

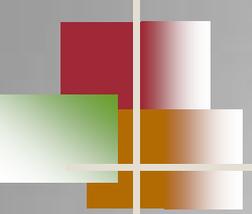
Using Computational Fluid Dynamics (CFD) to Determine T_{10} Contact Time

2015 PNWS-AWWA Conference
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Wally McCullough², Ray Leipold²

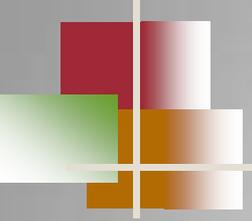
1-CH2M, 2-EWEB





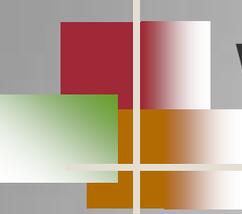
Presentation Overview

- **What is T_{10} and how is it calculated?**
- **How is T_{10} calculated using CFD?**
- **How do field/CFD methods compare?**



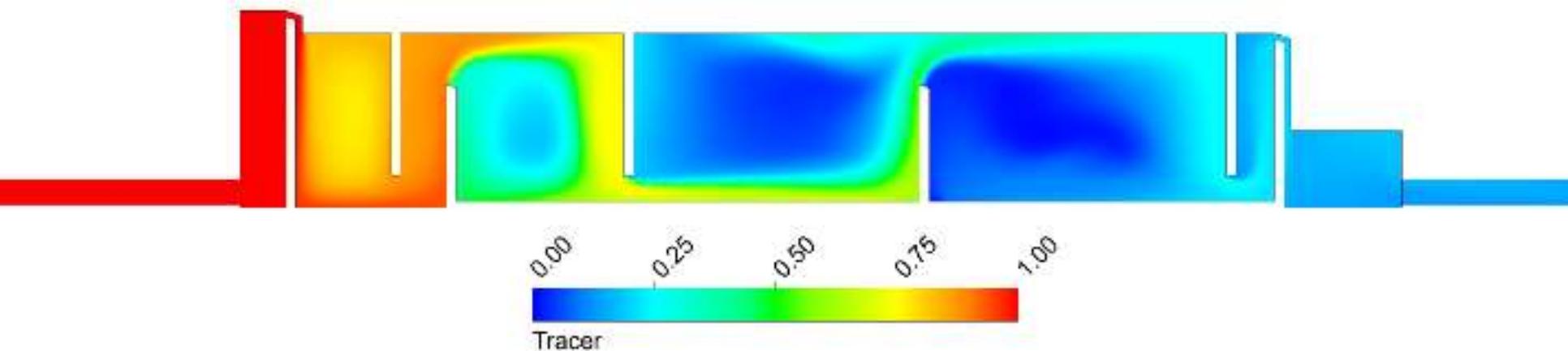
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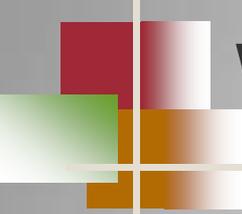
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What is T_{10} and how is it calculated?

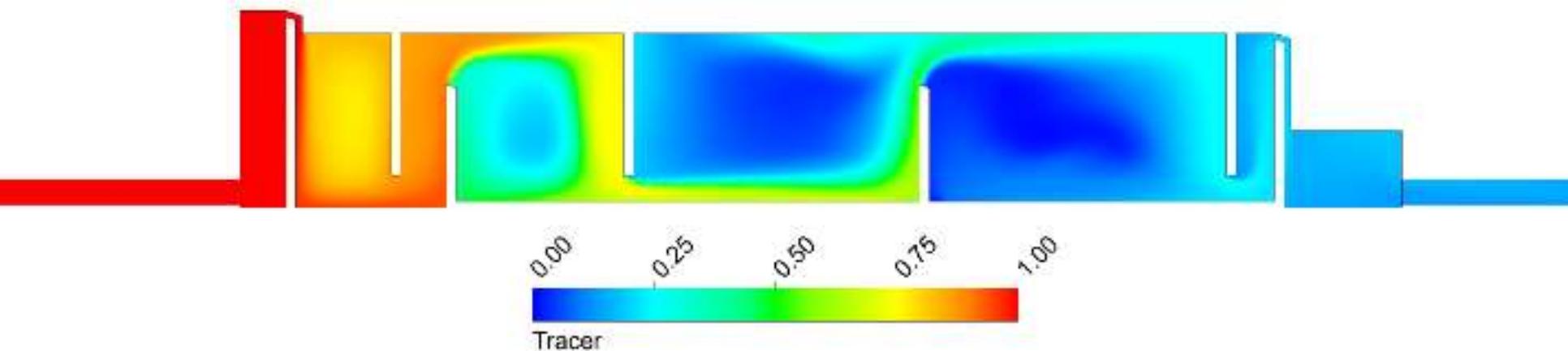
- Treatment plant operators need to account for **short-circuiting** and its reduction in **contact time** in plants.





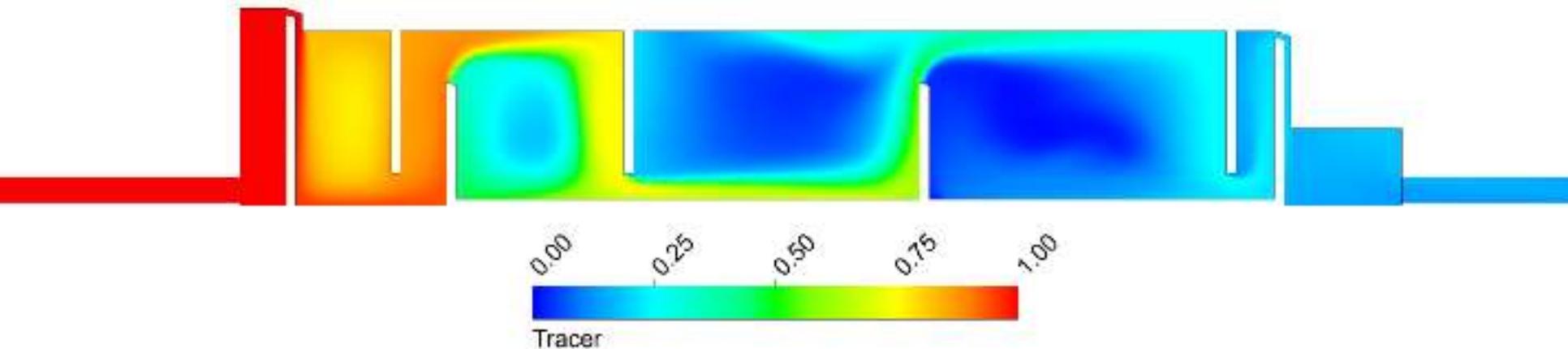
What is T_{10} and how is it calculated?

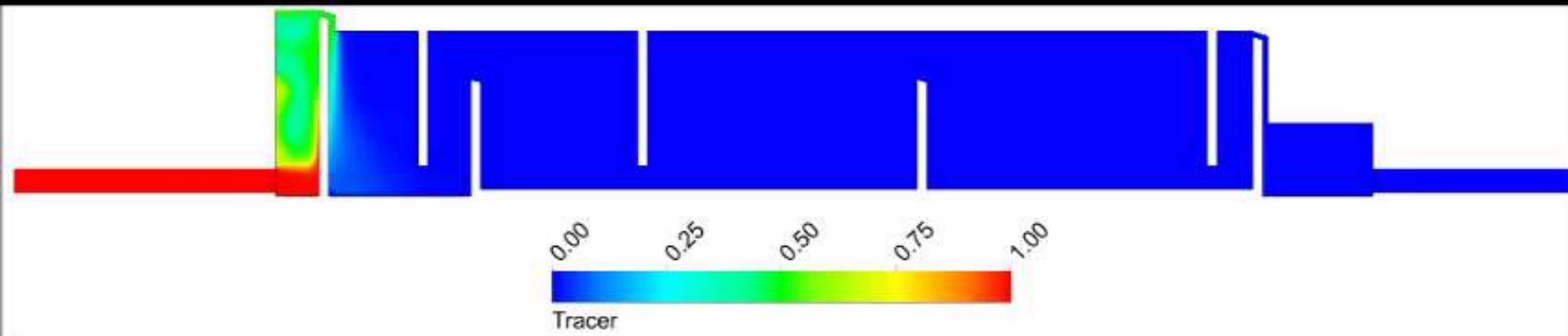
- The short-circuiting factor is T_{10}/T_h .
 - where:
 - T_{10} = time for the first 10% of water to pass through the defined storage volume.
 - T_h = theoretical detention time



What is T_{10} and how is it calculated?

