

Computational Fluid Dynamics (CFD) Applications for Wastewater Engineering

Laura Rozumalski

Principal Engineer

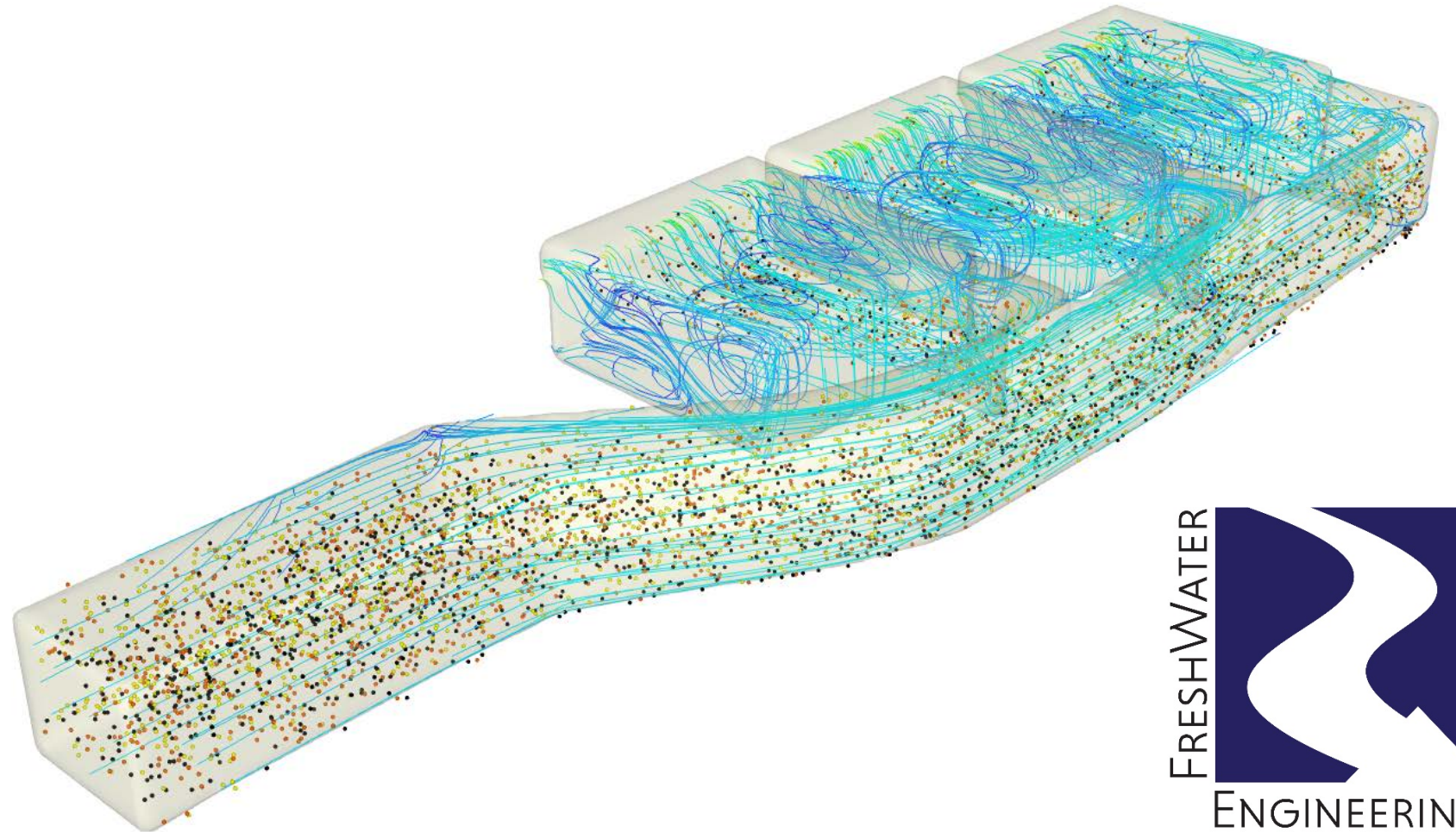
lrozumalski@freshwatereng.com

Nick Jordan

Water Resources & CFD Engineer

njordan@freshwatereng.com

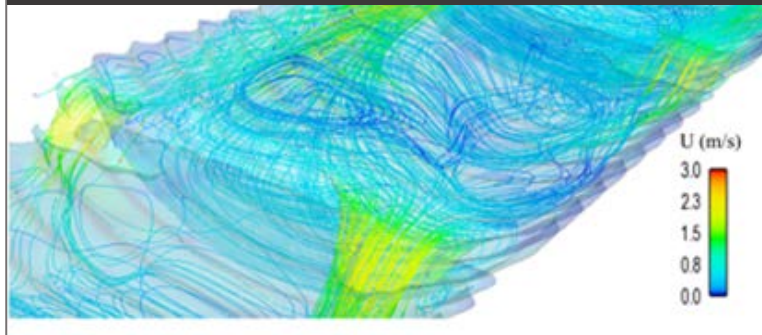
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About FreshWater Engineering

- Founded in 2014 by Laura Rozumalski
- Woman-owned small business
- Based in Madison

Hydrodynamic (CFD) Modeling



Ecosystem Restoration



Water Resources Engineering

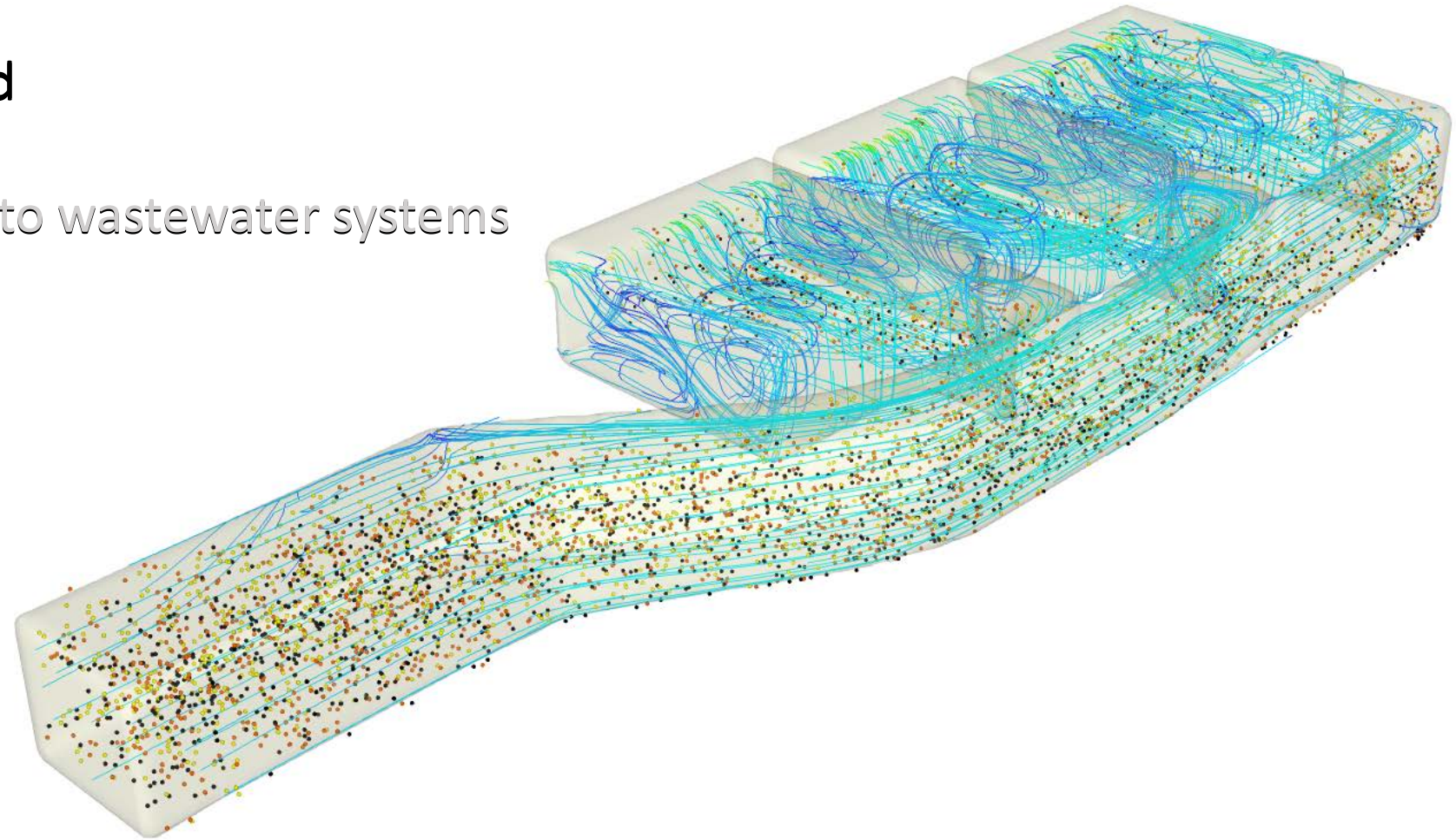


Hydrographic Surveying



Outline

- **CFD modeling background**
- **Capabilities of FLOW-3D**
- Applications of FLOW-3D to wastewater systems
- FWE project example

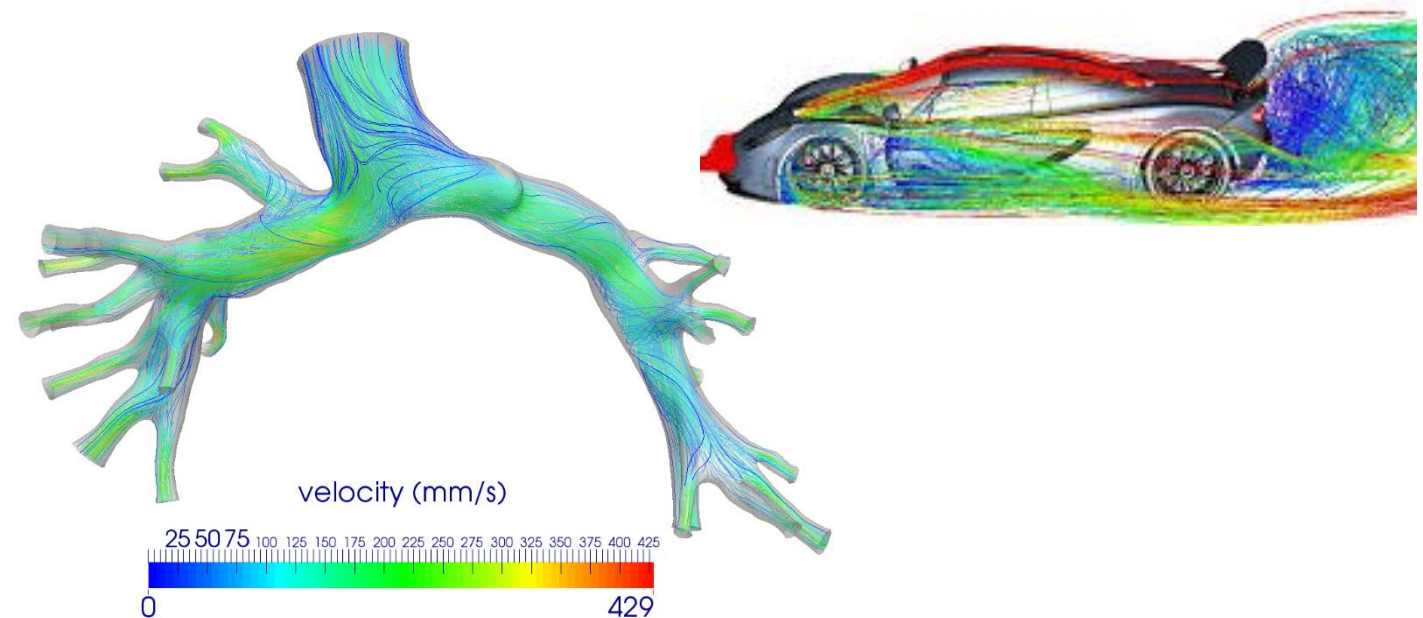
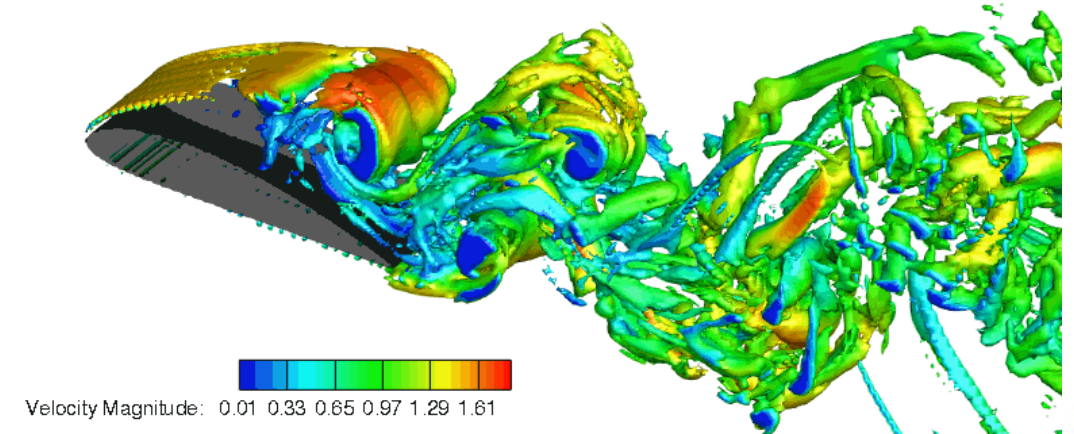


