient Removal

WWOA Conference 2015

Jim Fischer, PE







A brief History
Submersible Mixers: 50+ Years

- Submersible mixers invented by Flygt and first commercial versions in 1958!
- Photograph of set up with flow guide for ice prevention.

1975

Manure mixing trial

Overwhelming results

Sparked

- renewed interest
- Re-dedicated effort

What we discovered

The advantage with submersible mixers:

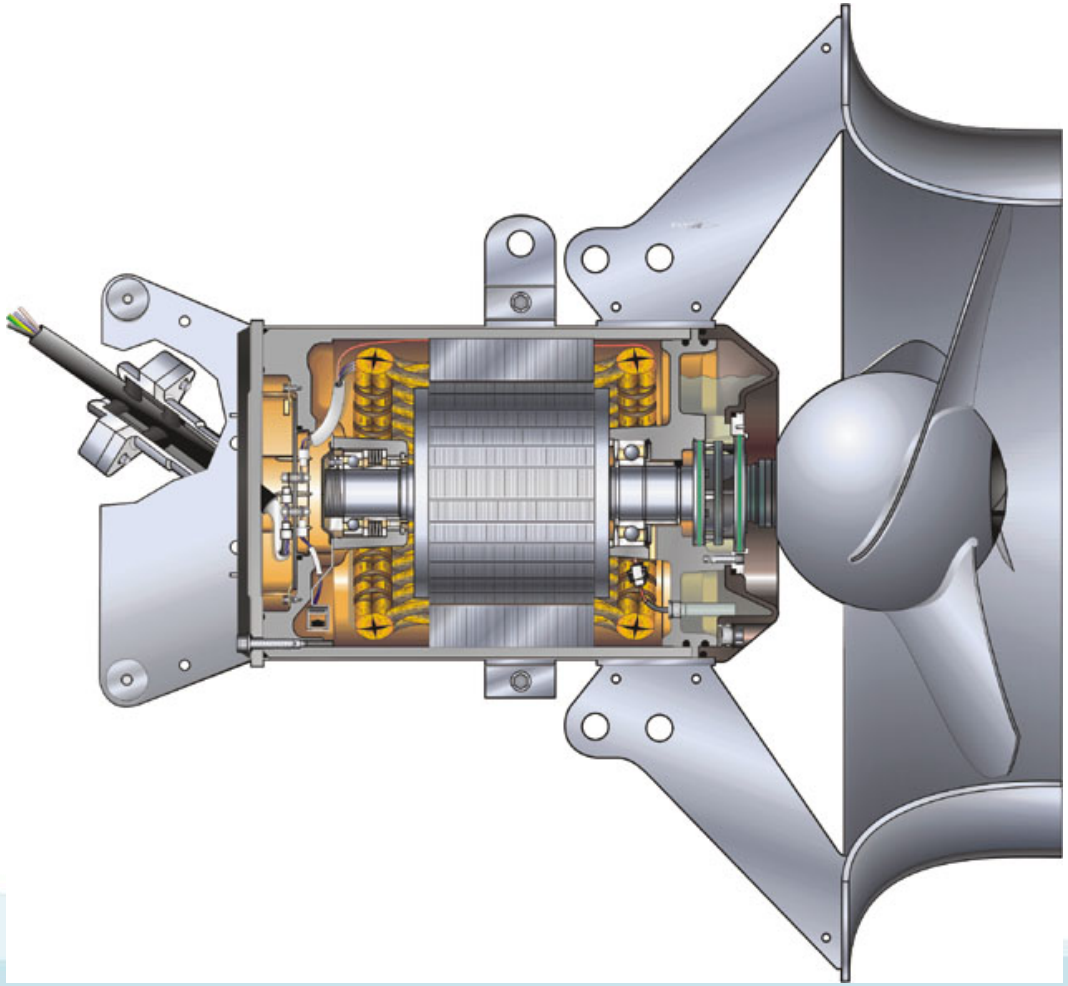
- Freedom of Positioning

1977

Submersible mixer
re-introduced to the world

Four sizes from 1.5 to 20 HP

1992
BNR Market
Compact Mixers



Mixer and Agitator Product Line

FLYGT
a xylem brand

Submersible compact mixers

4610-20 4630-40 4650-60 4670-80

Compact HE

4650 LSPM

New mk2

Top entry agitators

4850 4860 4870

Submersible midsize

4530 4460 7.5kW

New

Submersible low-speed mixers

4410 4430 4460

Jet mixers

JT4710 JT4715 JT4720 JT4730 JT4735

Hydro ejectors

JP4710 JP4715 JP4720

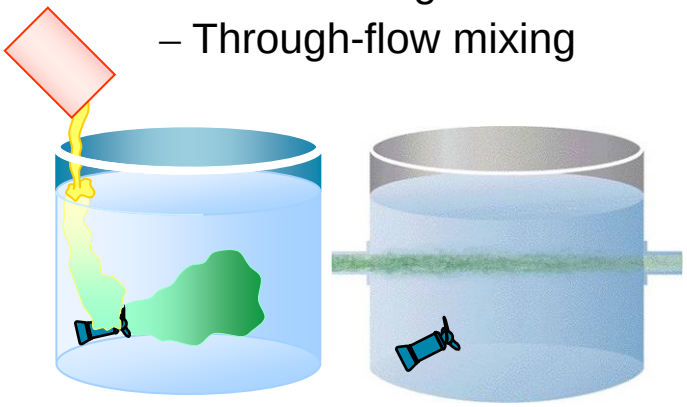
Ultra-low-head pumps

PP4630-PP4680

Installation Equip.

Common Mixing Duties

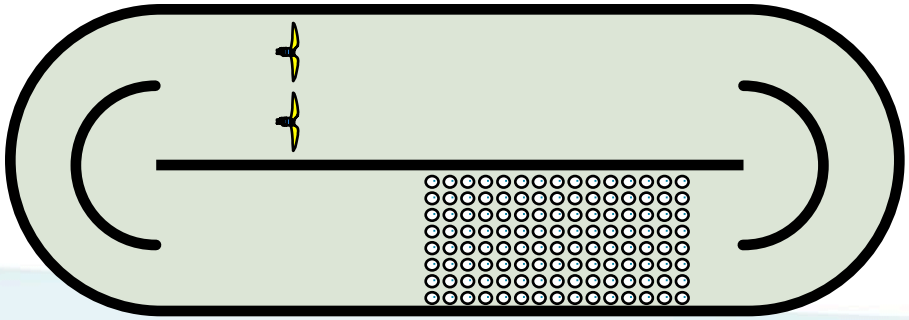
- Blending soluble liquids
  - Batch mixing
  - Through-flow mixing



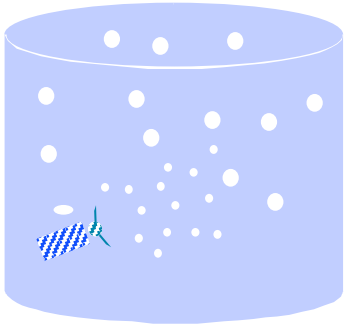
- Suspension
  - Re-suspending solids off bottom or drawing down solids from surface crust
  - Keeping solids in a homogeneous suspension