- The degree of short-circuiting can depend on many factors:
 - Inlet and exit connections
 - Depth of storage
 - Flow rate
 - Tank shape





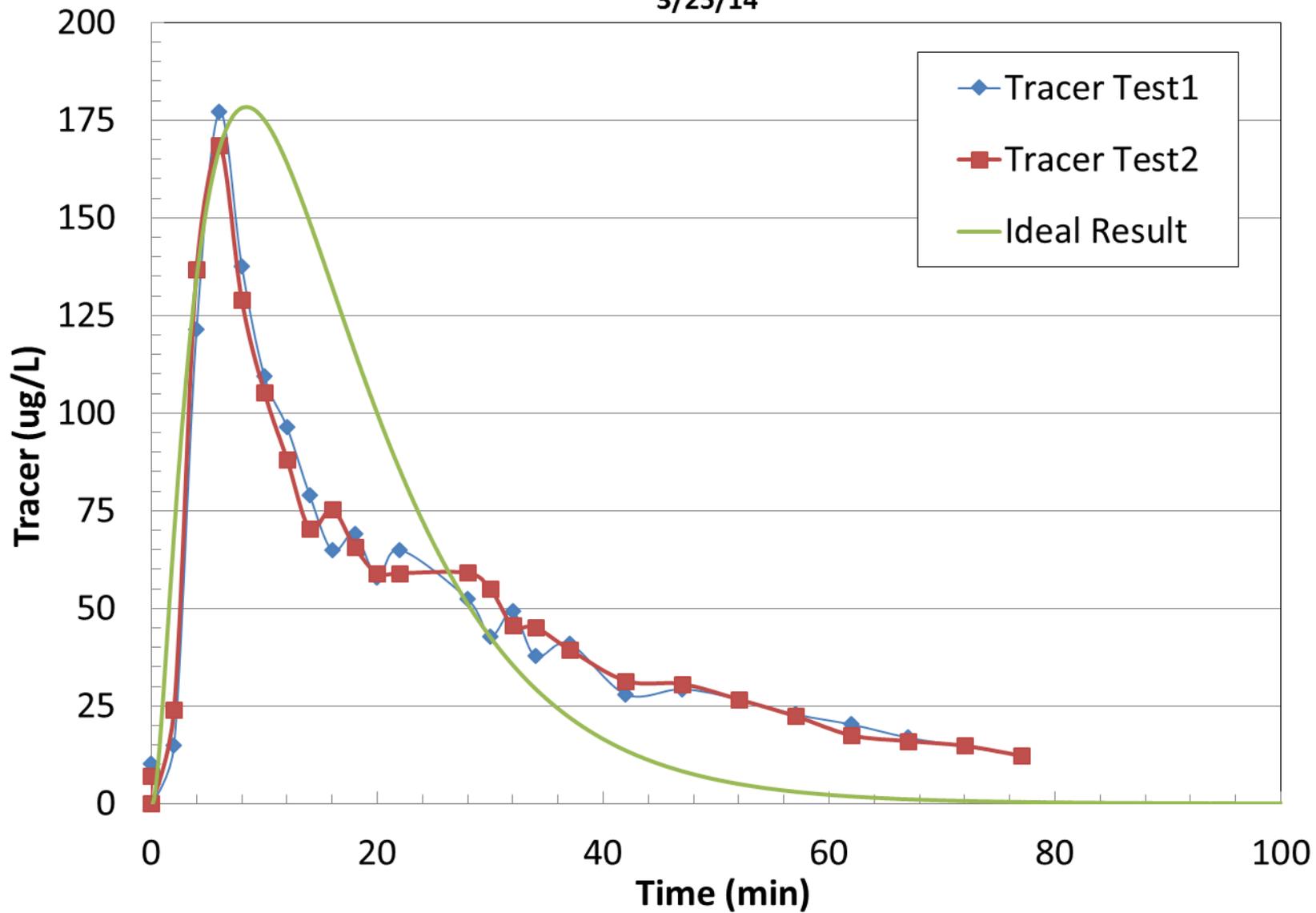


Field Tracer Study

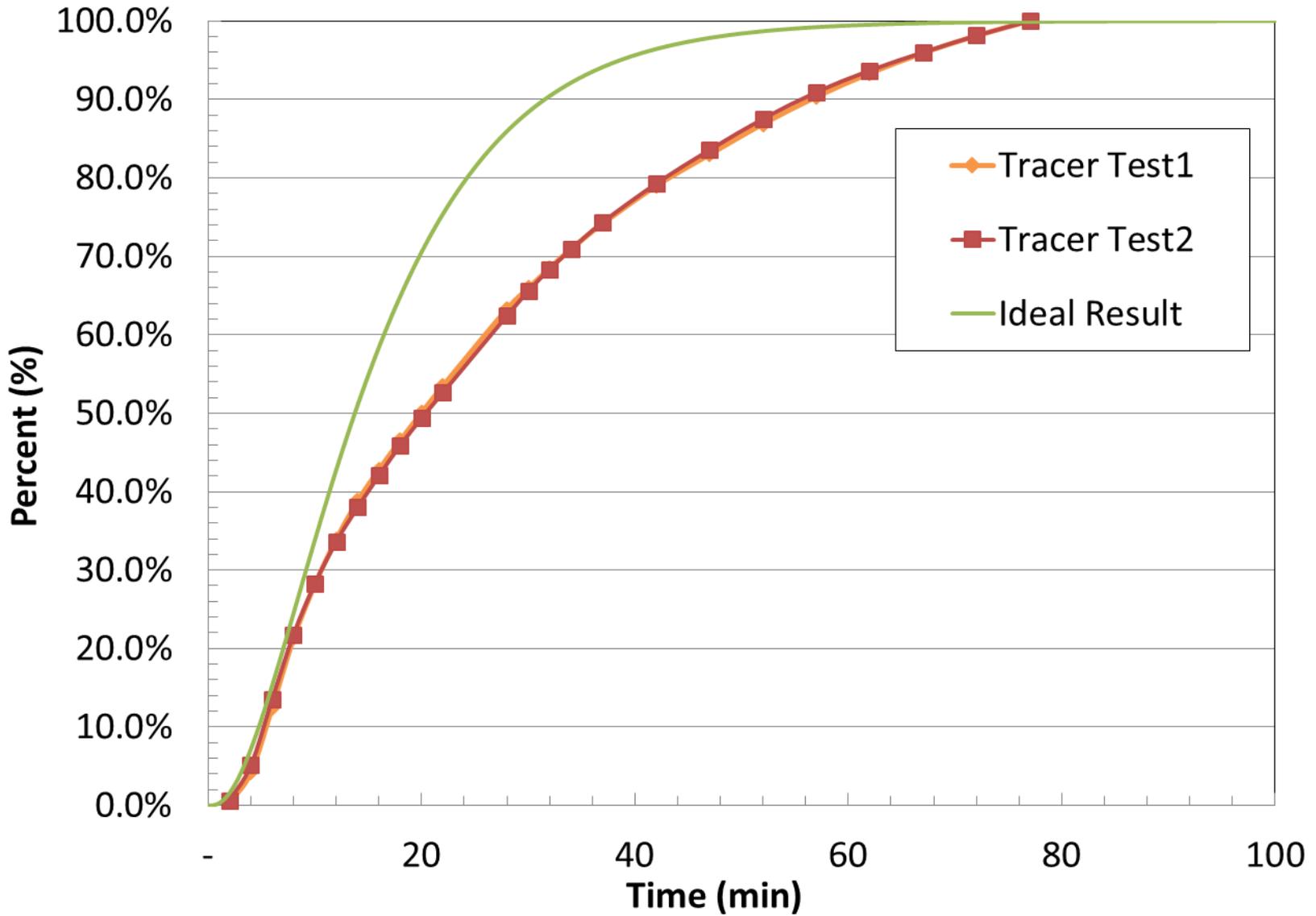
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Tracer Response Curve