Computational Fluid Dynamics

- Numerical analysis of Navier-Stokes equation to solve fluid flow problems
- Solves 2D/3D transient/unsteady flow problems
- Modeler must weigh **accuracy** and **efficiency**
- A powerful design and analysis tool

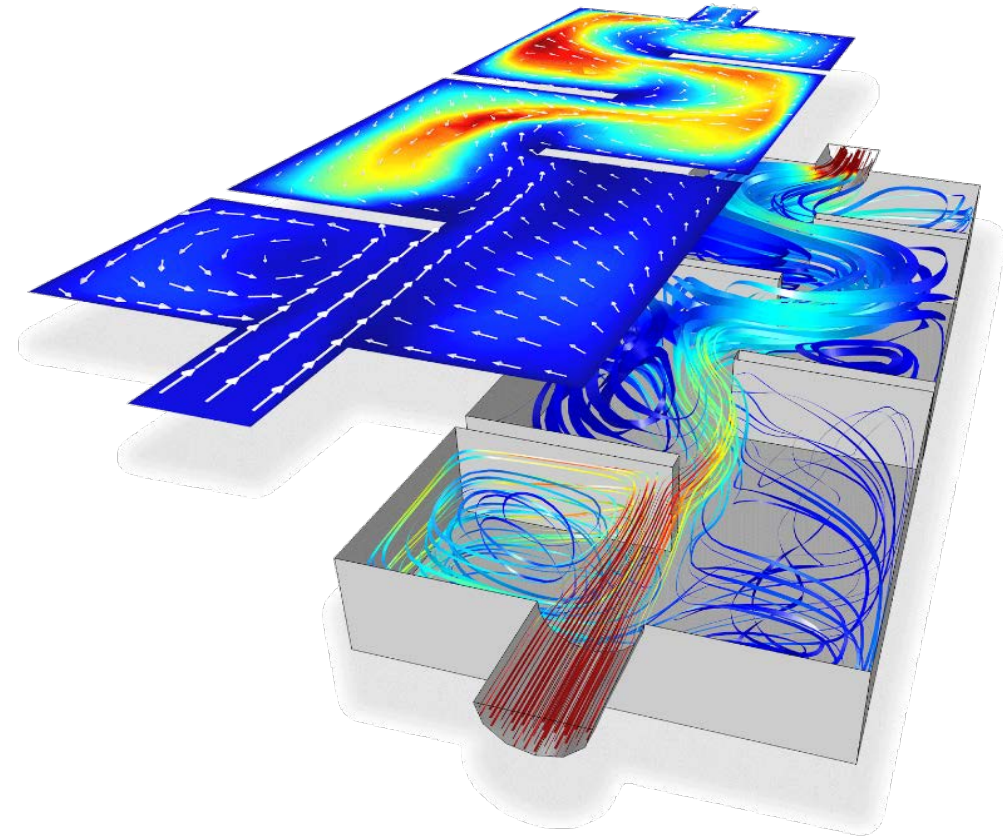
Applications

- Aerodynamic design
- Biomedical engineering
- Metal casting
- Hydraulic analysis & design
- Environmental modeling
- Municipal & wastewater systems



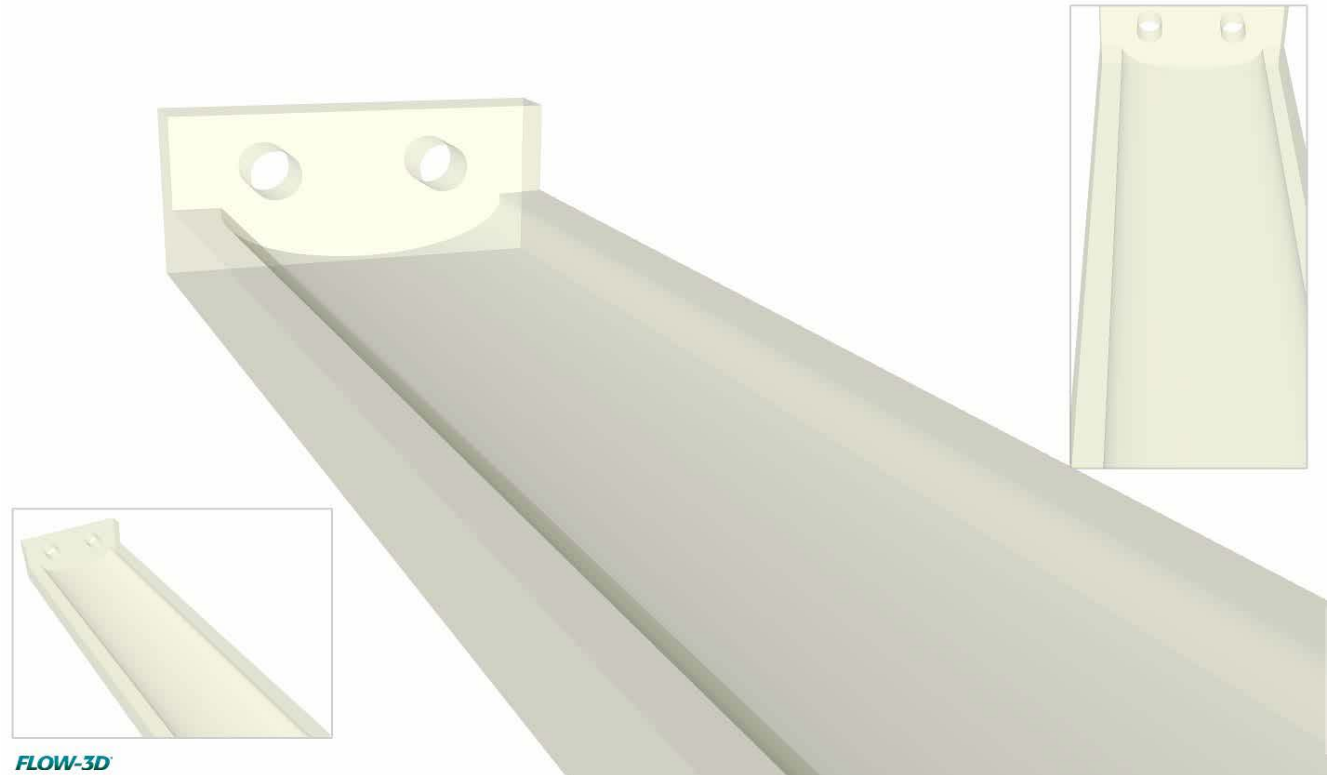
Applications of CFD to Civil Engineering

- Municipal & Wastewater
 - Conveyance/wet tunnel hydraulics
 - Grit and sediment control
 - Flow control structures
 - Contact tanks
 - Clarifiers and settling tanks
 - Sewer design
 - Aeration dynamics
- Rivers
 - Hydraulic structures
 - Thermal discharge & contaminant modeling
 - Scour & sediment transport
- Dams
 - Spillways and stilling basins
 - Fish passage
 - Dam breaks



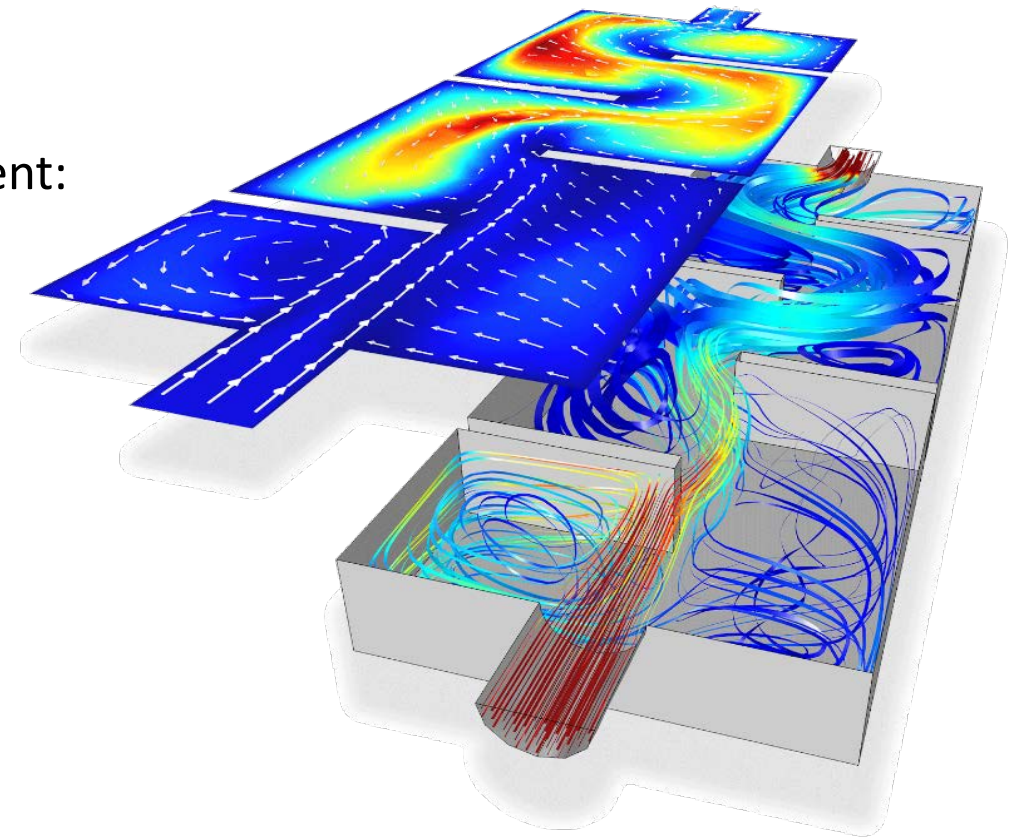
Advantages of CFD

- Fewer assumptions and uncertainties than most engineering models
- Clearly view system geometry
- Detailed understanding of flow
- Excellent correlation to physical modeling
- Less expensive than physical modeling
- Realistic simulations



Why use CFD to solve wastewater problems?