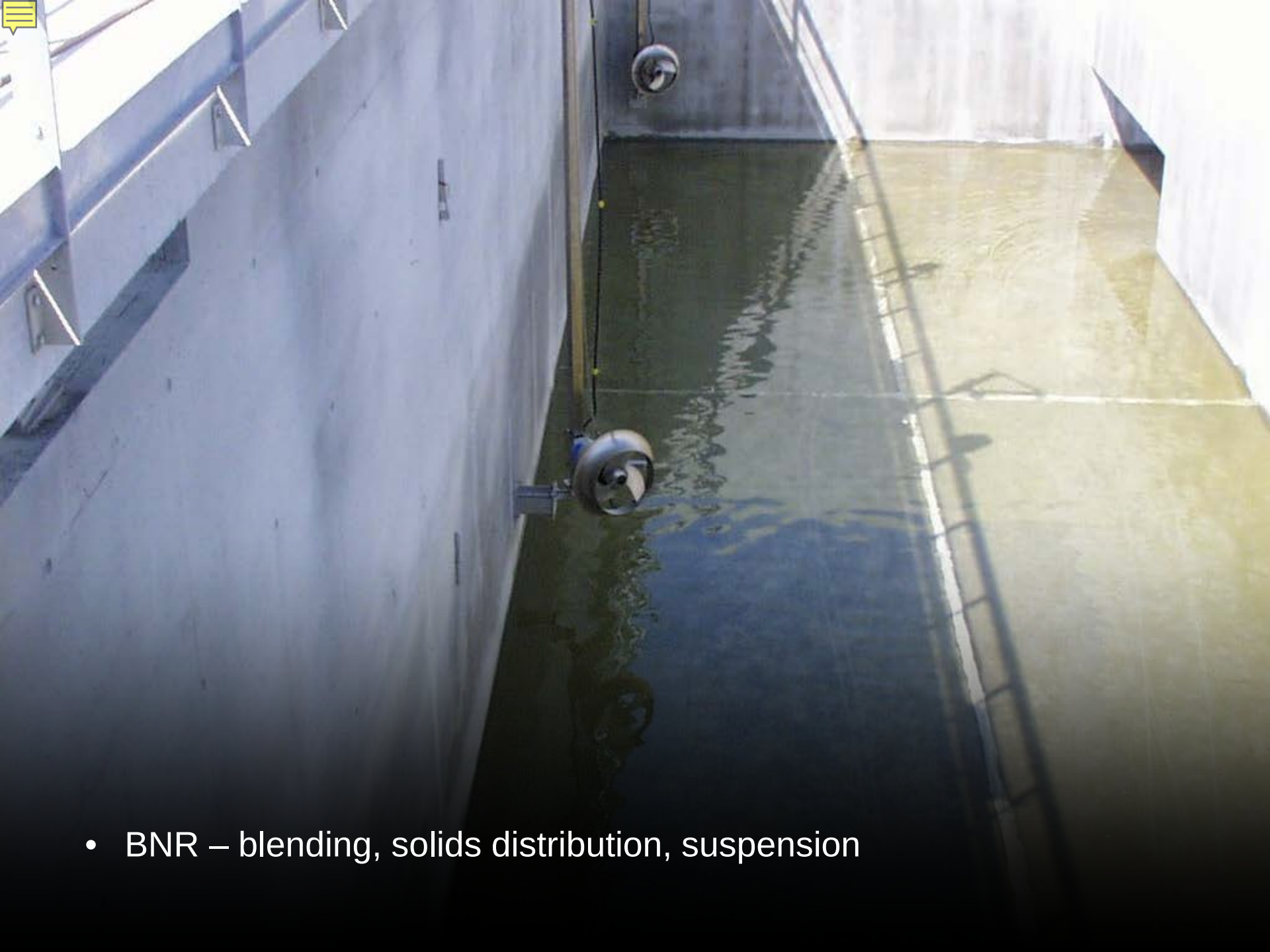
- Circulation

- Providing flow as in Oxidation Ditches



- Dispersion
  - Breaking up and distributing droplets, bubbles or particles





- BNR – blending, solids distribution, suspension

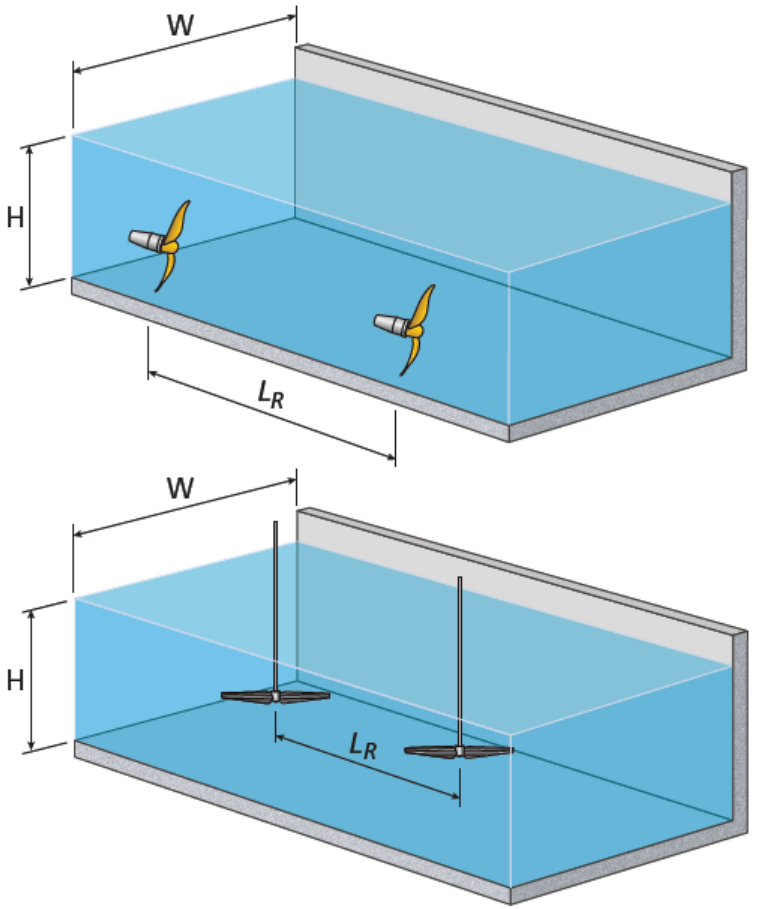
Mixing goals for BNR:

1. Prevent settling
2. Prevent short-circuiting
3. Force good biological contact
4. Minimize energy use

Repeat distance L_R or the required number of mixers

$L_R = 2.5\ W - D$ (SM/JM)