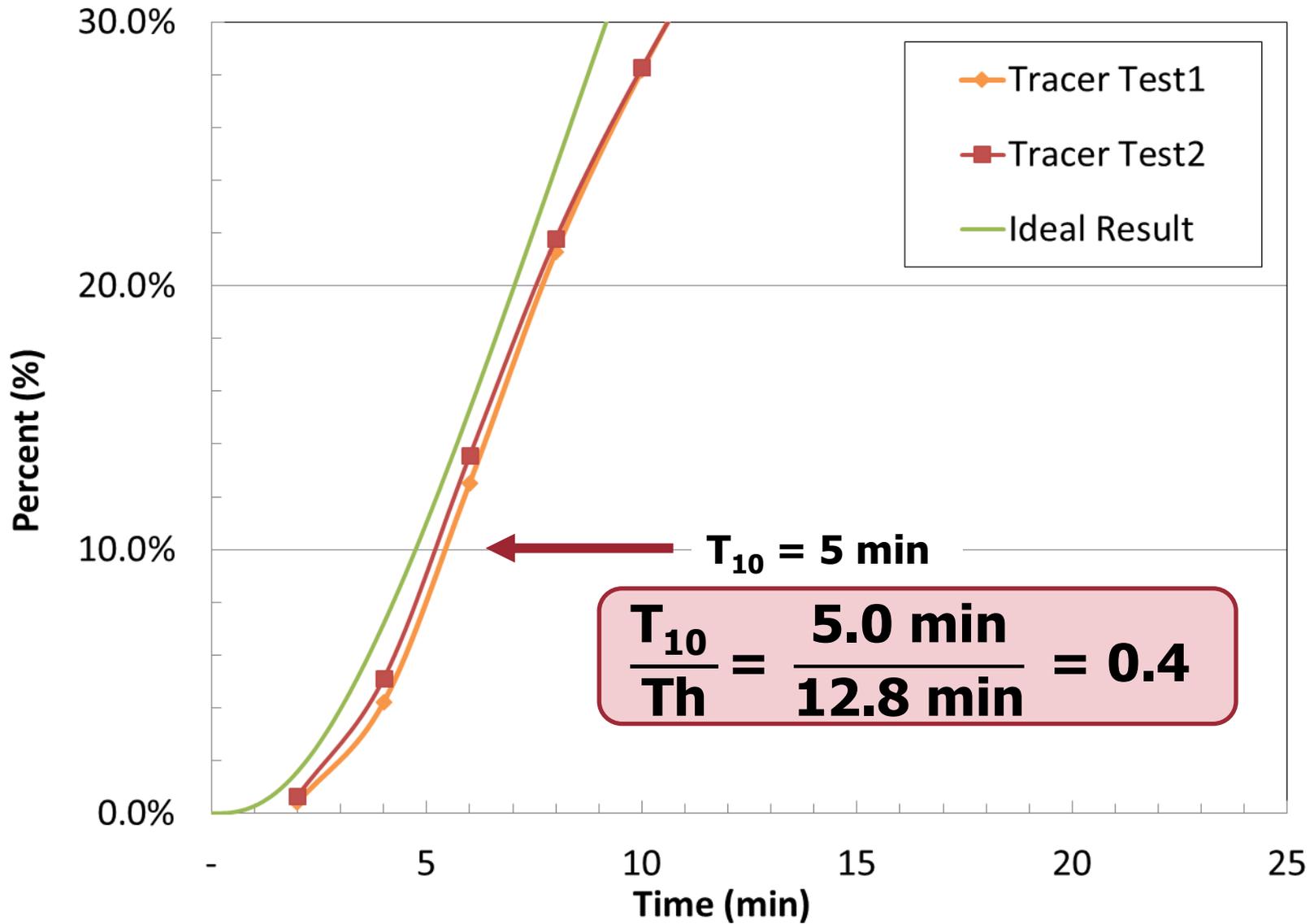
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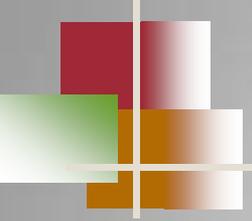