- Excellent design optimization tool
- Assess performance of existing systems
- Provide insight into complex interactions of hydraulic, chemical, and physical processes
- Gain understanding of system performance under different:
 - Flow conditions
 - Operation scenarios
 - Design alternatives



CONFIDENCE

FLOW-3D Capabilities

FLOW-3D[®]

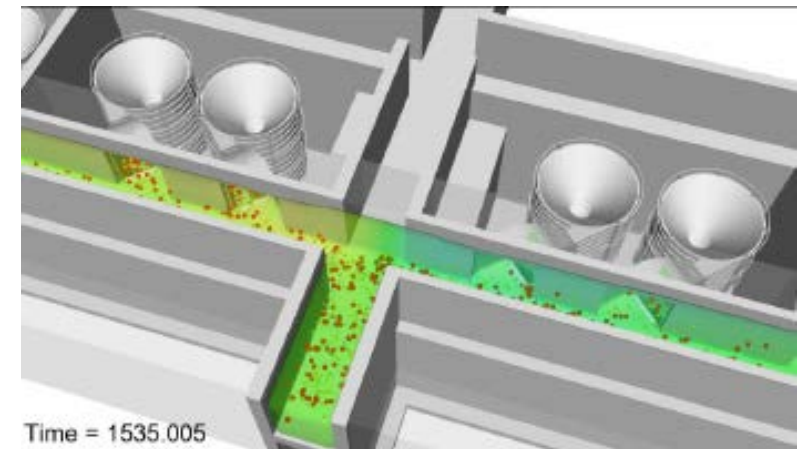
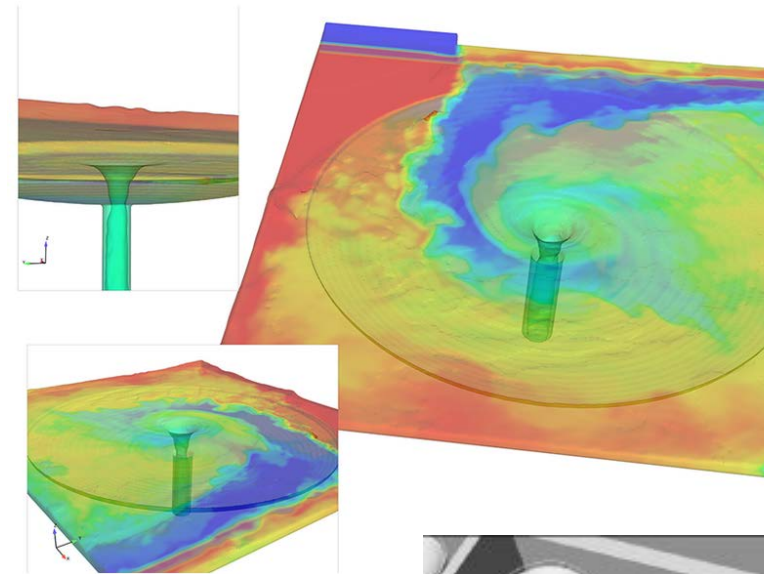
- **Versatility**

- Geometry based on CAD designs
- 27 physics packages
 - Particle transport
 - Chemical reactions
 - Sludge settling
 - Moving objects
- Excellent visualization options

- **Accuracy & Dependability**

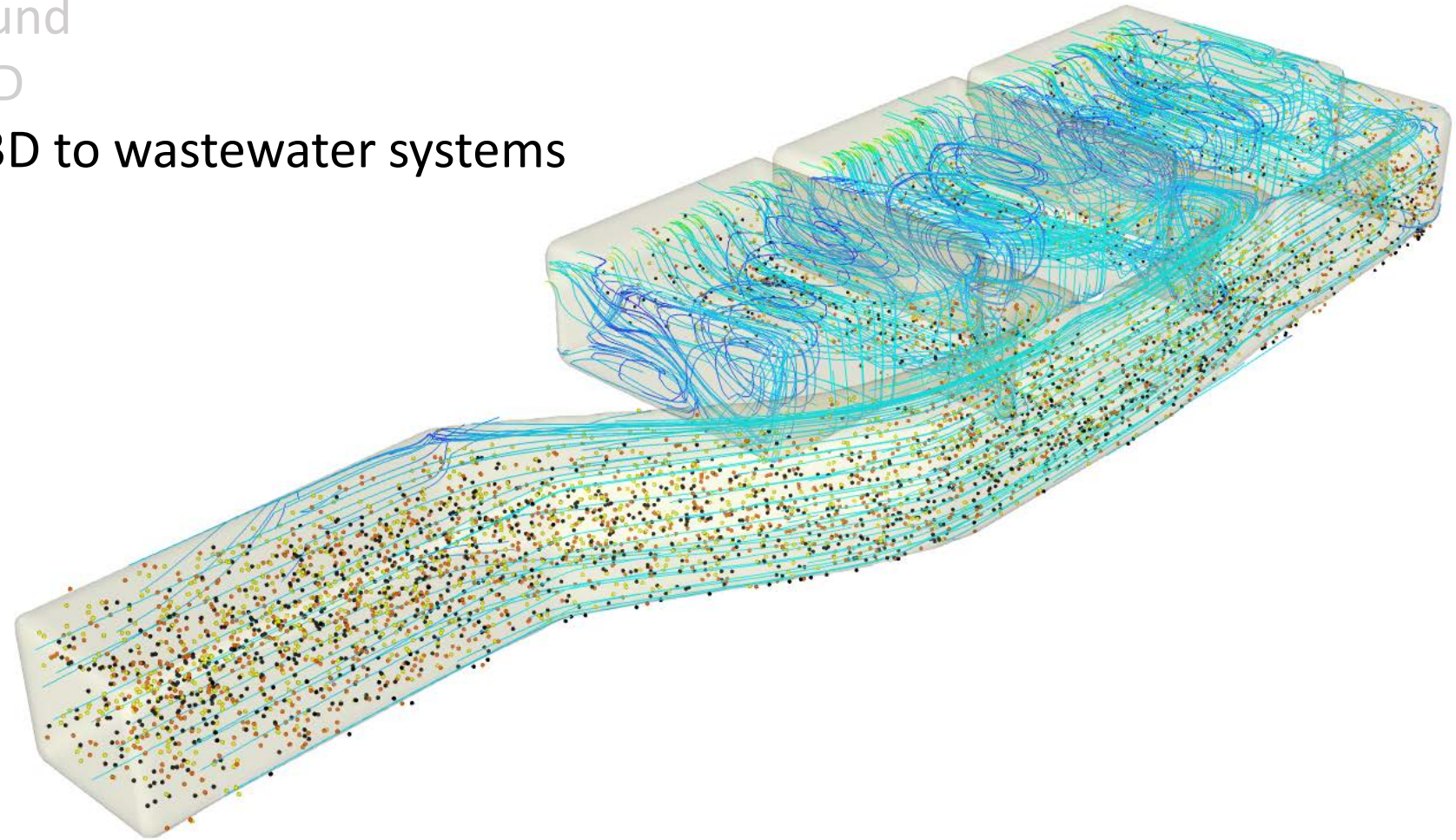
- Industry-standard CFD model
- Well validated
- Free surface and pressurized flow

- **Efficiency**



Outline

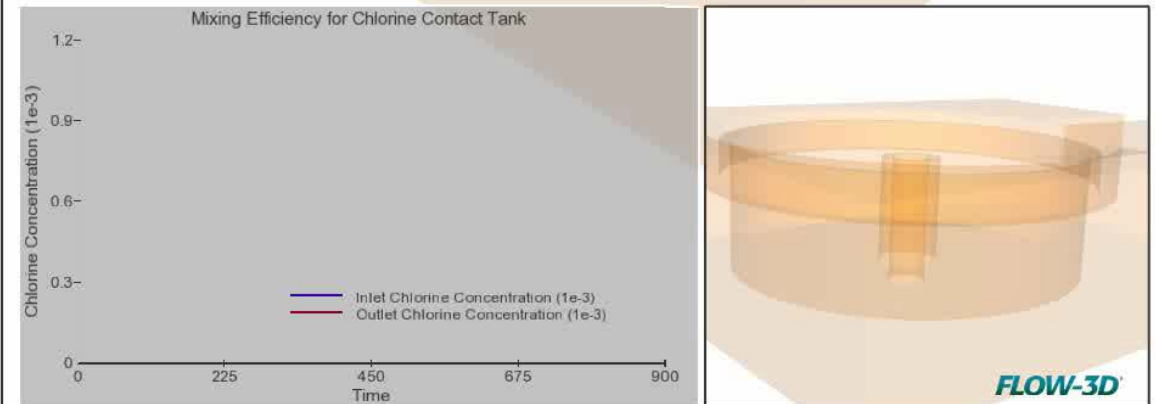
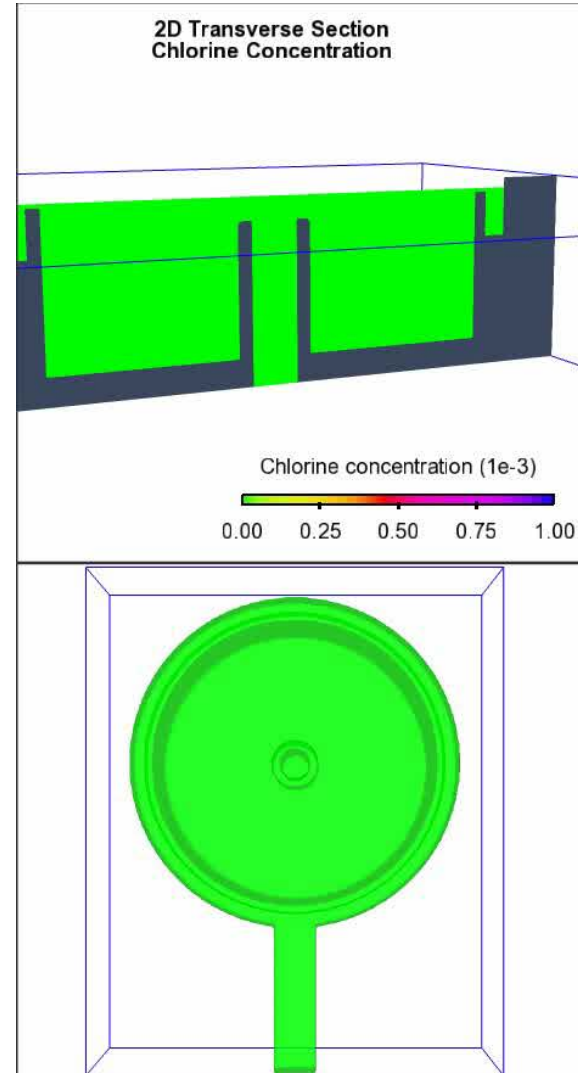
- CFD modeling background
- Capabilities of FLOW-3D
- **Applications of FLOW-3D to wastewater systems**
- FWE project example