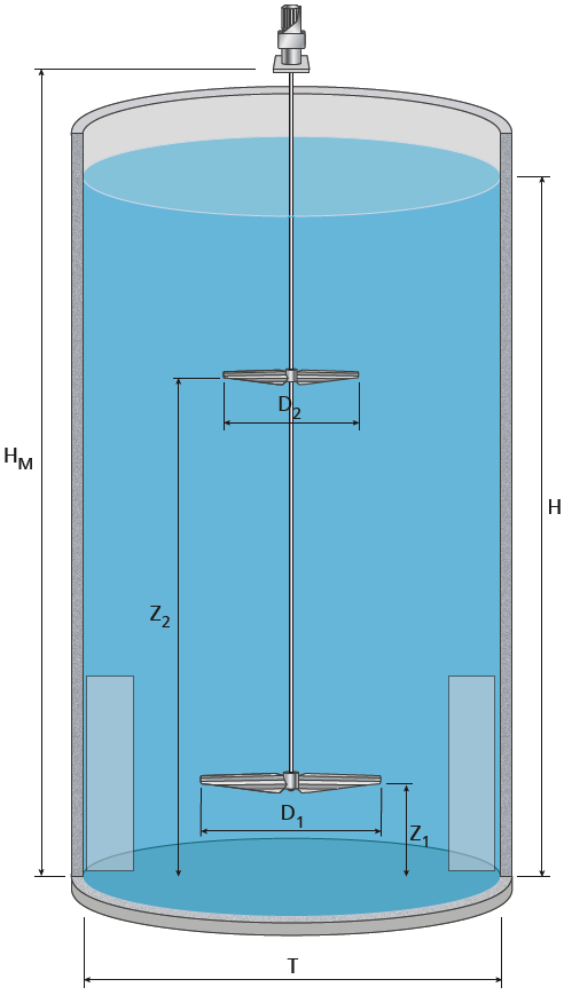
$L_R = 1.5$ (up to 2) W (TEA)



Multiple impellers in a tall narrow tank

Rule of thumb:

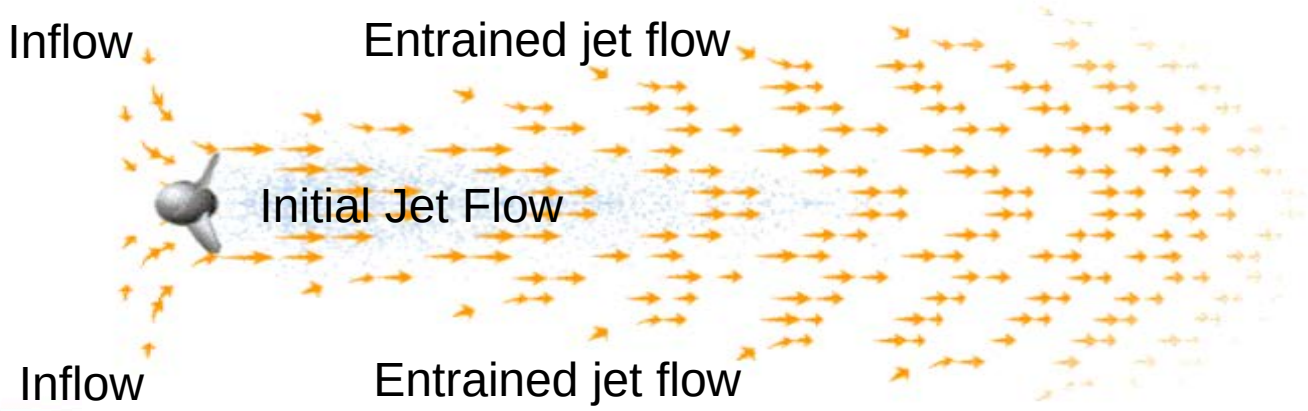
Add an impeller each time H/T passes a multiple of 1.25



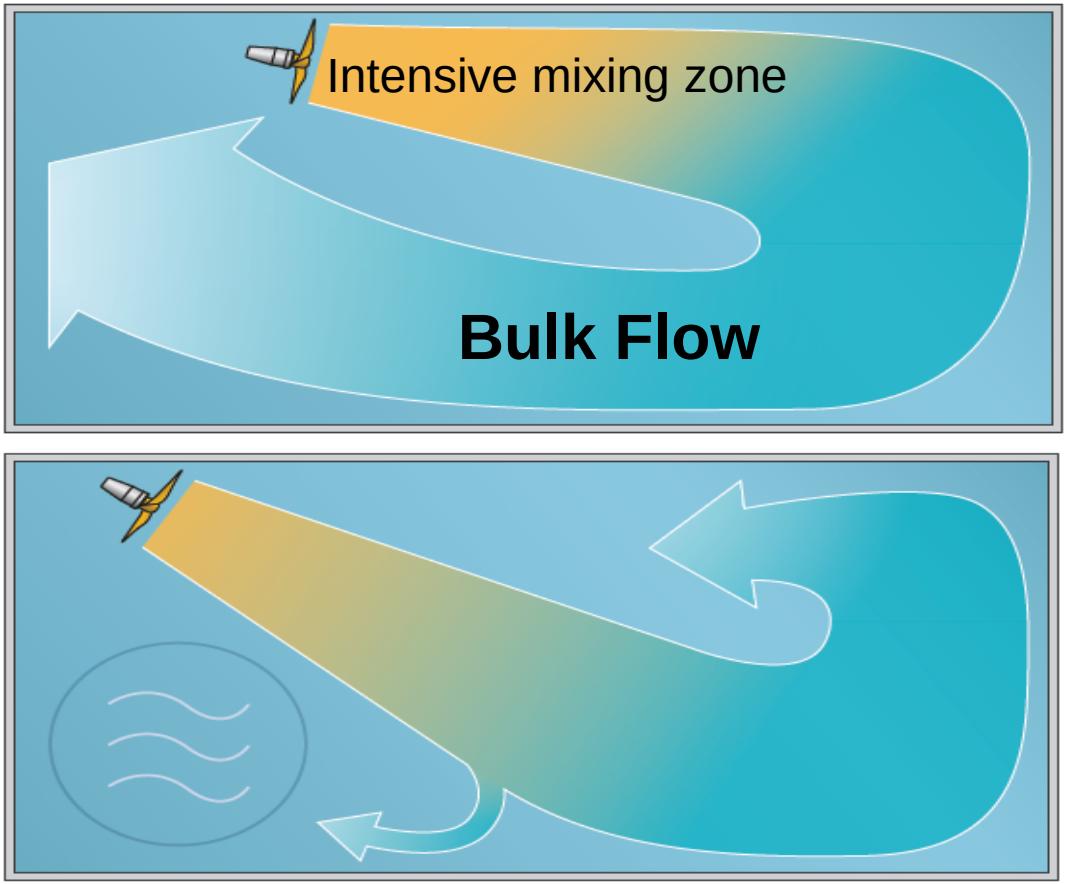
Flygt Mixer Positioning
Creating Mixing and Bulk Flow

Many flows, one source

- Inflow
- Outflow, better known as primary flow
- Jet: initial jet and entrained flow
- Bulk Flow