Cumulative Tracer Out



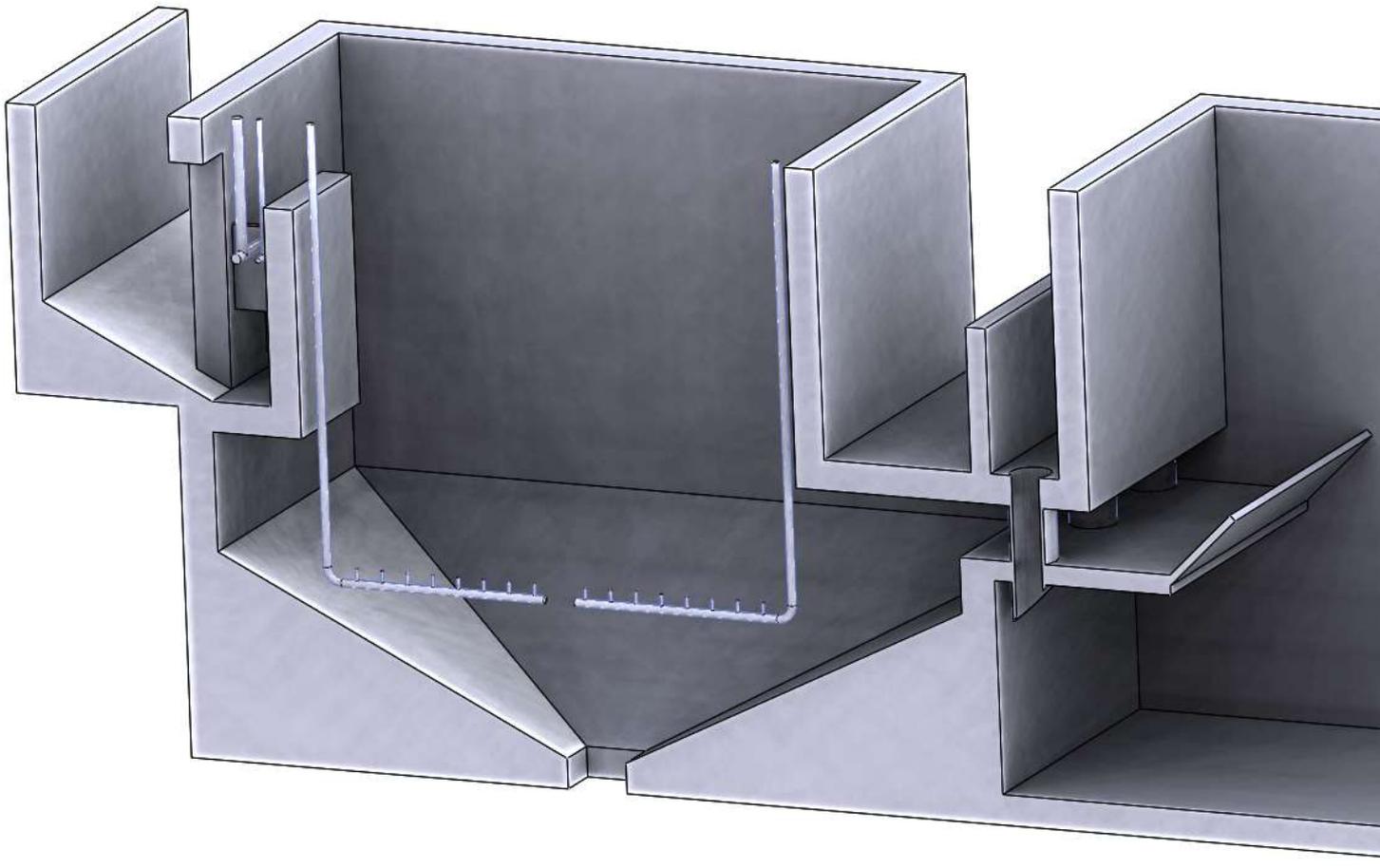
Cumulative Tracer Out



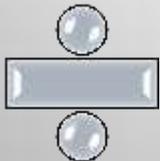


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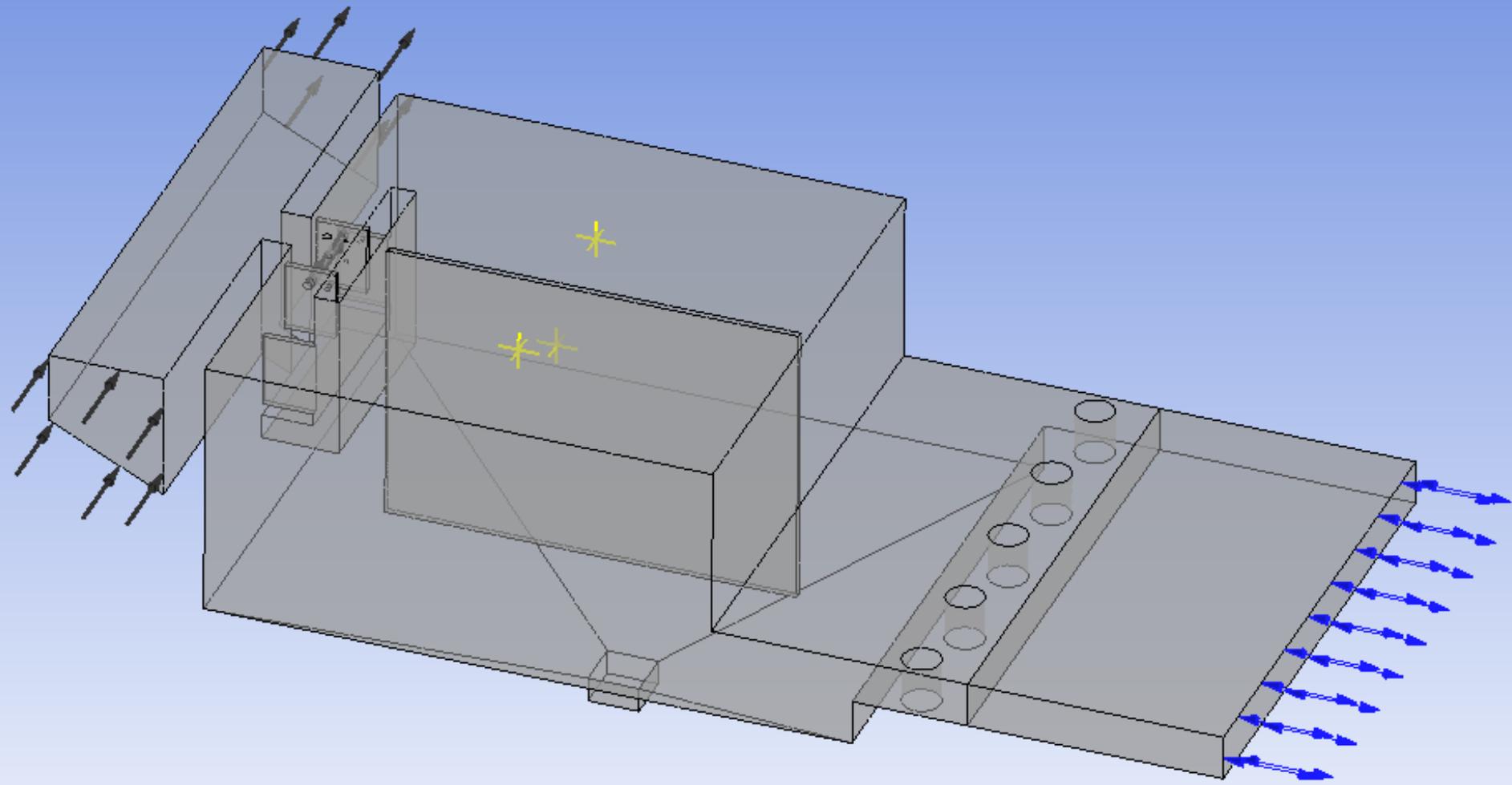
Volume
7200 ft³