Circular Contact Tank Design Optimization

- *Poor mixing efficiency*
- *Not hydraulically efficient*
- *Poor performance*

- Fully coupled **hydraulic** and **chemical** models
- Existing system analysis

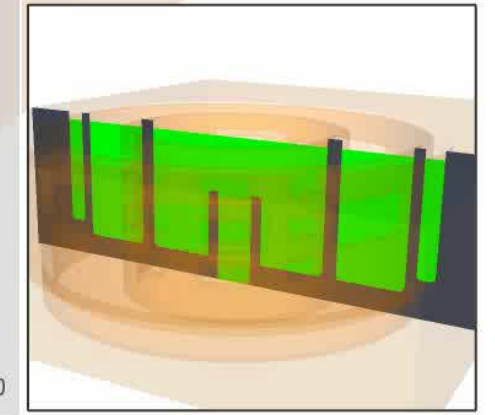
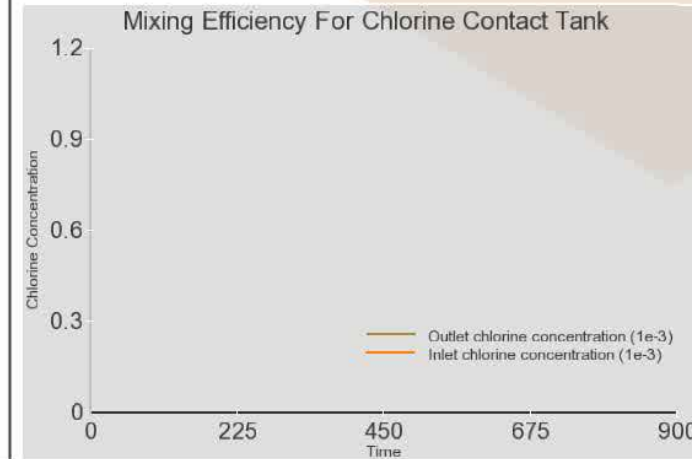
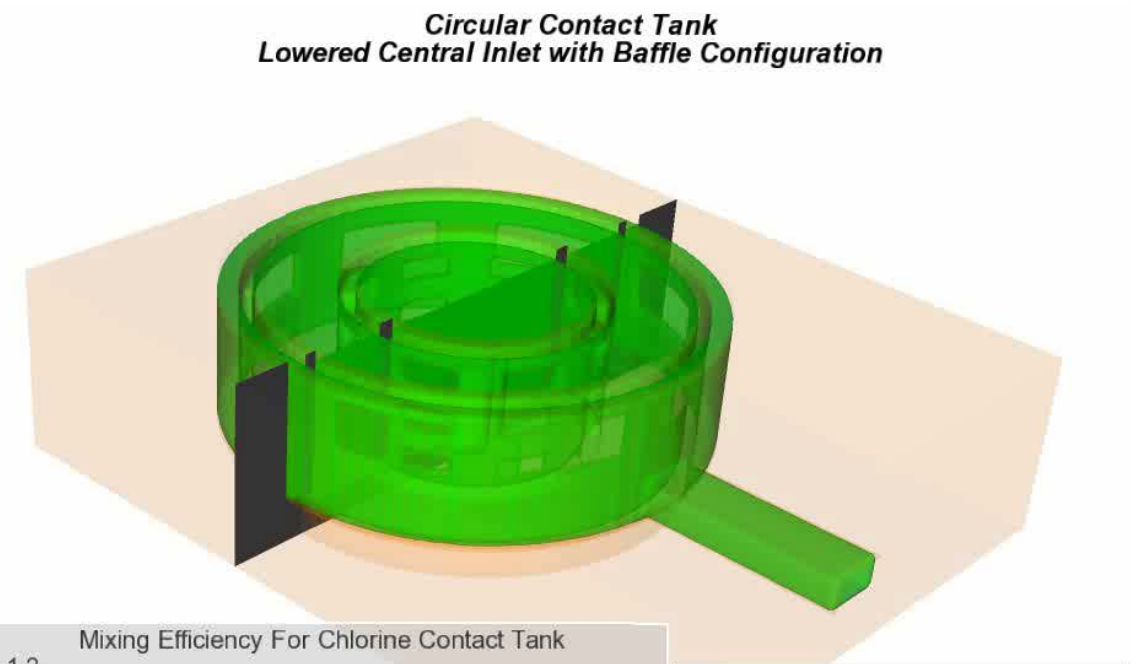
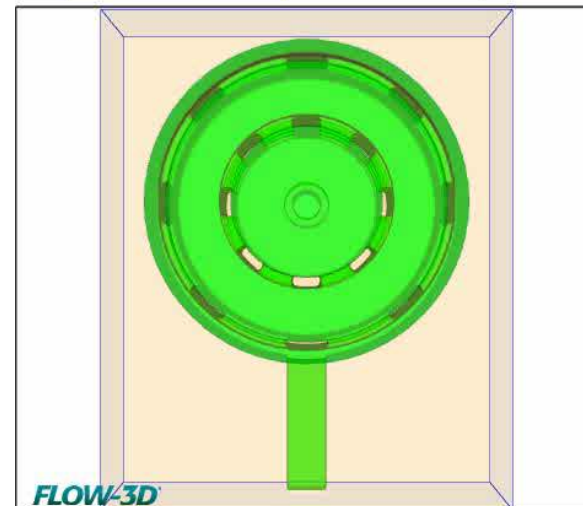
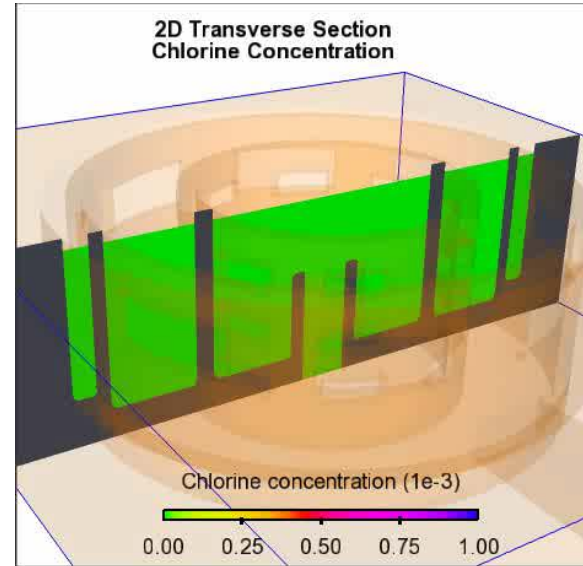


Circular Contact Tank Design Optimization

- Lowered center inlet
- Introduced center and outer baffles
- Improved mixing efficiency
- Even residence time distribution
- Hydraulically efficient

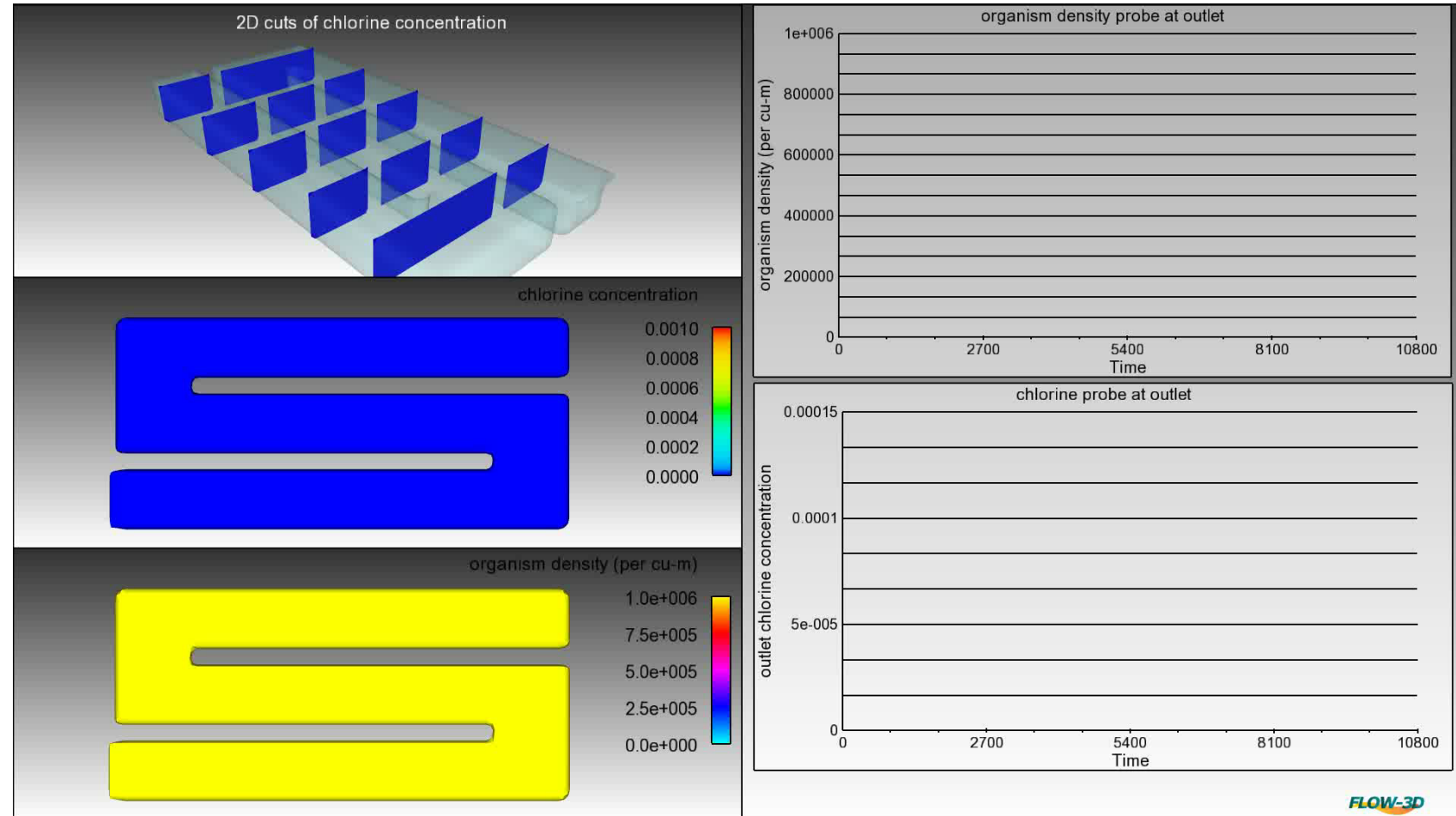
Modeling Capabilities

- Design optimization
- Assess existing systems
- Diagnose problems



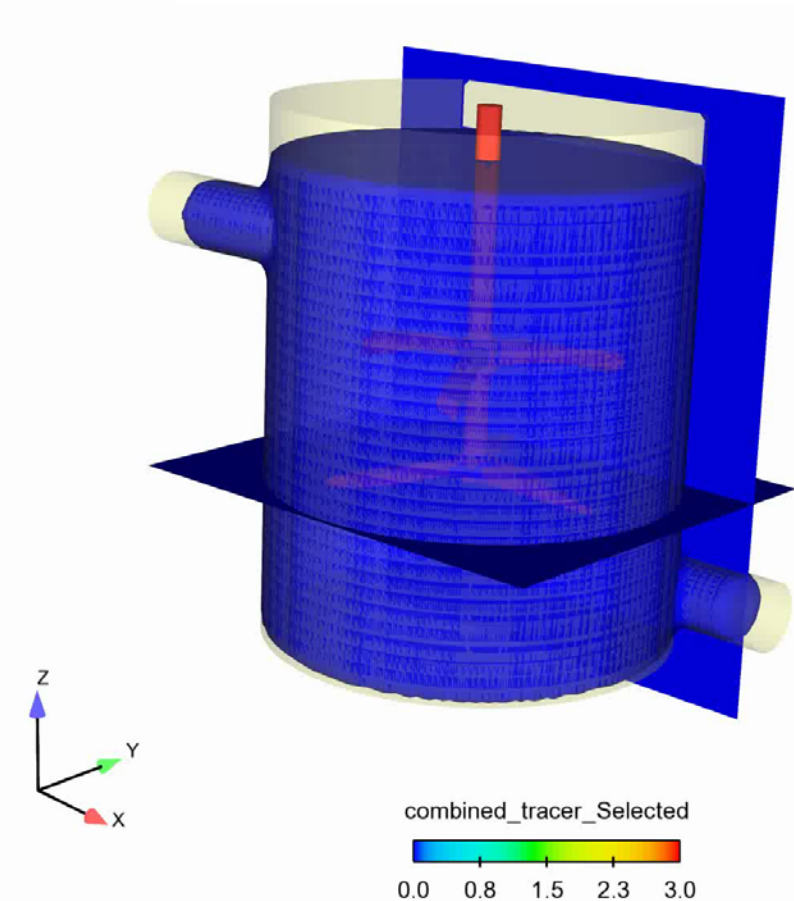
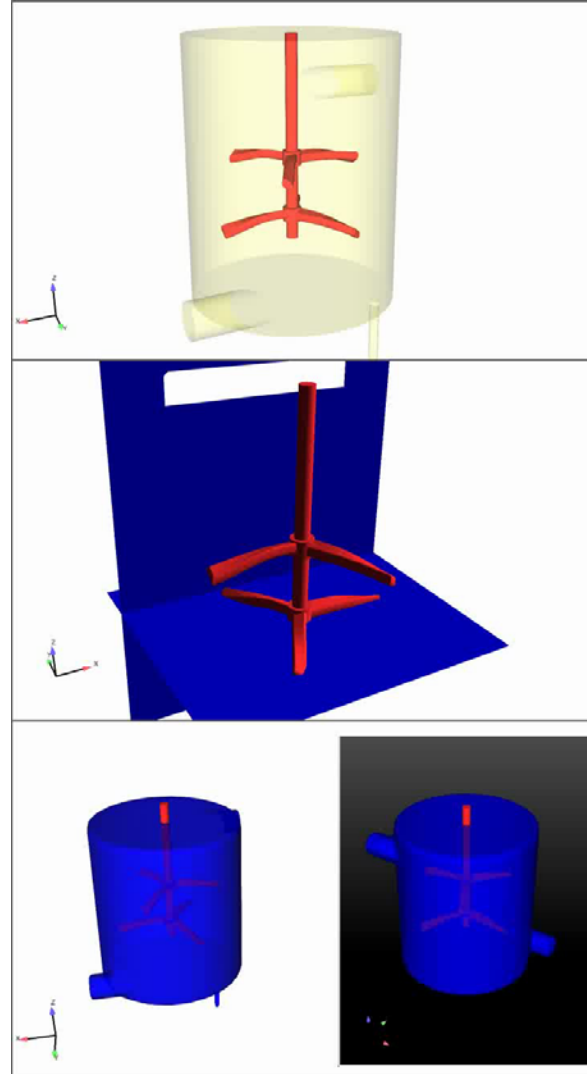
Contact Tank Analysis

- Coupled **hydraulics**, **chemical**, and **micro-organism decay** models
- *Hydraulic performance*
- *Mixing*
- *Chemical/organism decay*
- Design optimization
- Assess existing systems
- Simulate regulatory tests (residence time, species concentration, etc.)