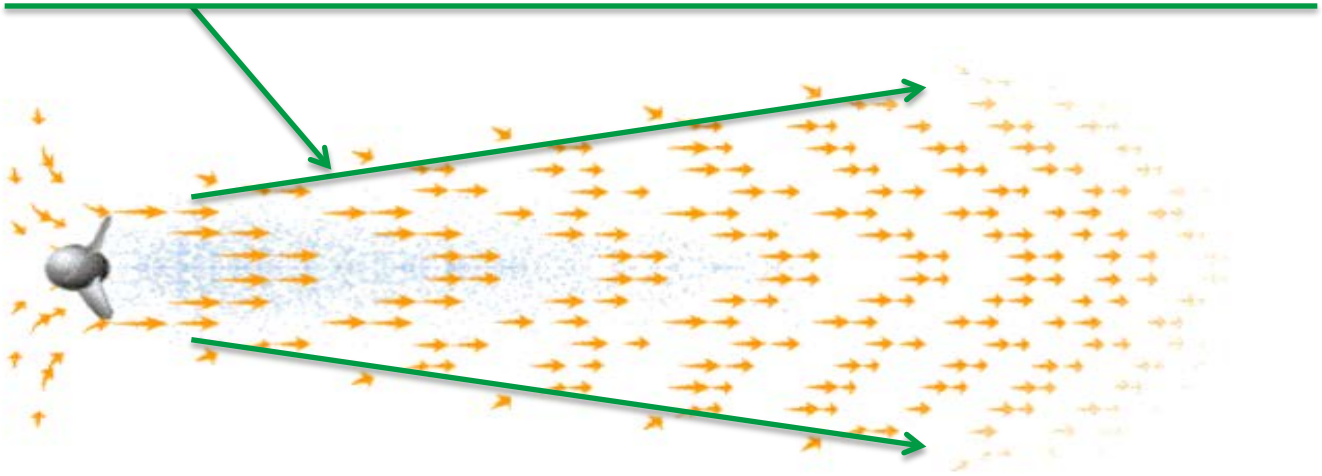


Flygt Mixer Positioning
Creating Mixing and Bulk Flow



Flygt 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



Flygt Mixer Positioning for a bulk flow loop

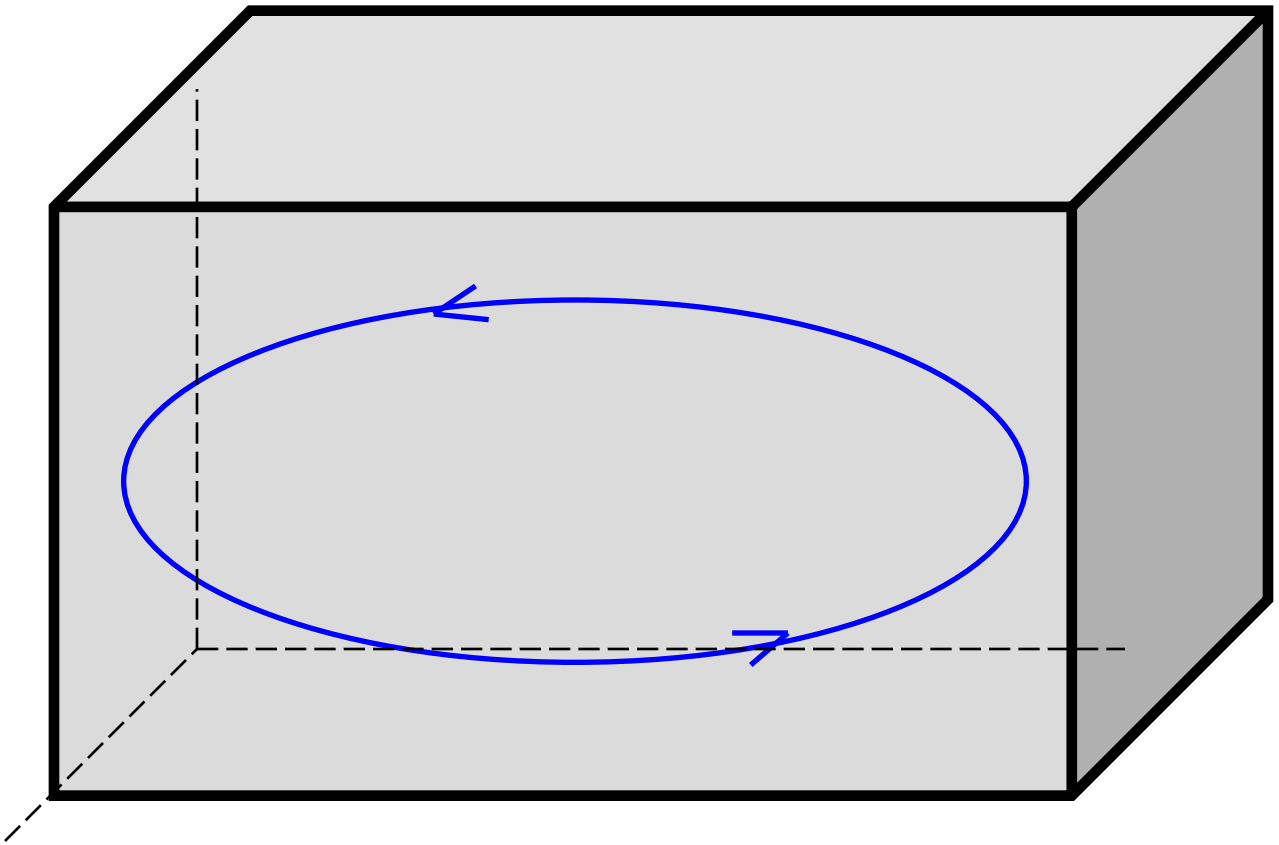
1. Determine an efficient bulk flow loop

- Smooth jet deflection for low losses
- Because mixing happens along the jet border, the longer the jet-path, the more mixing takes place
- This often means the mixers are located in corners