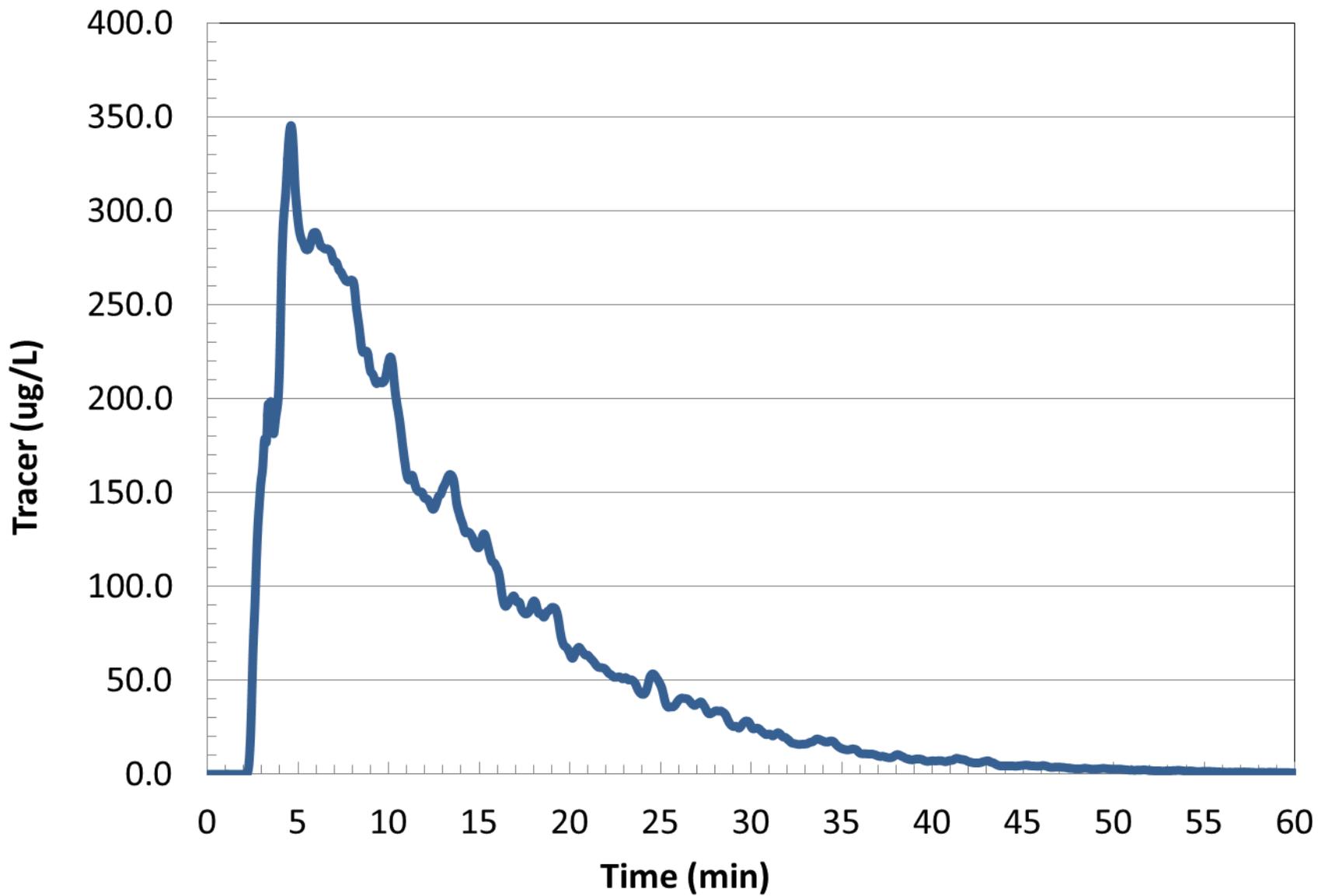
Inflow
9.3 ft³/sec



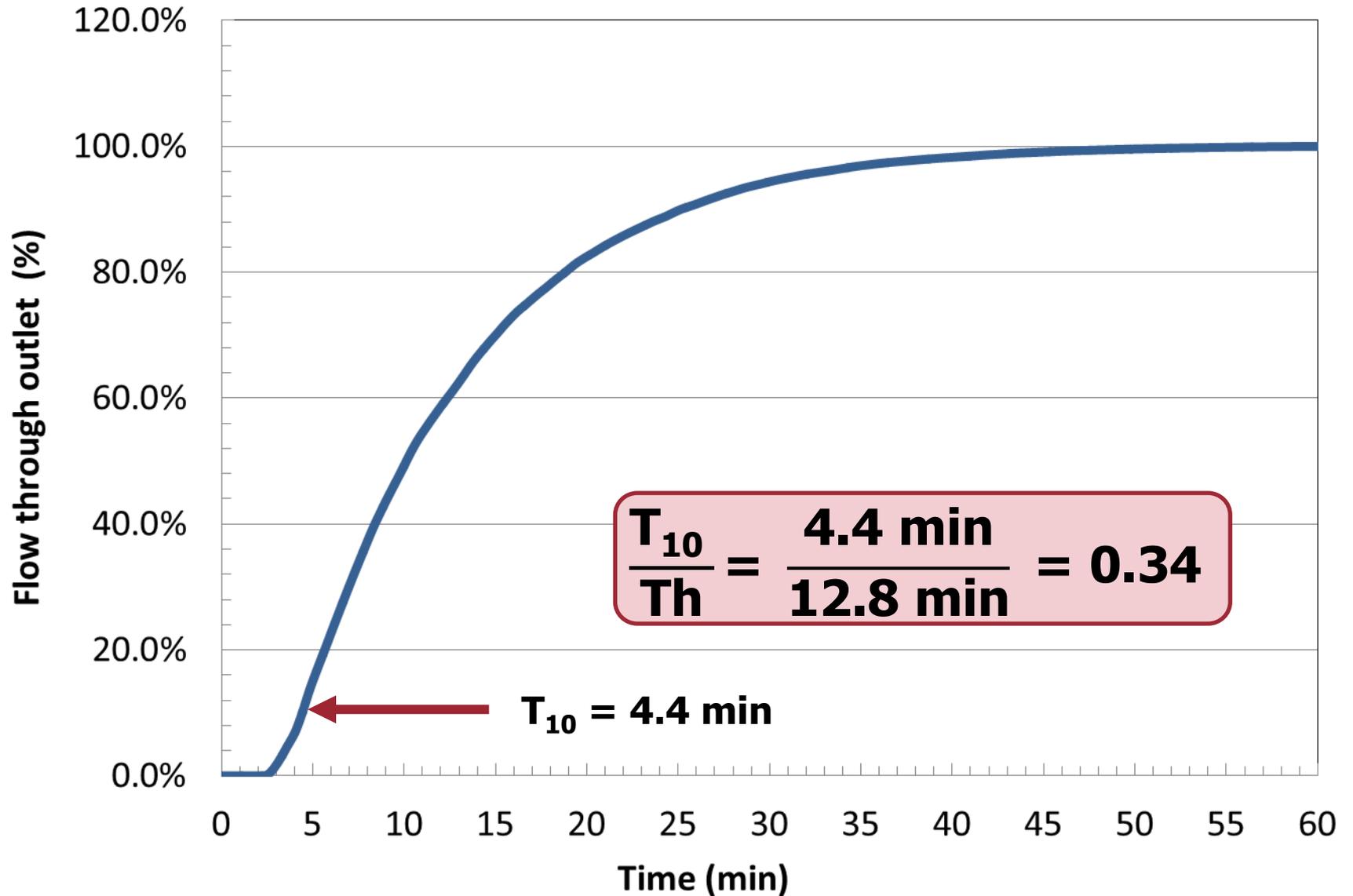
Theoretical
Time
12.8 min