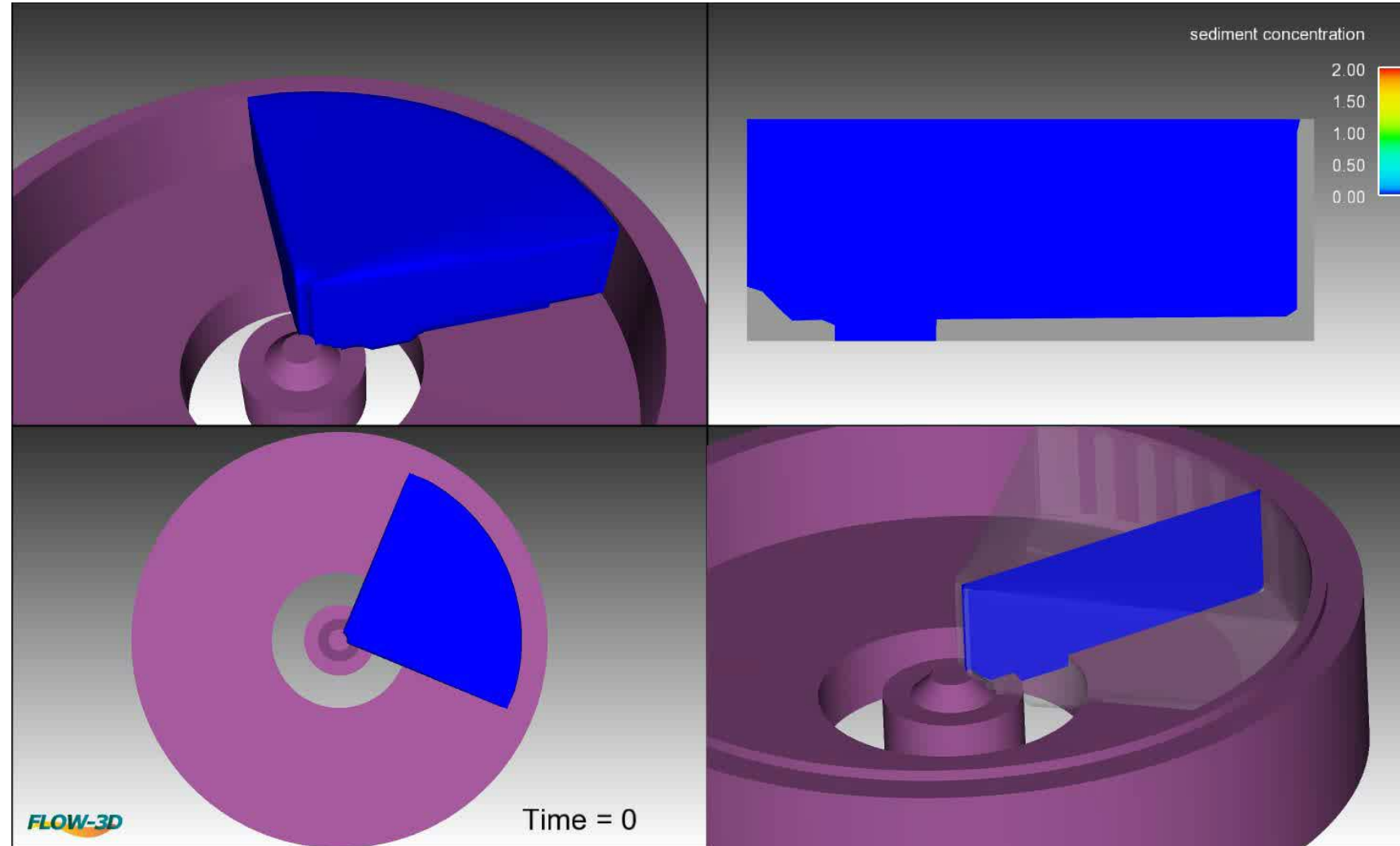
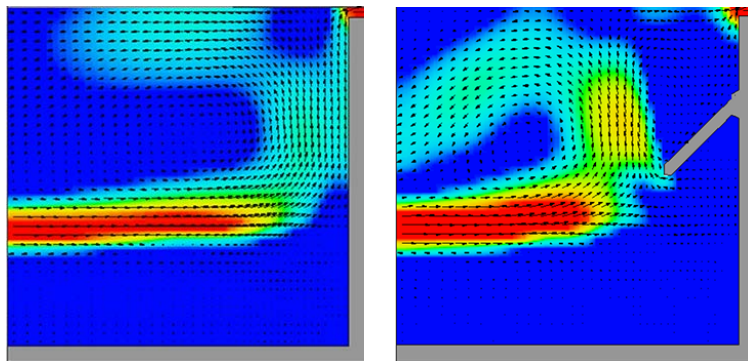
Mixing Tank with Airfoil Impellers

- Moving and rotating object simulations
- **Fluid/structure** interactions
- *Impeller design, type, rotational speed*
- *Mixing efficiency*
- *Hydraulic performance*
- Design optimization
- Evaluate current systems
- Diagnose issues



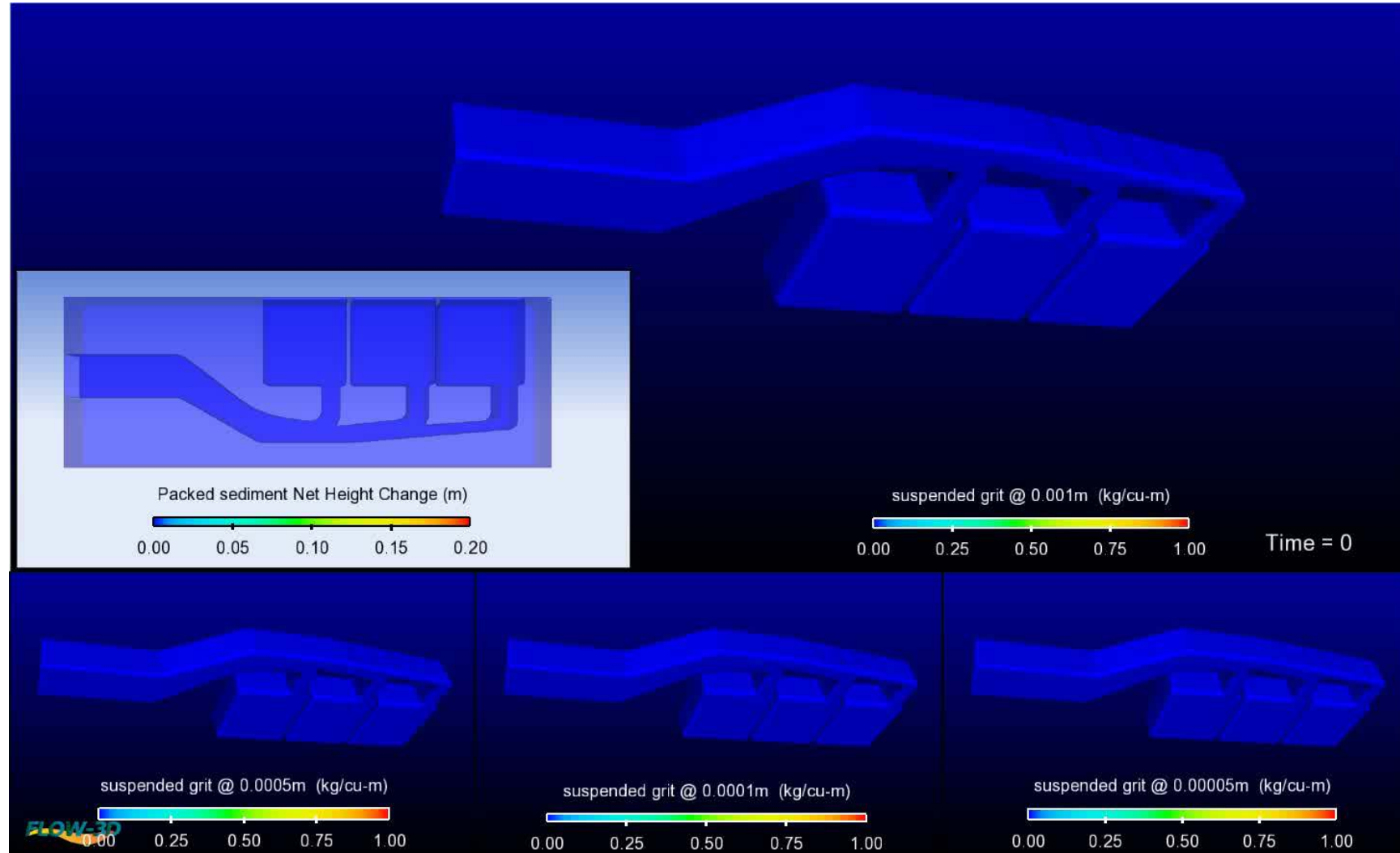
Secondary Clarifier Design

- Customizable sludge settling velocity models
 - *Density currents*
 - *Hydraulic performance*
- Design optimization
- Evaluate existing systems