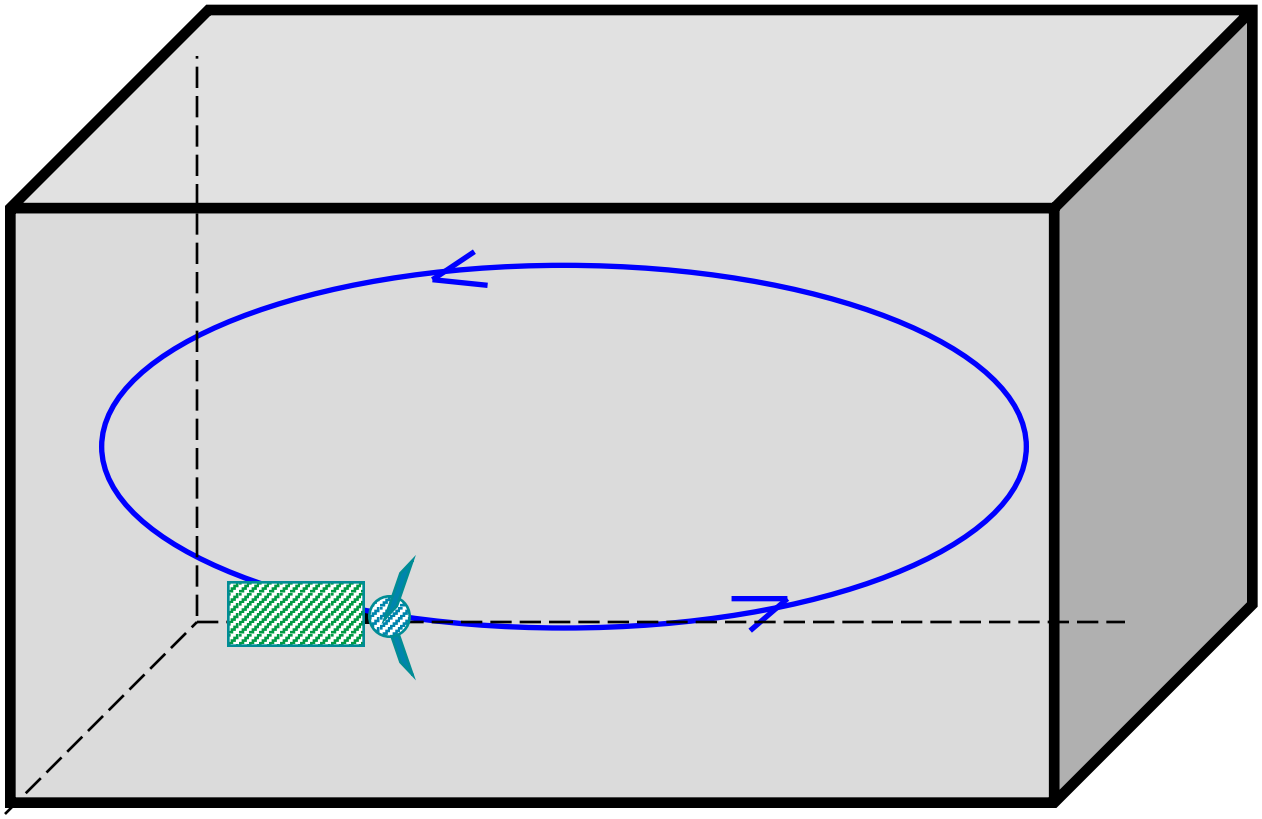
2. Locate the mixer(s) so they are directed along the streamlines of the loop

3. Aim the jet to steer clear of obstacles

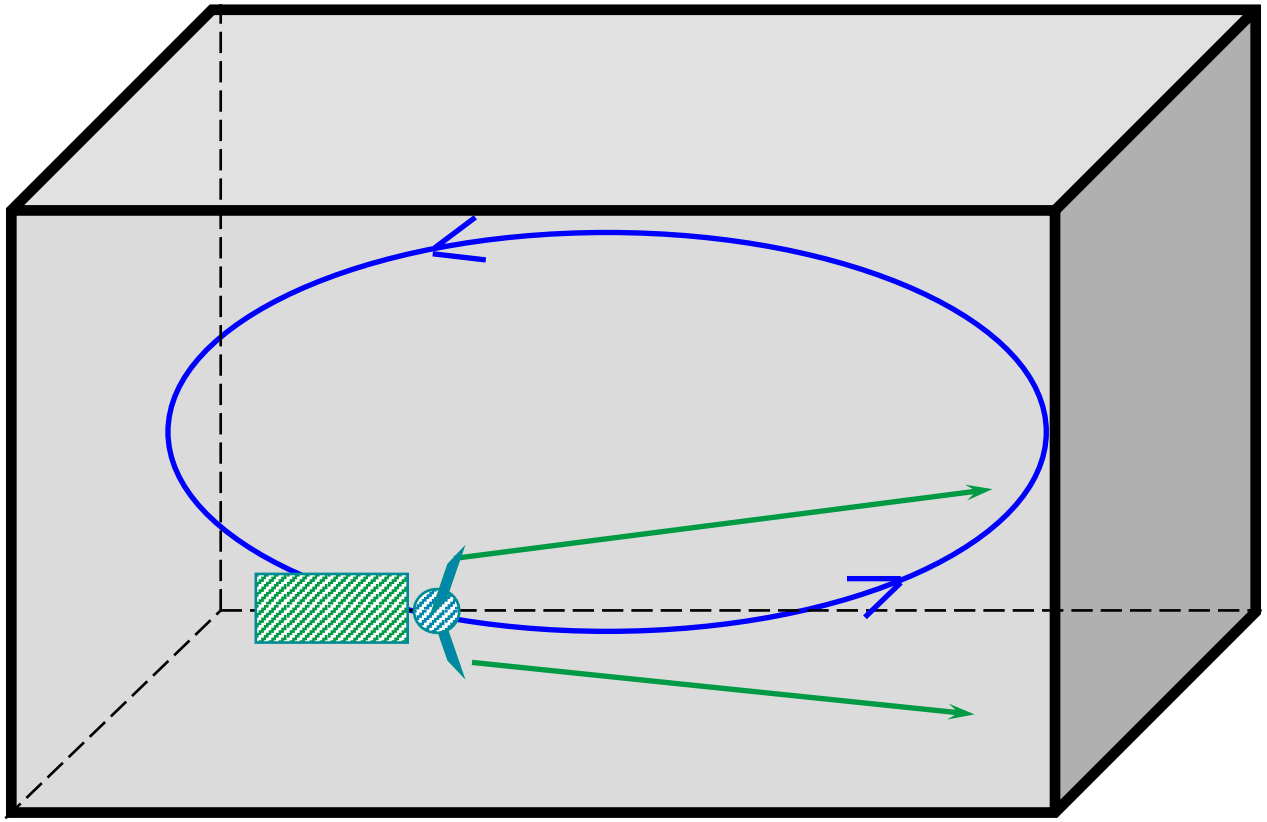
Submersible Mixer Positioning
1. Determine an efficient bulk flow loop



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



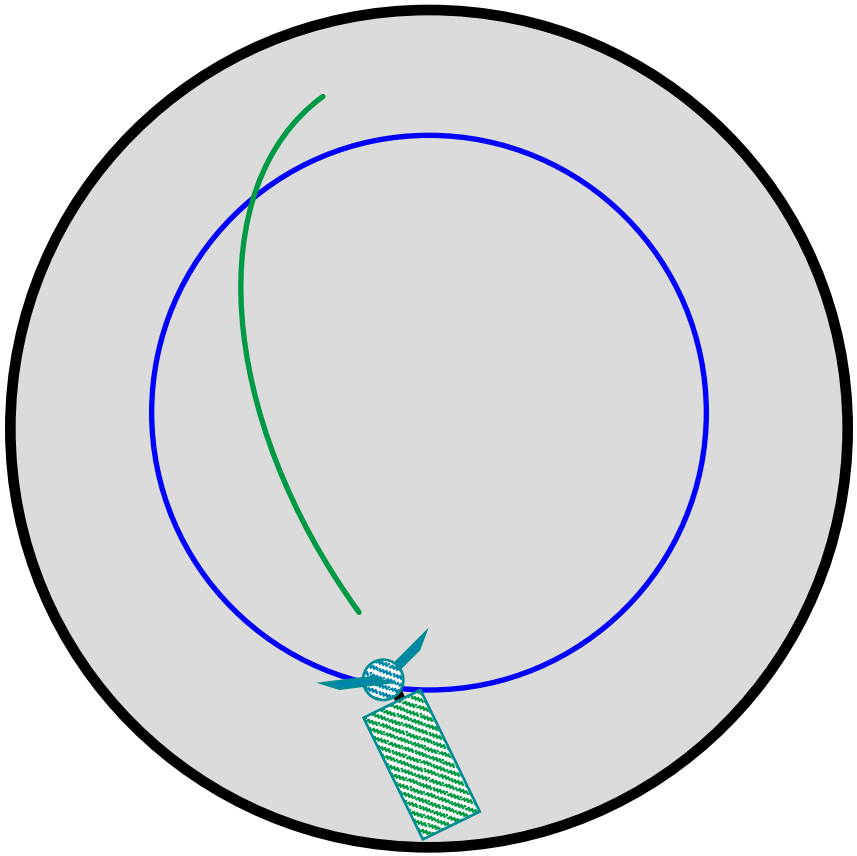
Submersible Mixer Positioning
3. Long jet path