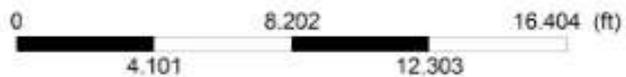
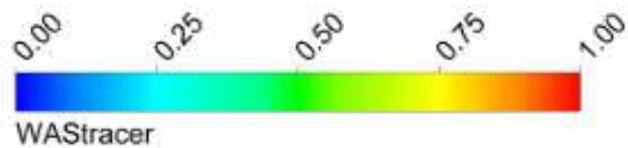
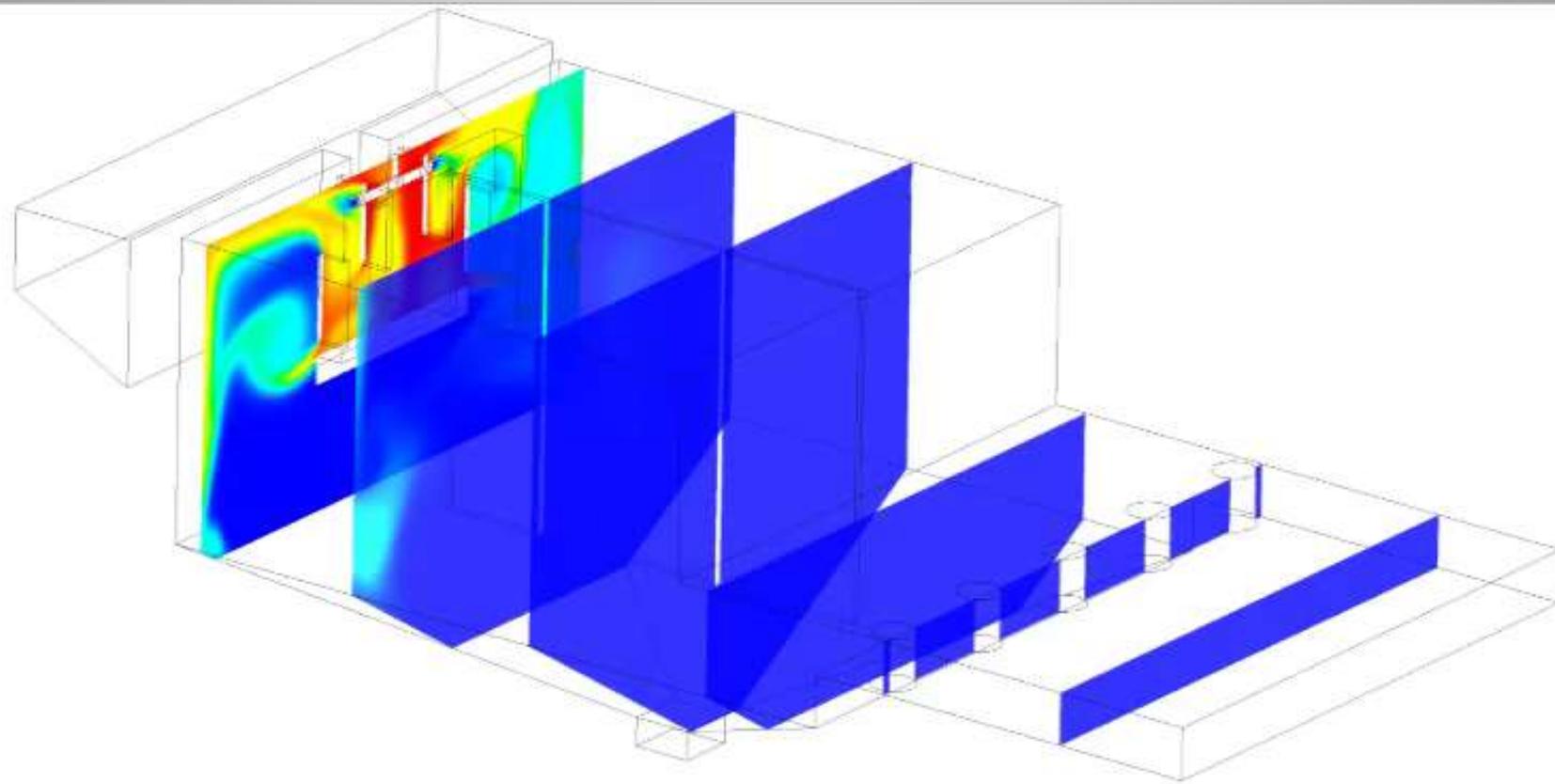