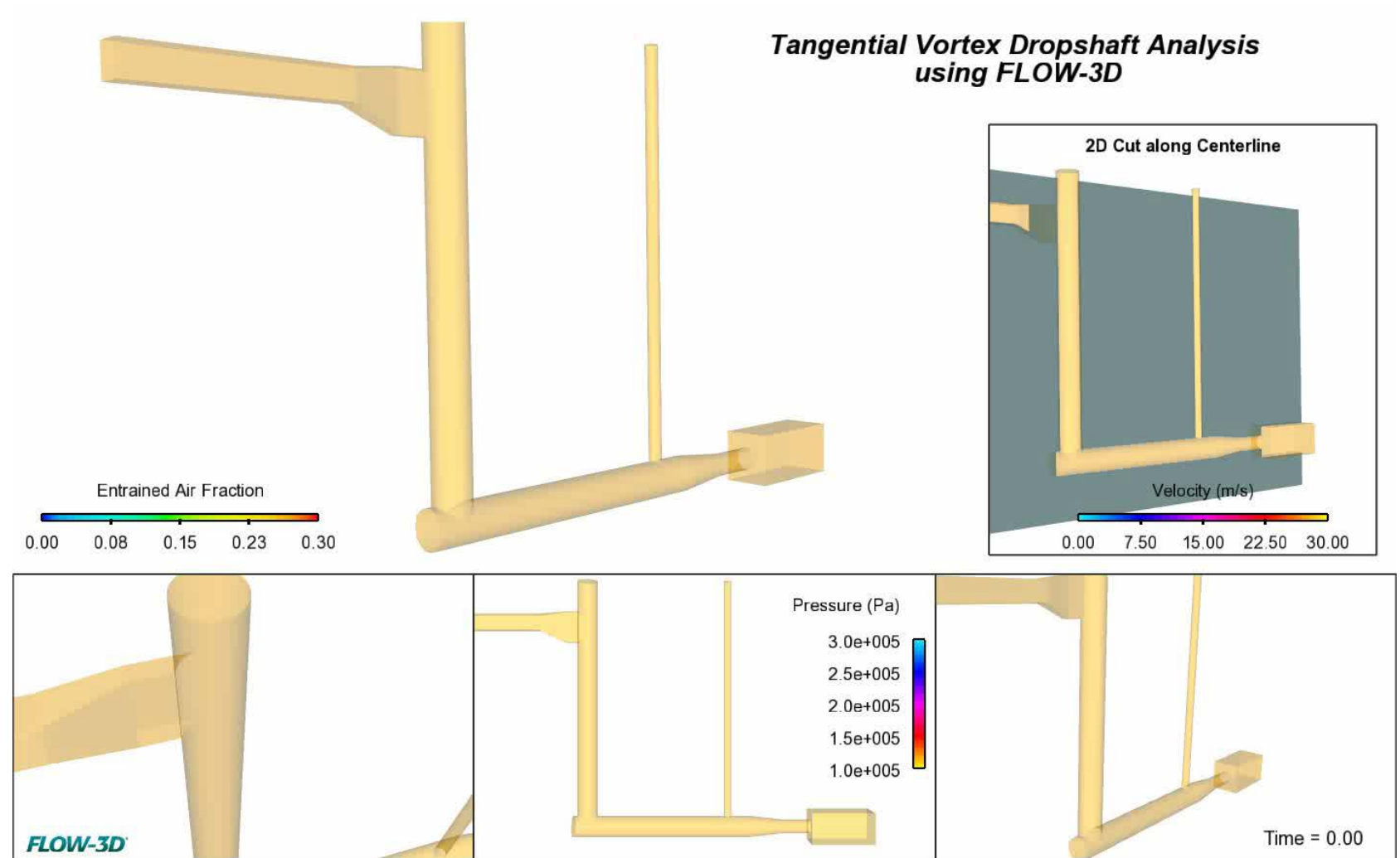
Flux Splitting Grit Separator

- Drift flux and sediment transport models:
fluid/particle interactions
- *Hydraulic balance and efficiency*
- *Sediment scour / buildup*
- Design optimization
- Assess performance for various flow conditions and sediment species
- Address operation and maintenance issues



Complex Pipe System Analysis

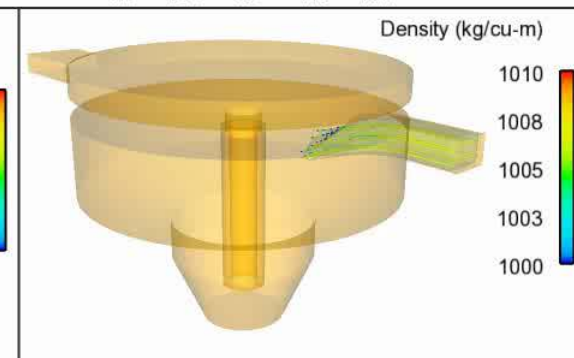
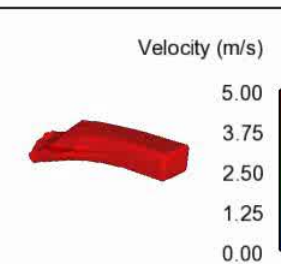
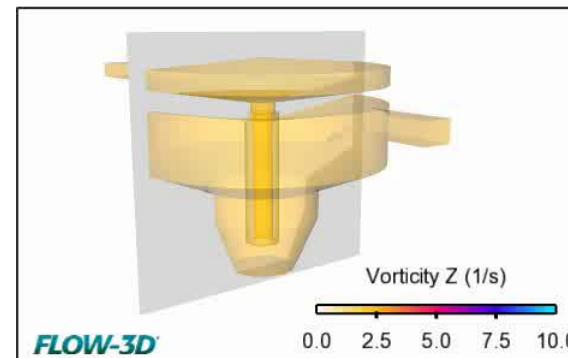
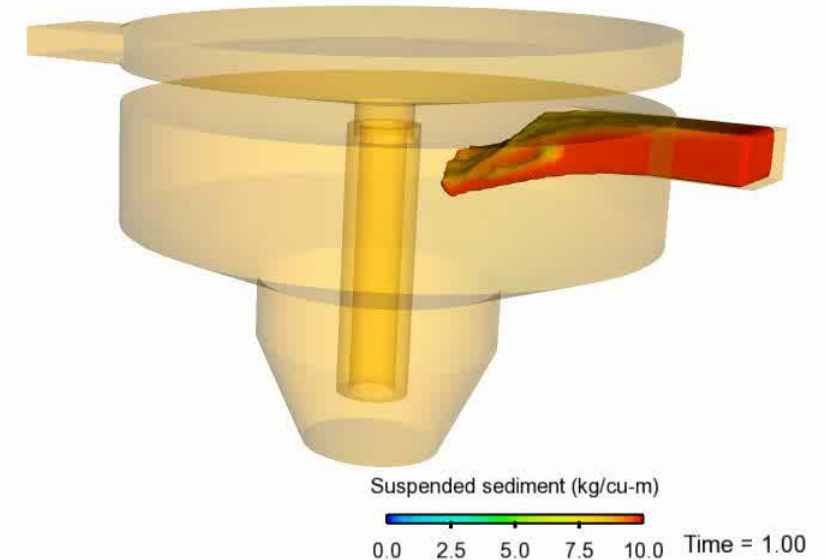
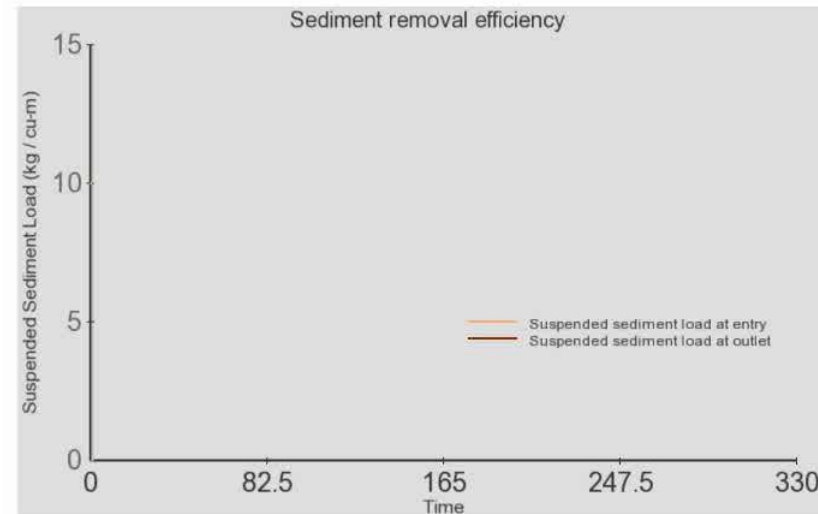
- Complex, time-varying, 3D flows
- Air entrainment processes
- *Fluid discharge*
- *Hydrostatic and dynamic pressures*
- Optimize structure designs
- Analyze current systems
- Diagnose problems



Municipal: Vortex Grit Chamber

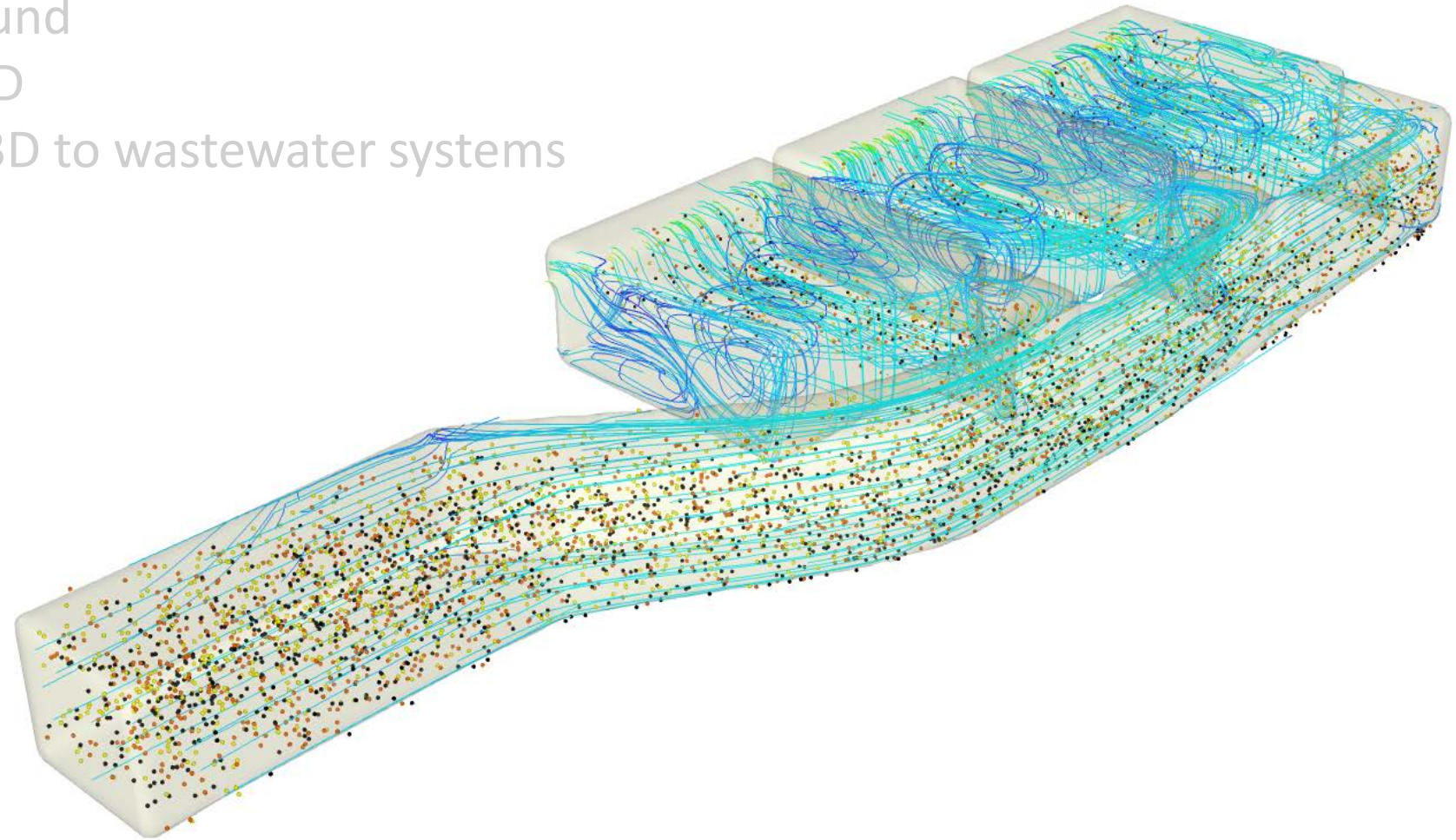
- Vortex modeling capabilities
- Fully coupled hydraulics and particle transport models
- *Multiple particle sizes*
- Analyze suspended sediment removal efficiency
- Residence time analysis
- Location-specific sediment deposition rate