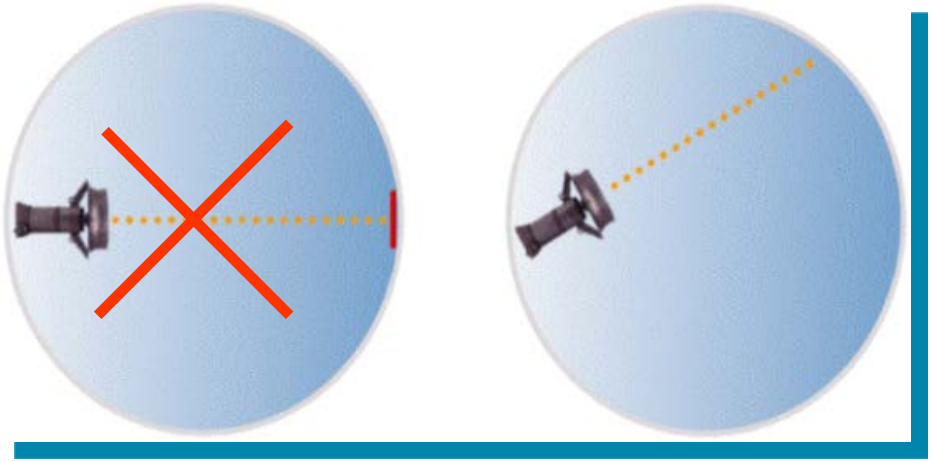
Large fluid entrainment and bulk flow

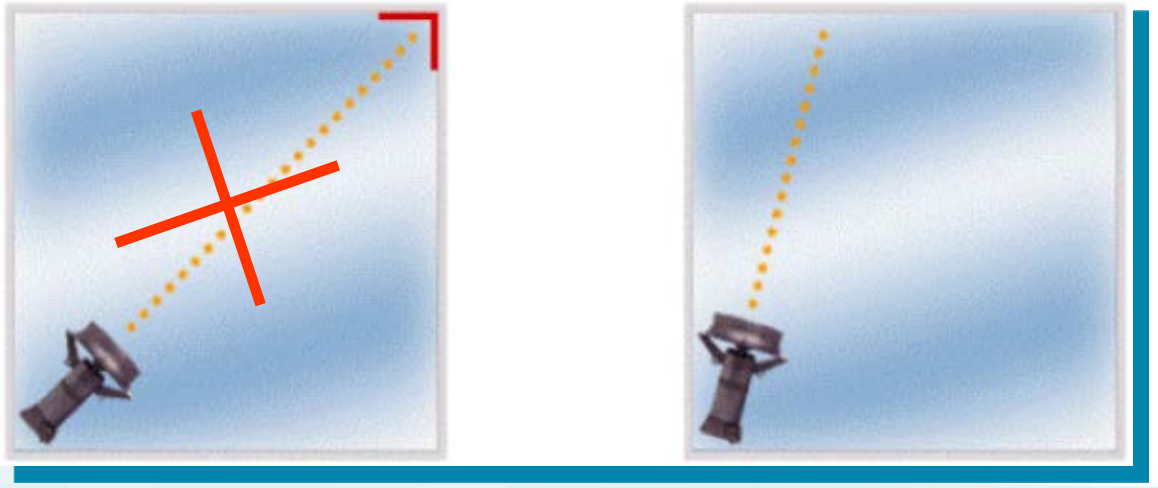
Submersible Mixer Positioning
4. Smooth jet deflection

Smooth jet deflection:
Yields low hydraulic losses



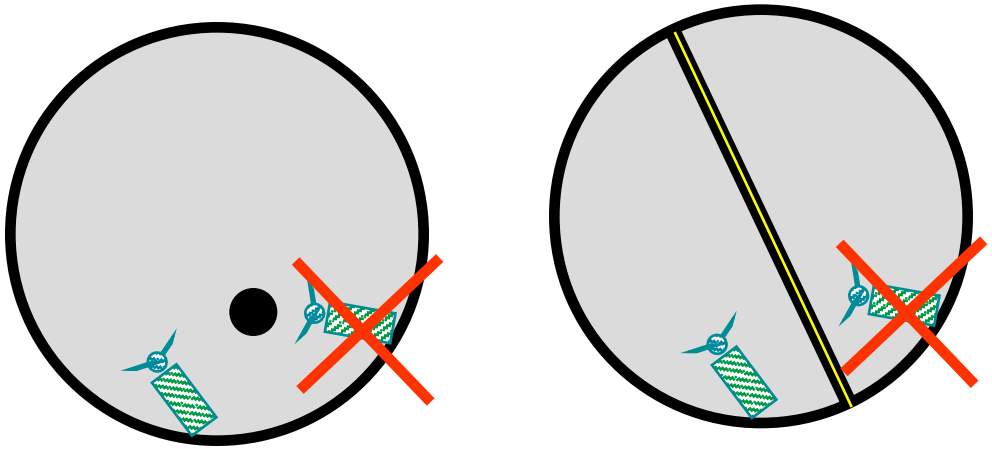
Submersible Mixer Positioning
Long jet path & smooth deflection



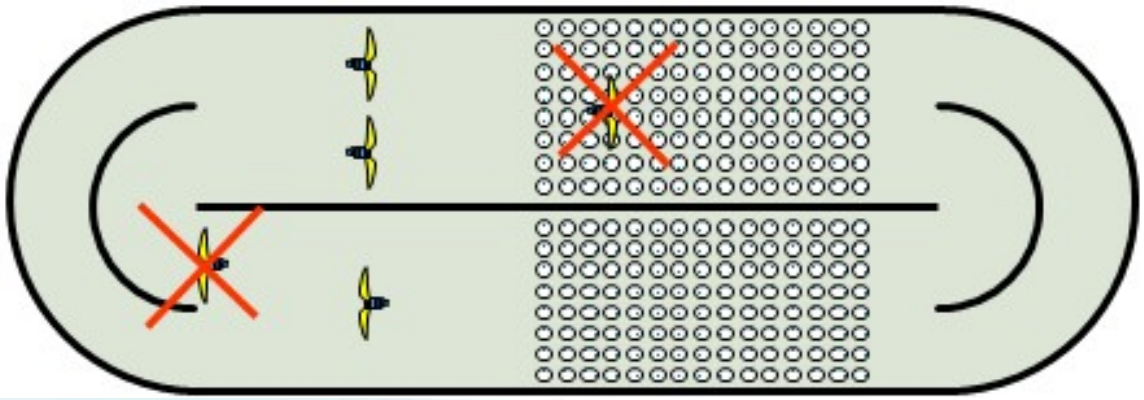


Submersible Mixer Positioning
5. Away from obstacles

- Pipes, Pillars ...