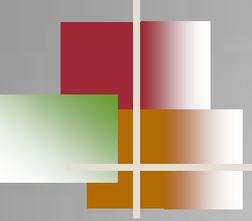
CFD Tracer Response Curve



Outlet Concentration vs Time



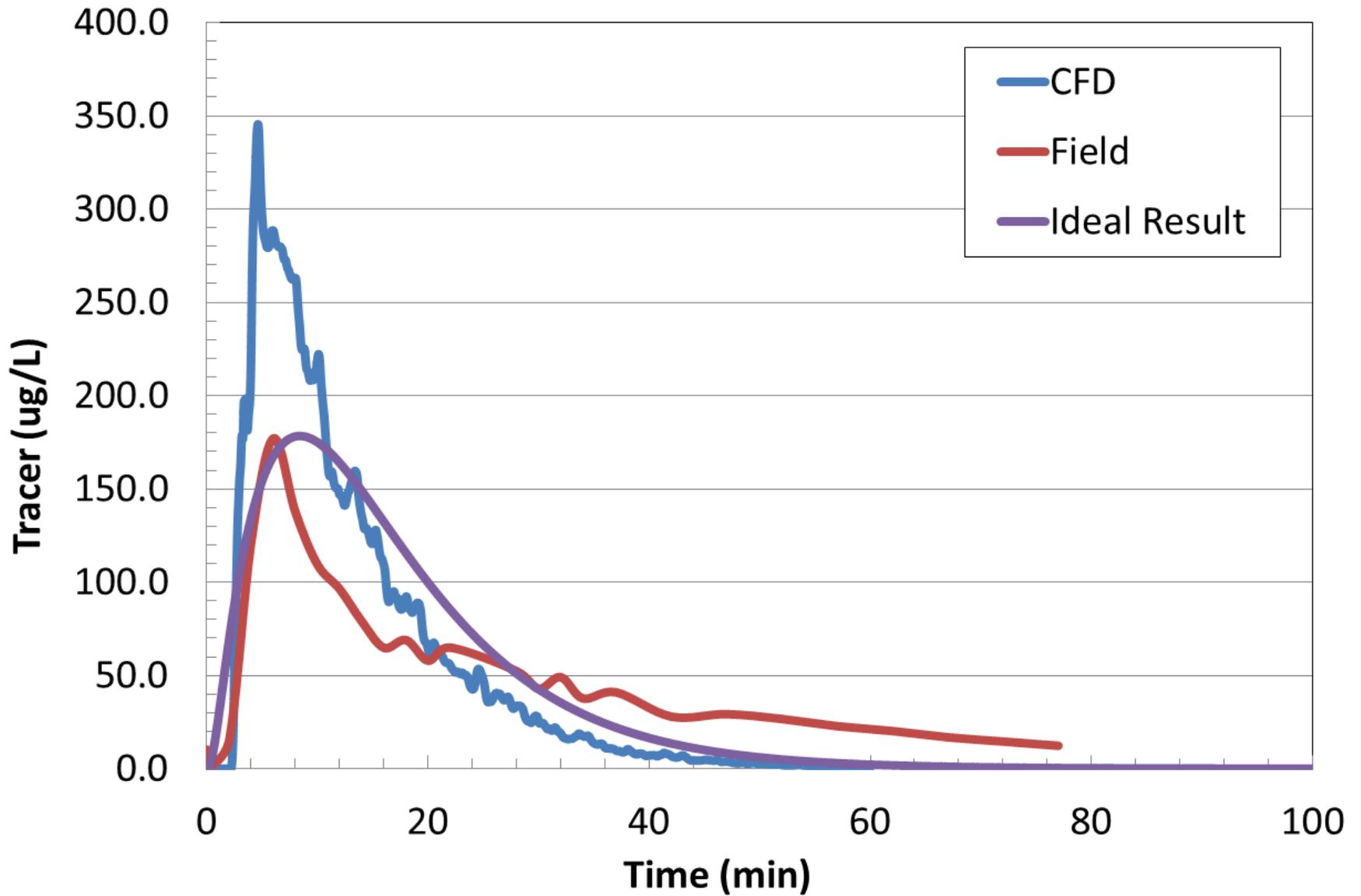




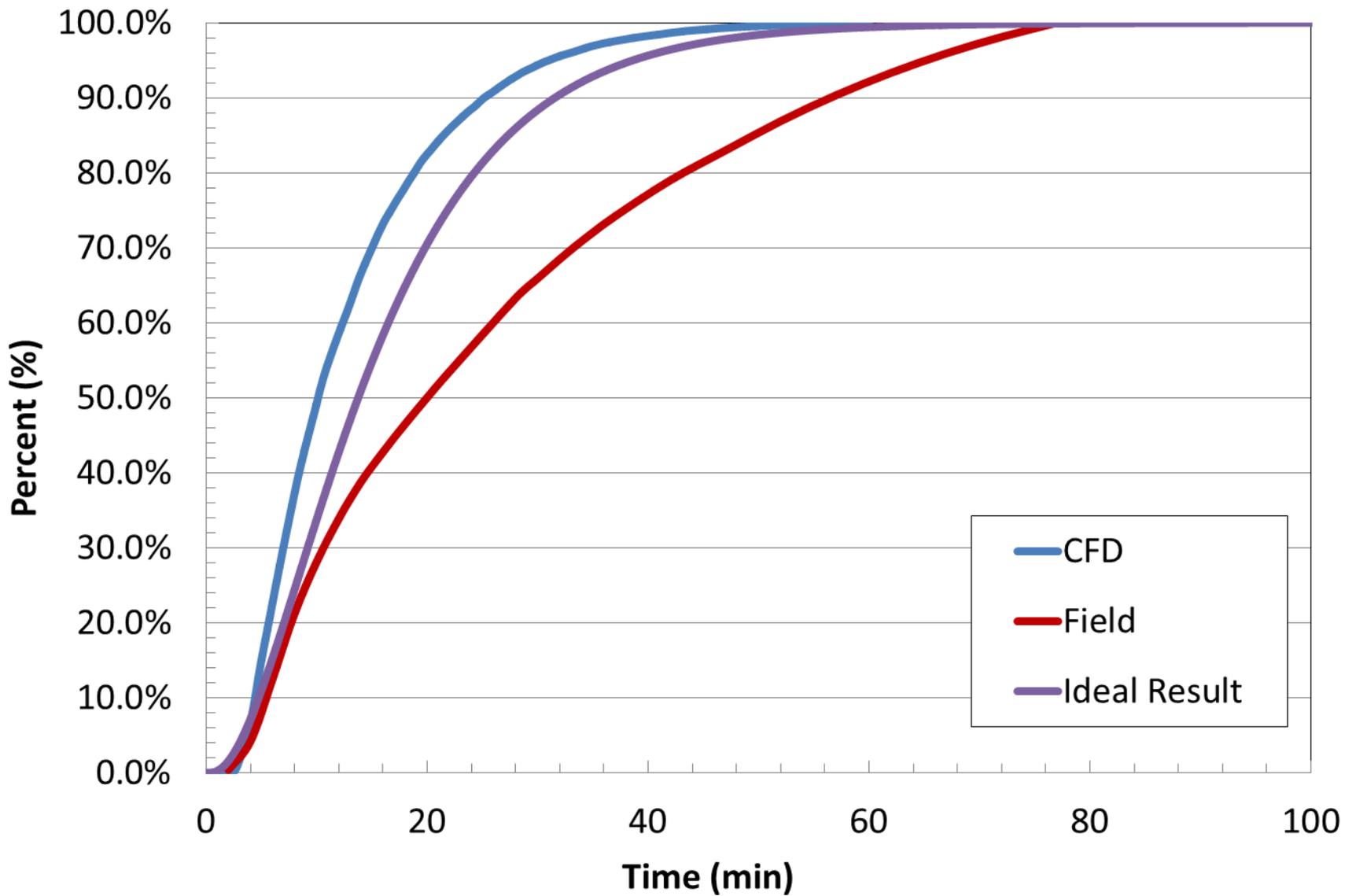
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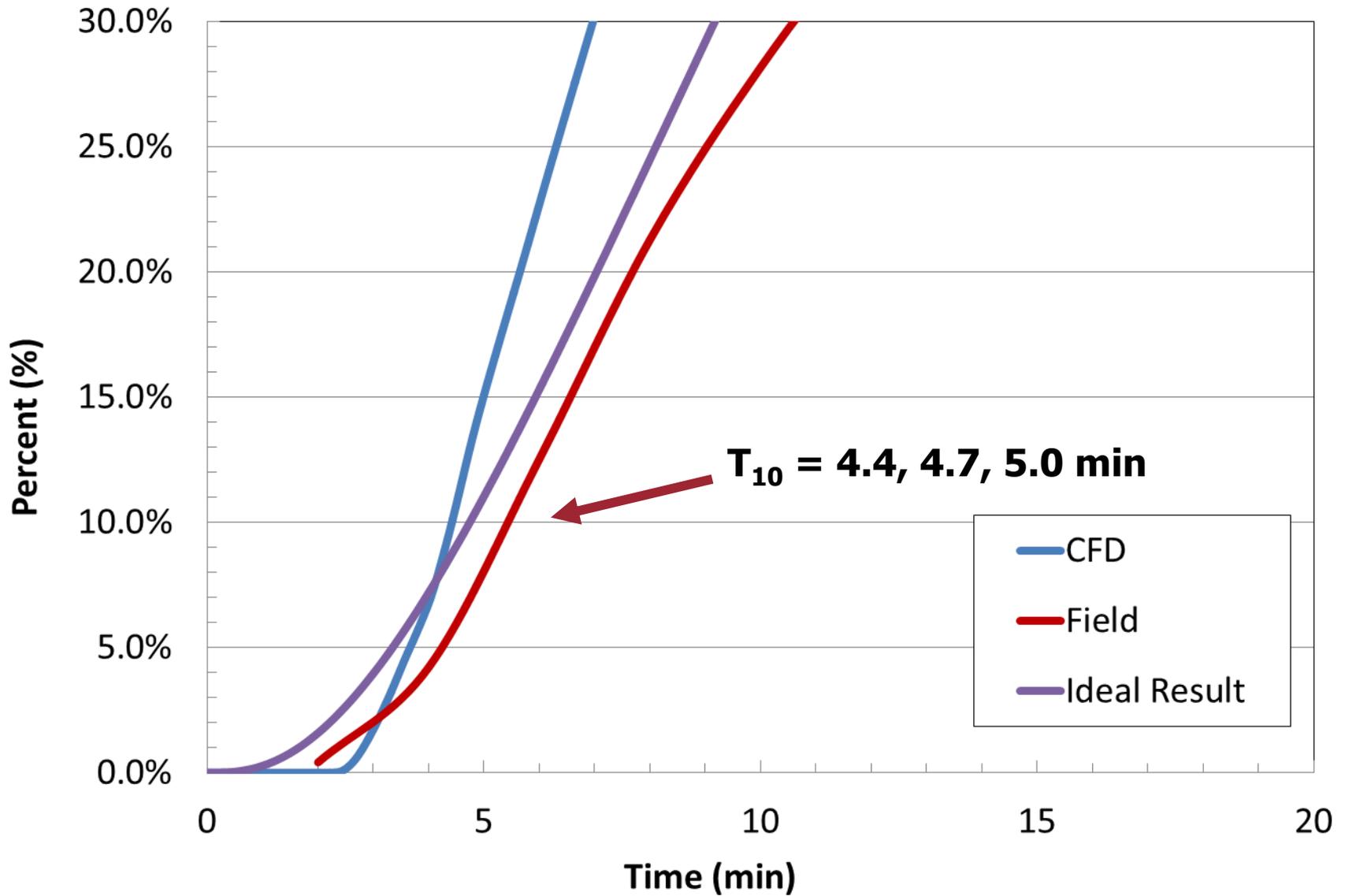
Tracer Response Curve