Vortex Grit Chamber Analysis using FLOW-3D



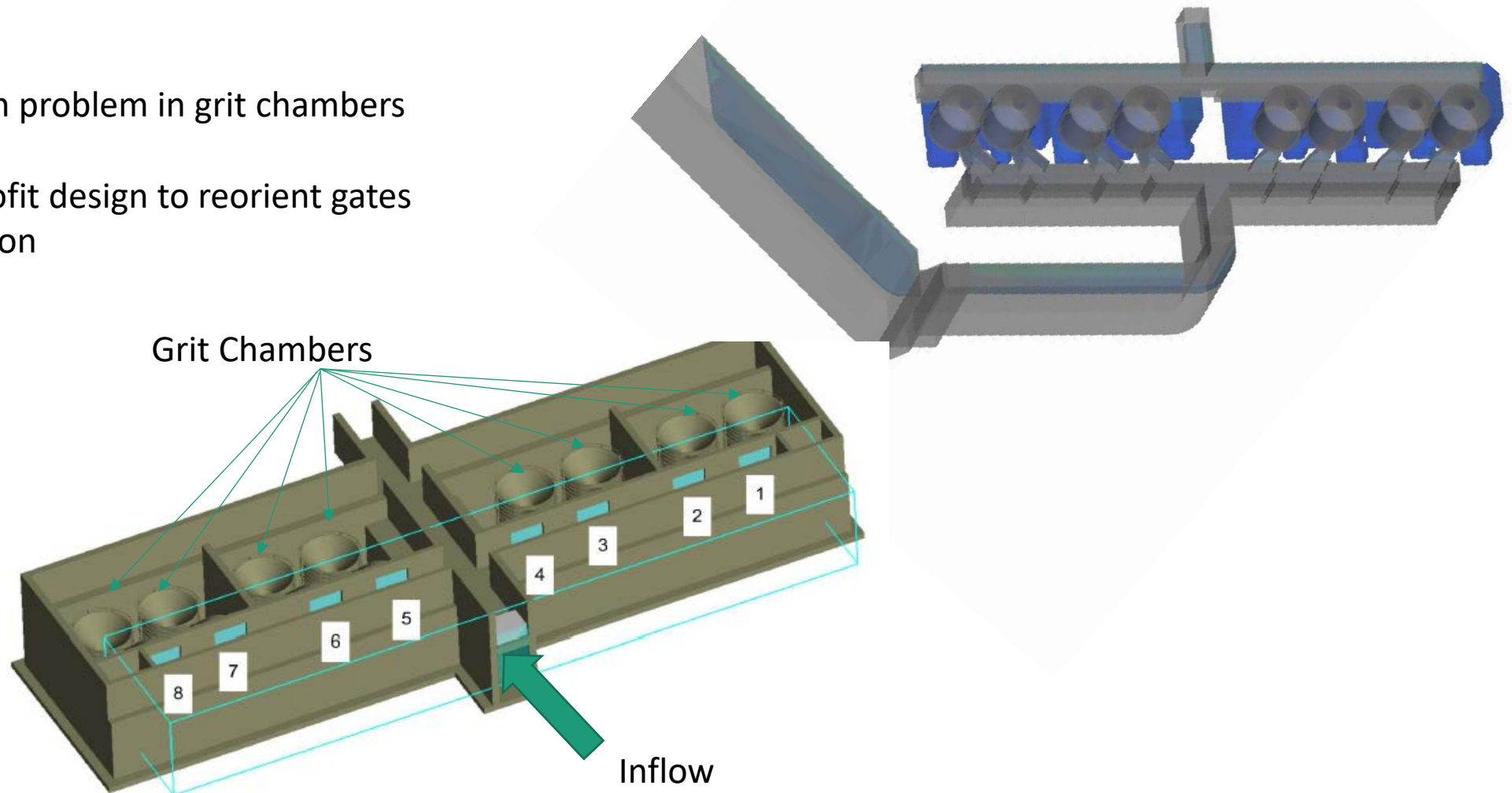
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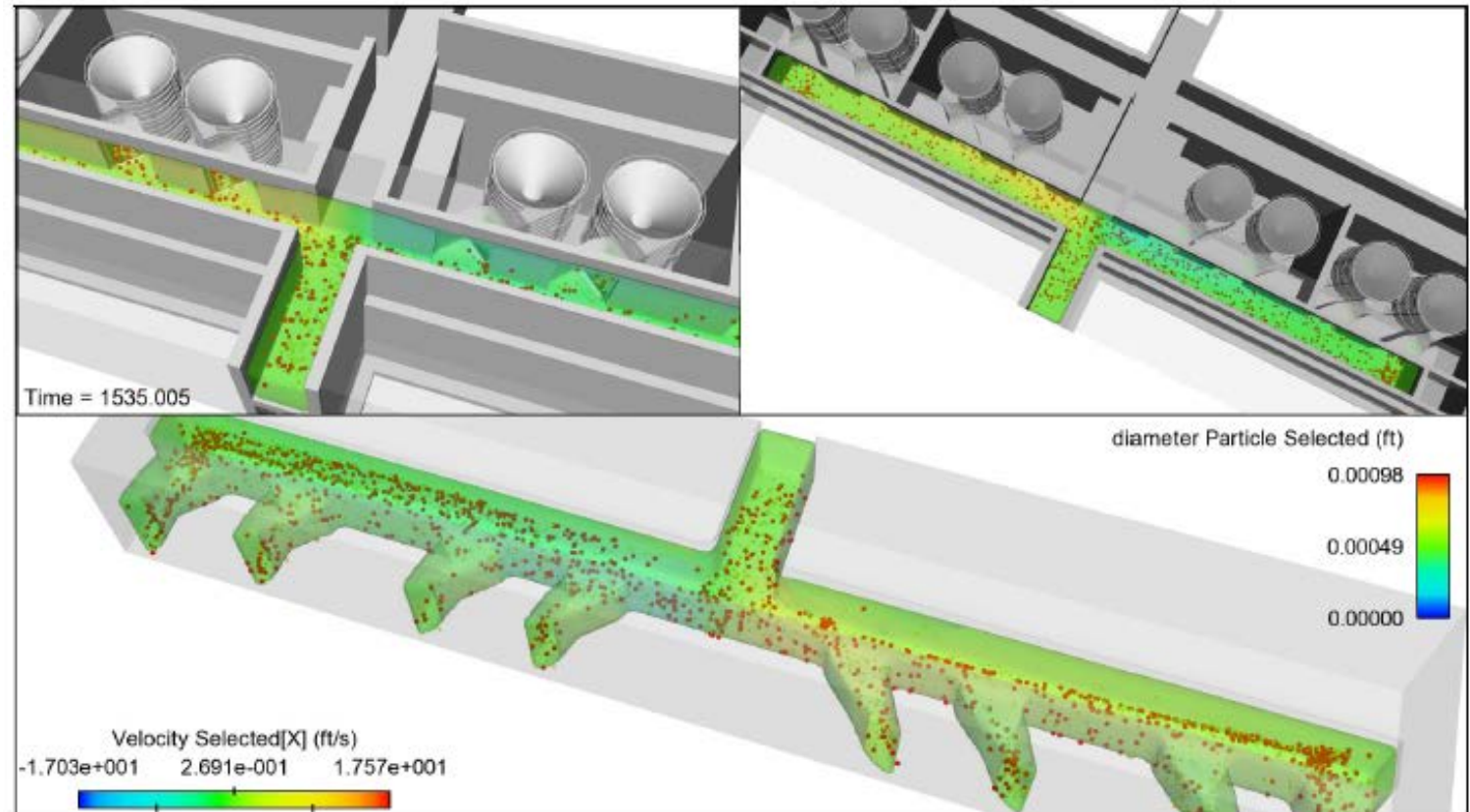
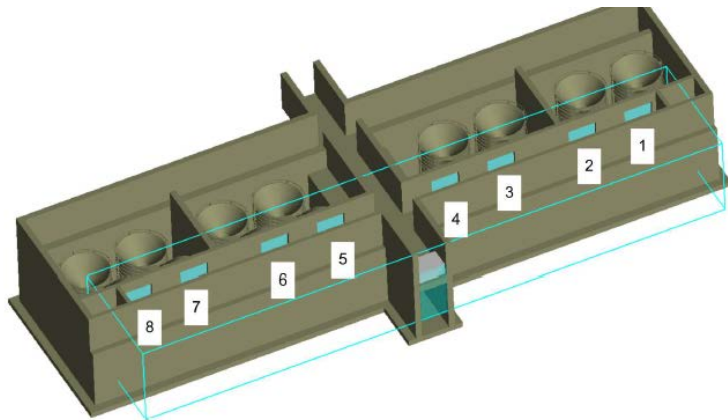
Project Example: Grit Chamber Optimization for DMWW

- Existing sedimentation problem in grit chambers
- CFD resulted in a retrofit design to reorient gates for even grit distribution



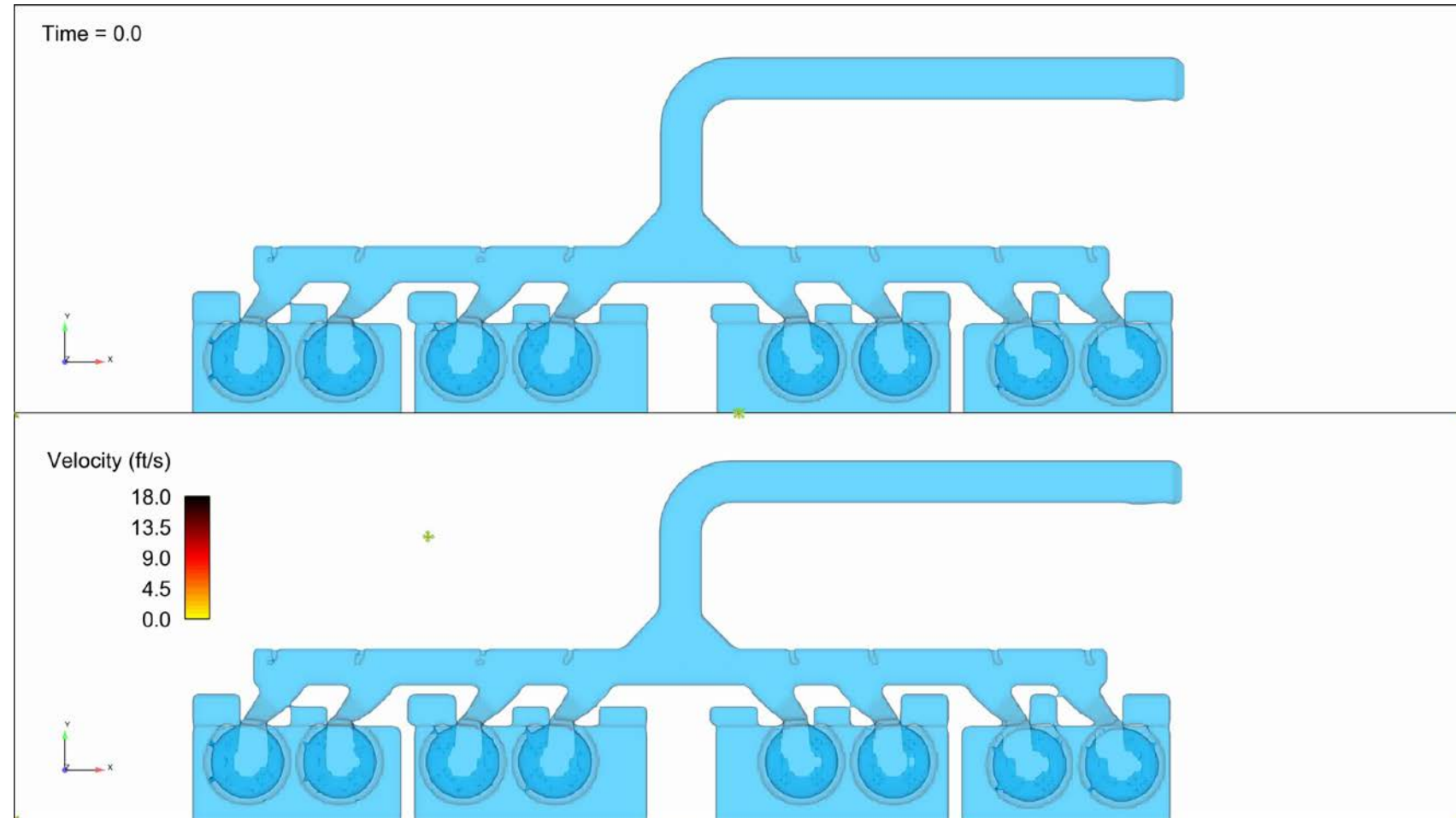
Project Example: Grit Chamber Baffle Optimization for DMWW