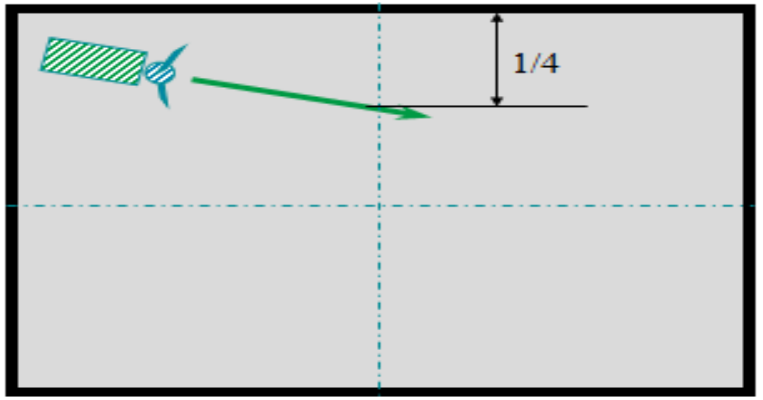


- Bends, Aerators ...



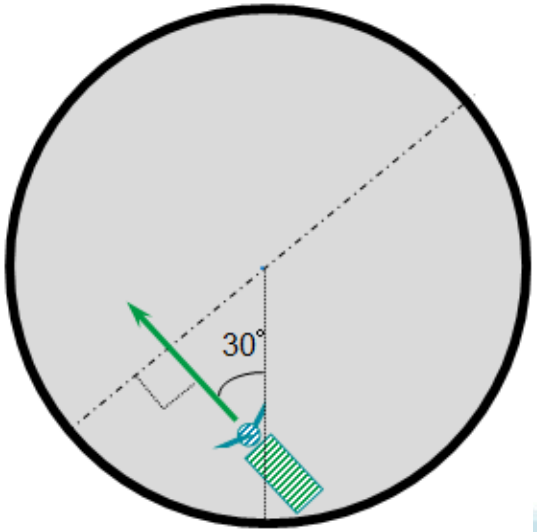
Submersible Mixer Positioning
Optimal positioning

Rectangular tanks



Circular tanks

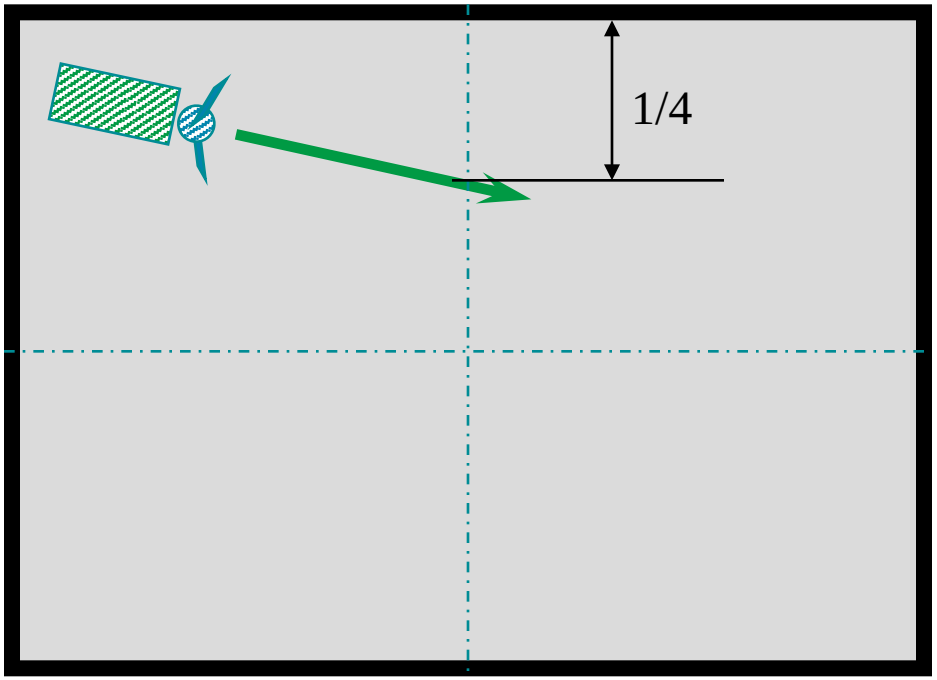
Tanks viewed from top

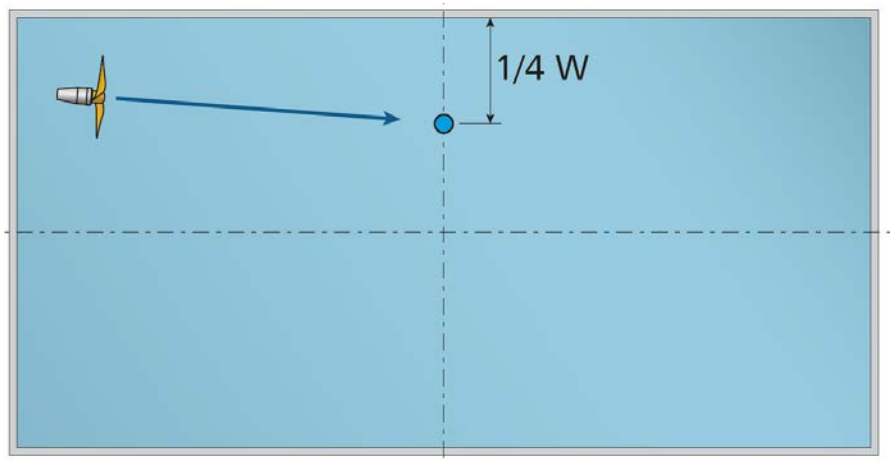


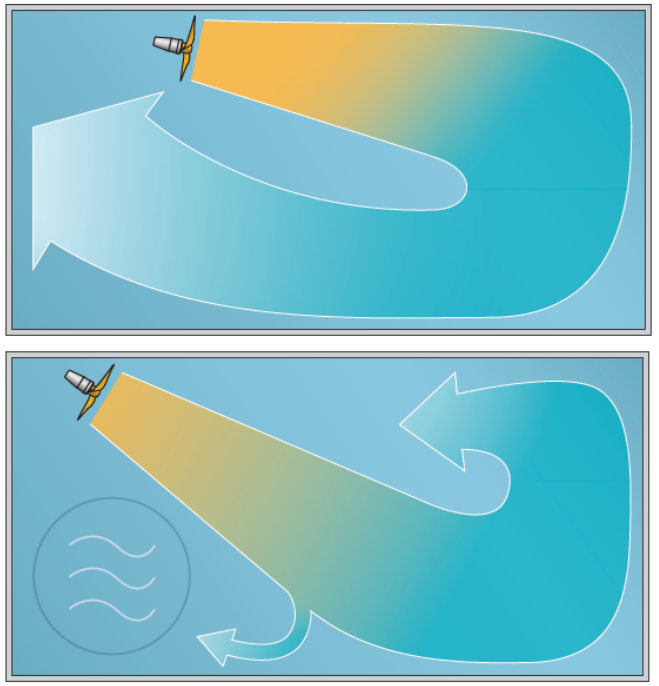
Submersible Mixer Positioning
Rectangular tanks: Single mixer