- Existing sedimentation problem in grit chambers
- Design alternatives modeled to determine best gate orientation for improved grit distribution
- Flow conditions of 60-220 MGD
- Simulated movement of 100-, 200-, & 300-micron particles



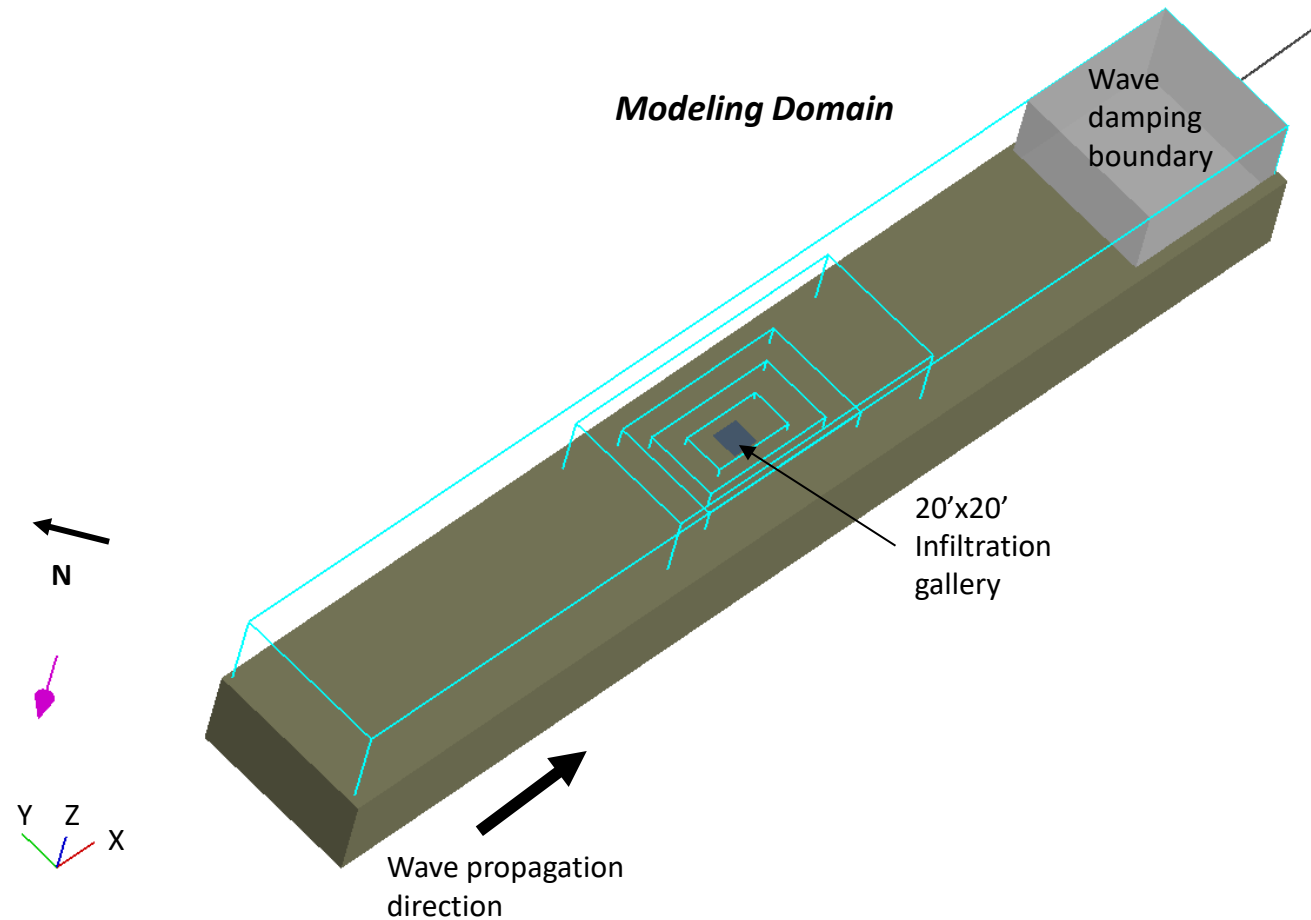
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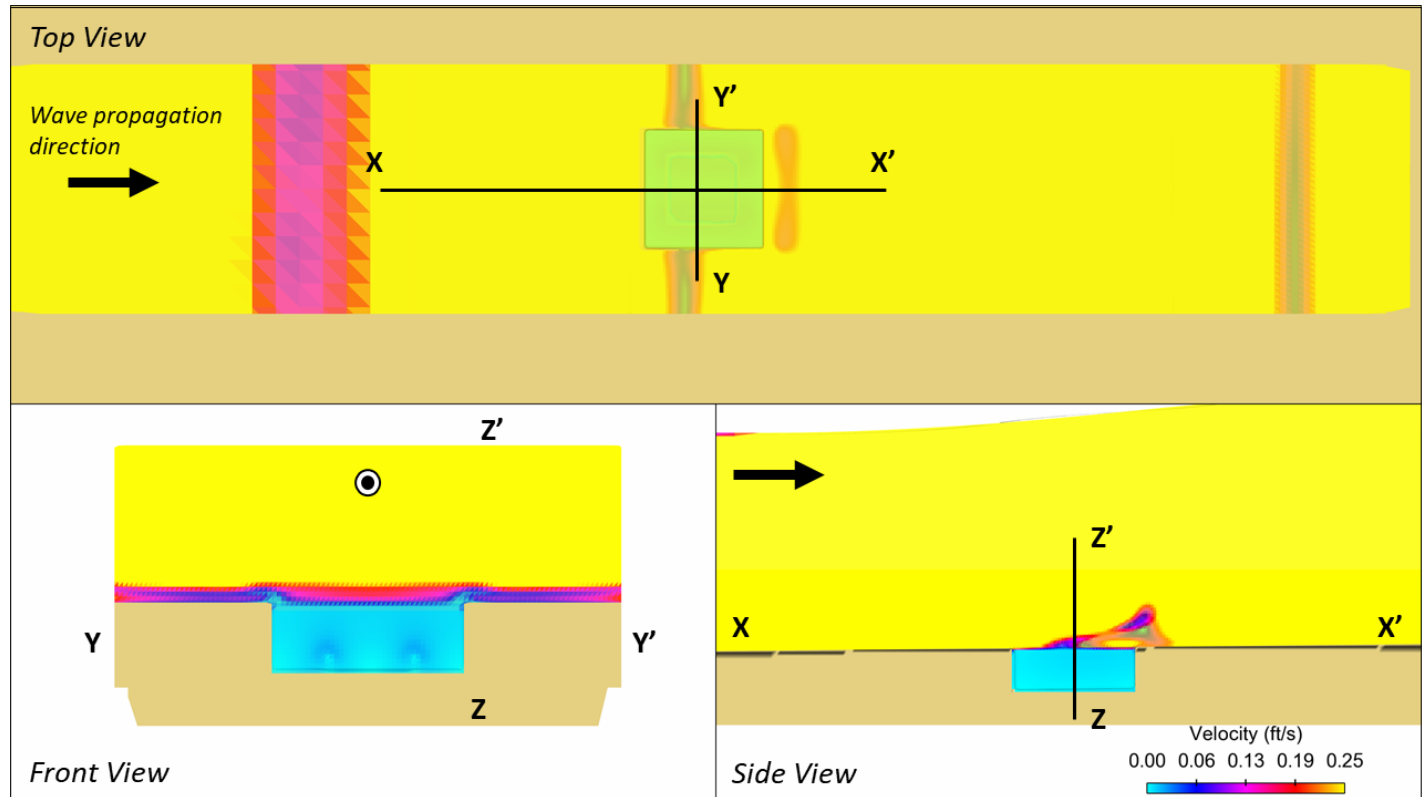
Project Example: Infiltration Gallery Assessment

- Proposed design for an infiltration gallery-type water intake in the Great Lakes
- Located in intermediate water depths
- Modeling investigated scour potential and flow characteristics of the preliminary design
- '1-year' wave conditions simulated



Project Example: Infiltration Gallery Assessment

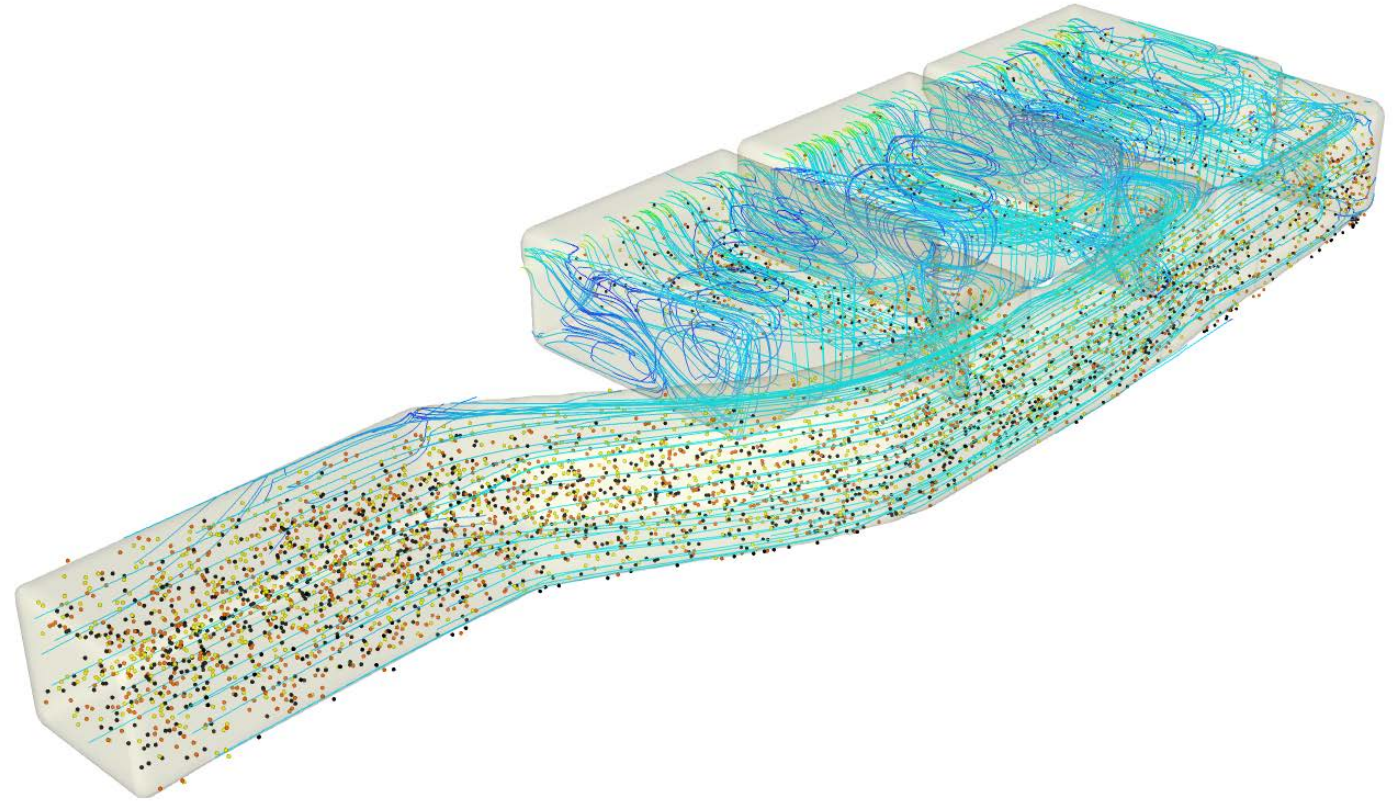
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Is CFD the right choice?

Considerations

- Project objectives
- Budget and timeline
- Regulatory requirements
- Impact of modeling insights



Thank you!

Take-Away Messages

- CFD is a powerful tool that can provide insight to a wide array of wastewater & municipal projects
- *Versatile, accurate, and efficient* models have enormous value that cannot be overstated

Questions?

Contact Us!

FreshWater Engineering
freshwatereng.com

njordan@freshwatereng.com