Aim for 1/4 width for maximum bulk flow

View
from top







View from top

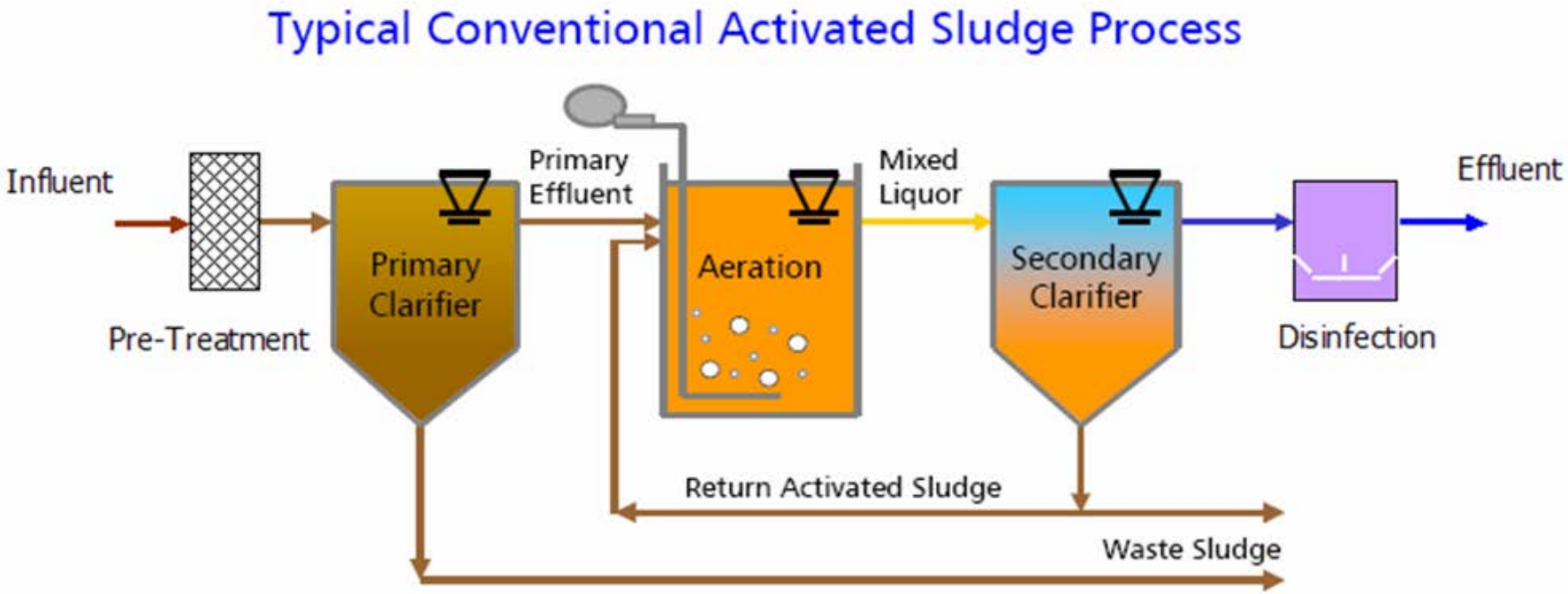
Madison, WI Nine Springs WWTP

Anaerobic Selector Basin Dimensions

33’ Long
30’ wide
17’ deep

Madison Metropolitan Sewerage District

Typical Activated Sludge Layout



Madison Metropolitan Sewerage District

Grit Removal
Fine screens

Added to the plant

Enabled lower mixing energy

FLYGT

Anaerobic Zones Mixer sizing

1996:

7.5 HP - 1.15 ft/sec

2012:

2.5 HP - 0.7 ft/sec

4 HP - 0.85 ft/sec

FLYGT

Mixing energy
Cut in half

FLYGT

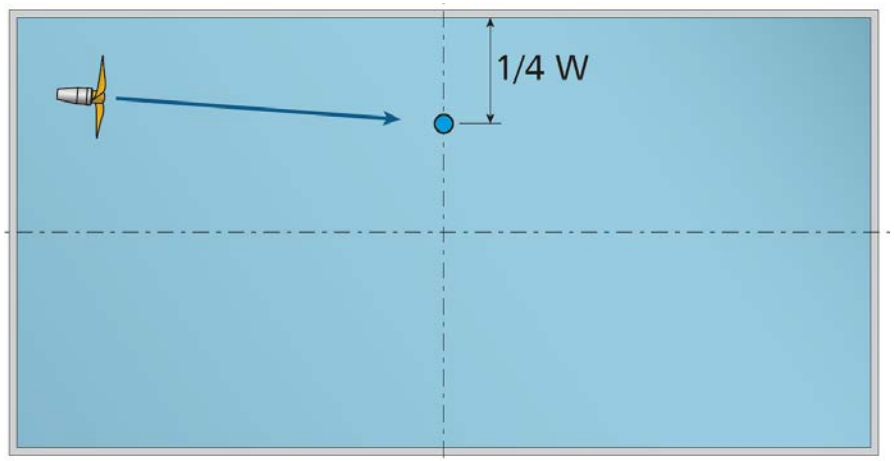
7.5 HP vs 2.5 & 4 HP

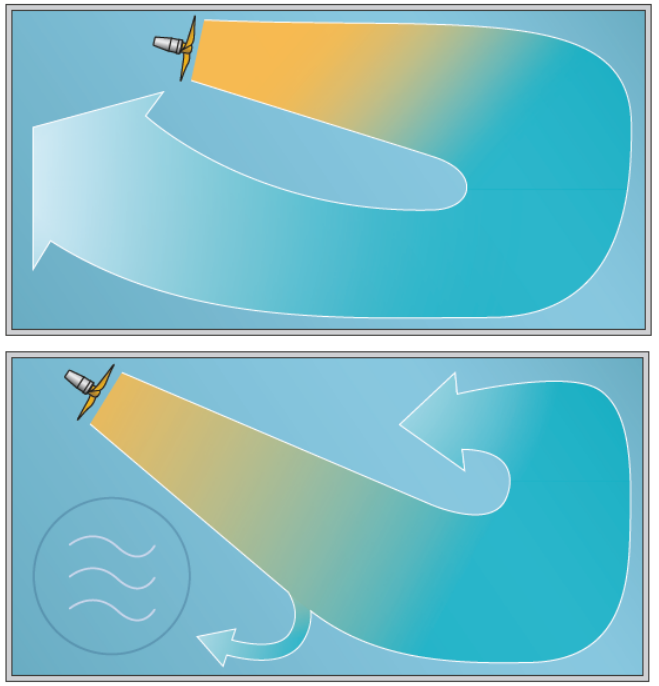
Before

7.5 HP

Before

Madison Metropolitan Sewerage District





View from top

Most efficient mixer today: large diameter, slow speed

Questions?