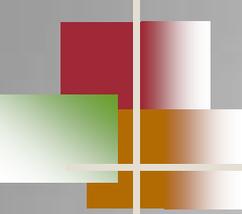


Cumulative Tracer Out



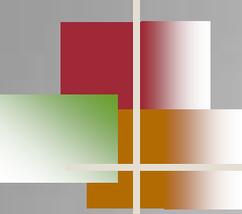
Cumulative Tracer Out



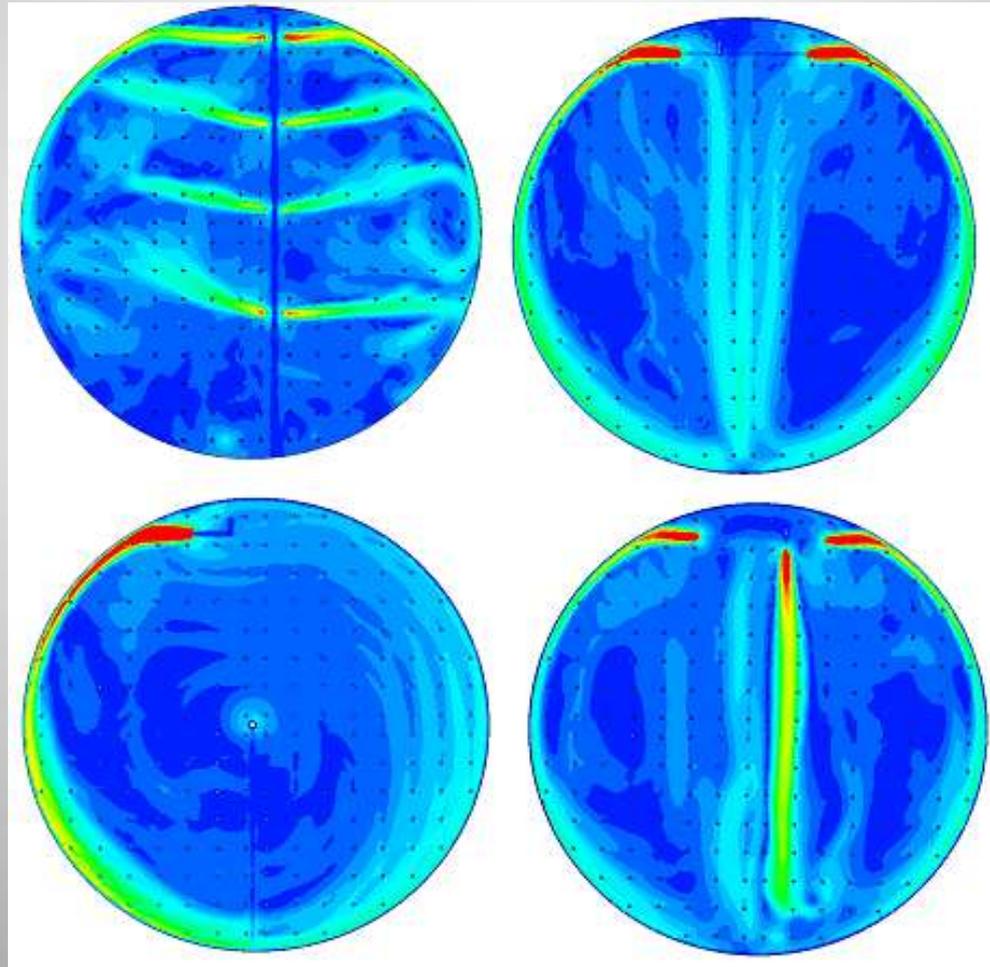


How do field/CFD methods compare?

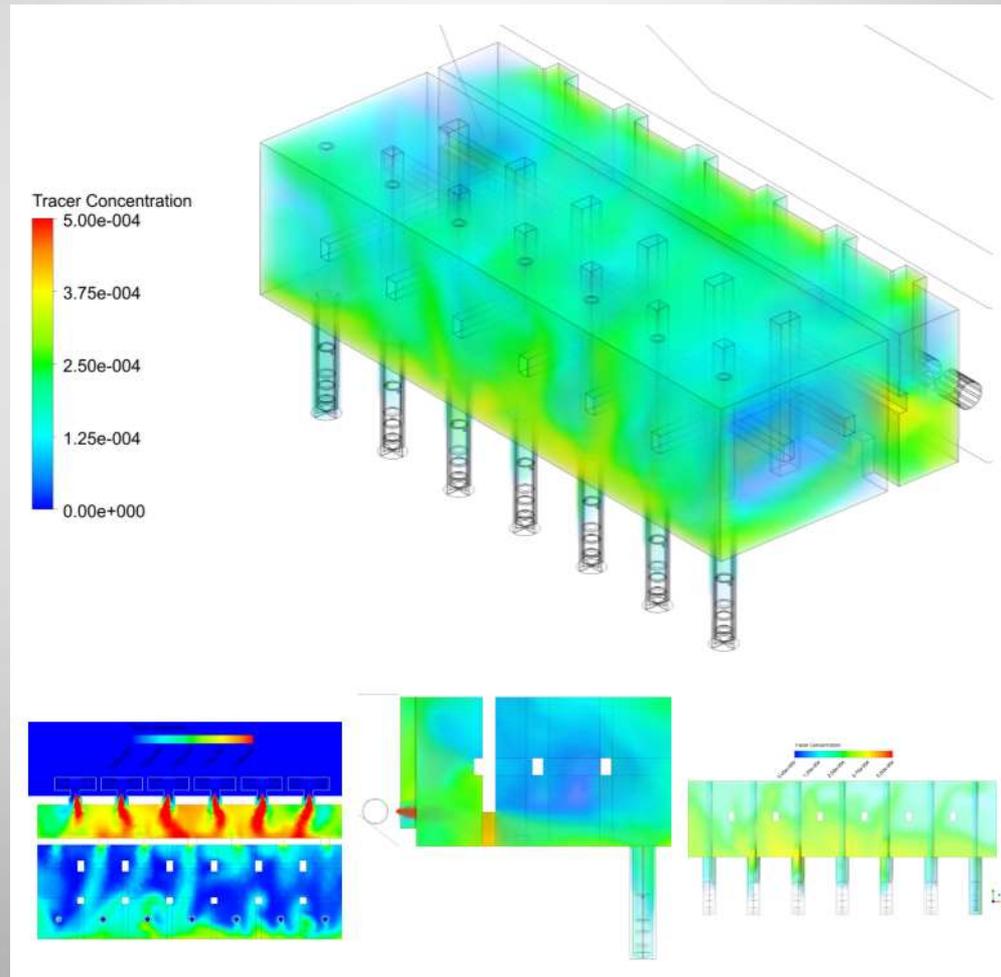
- CFD can be cheaper than field tests.
- CFD provides several scenarios instead of one test point.
- CFD provides flexibility with the injection/collection points.
- CFD can be used to test designs before construction (or estimate T_{10} before field study).

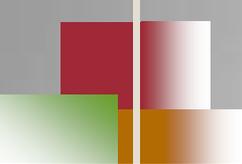


Examples – Clearwells

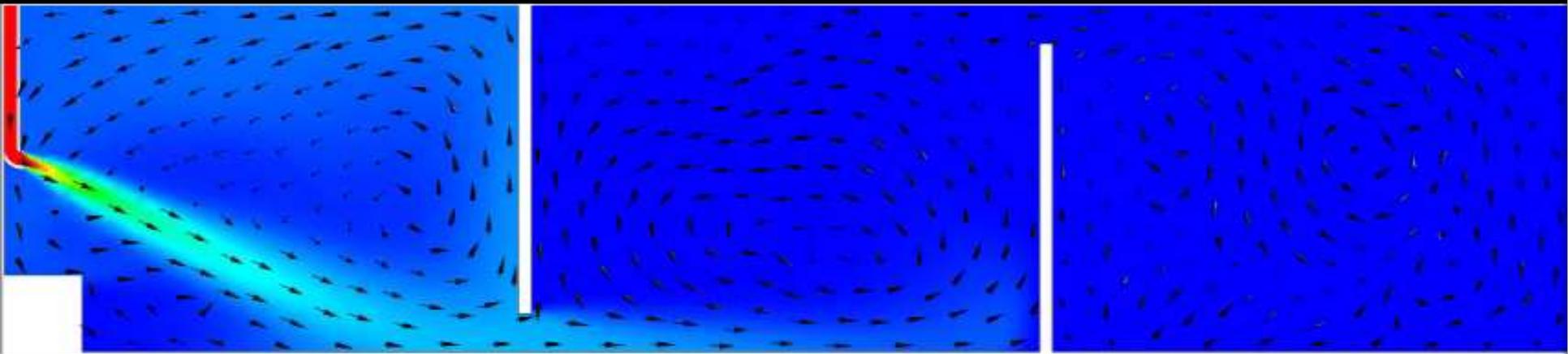


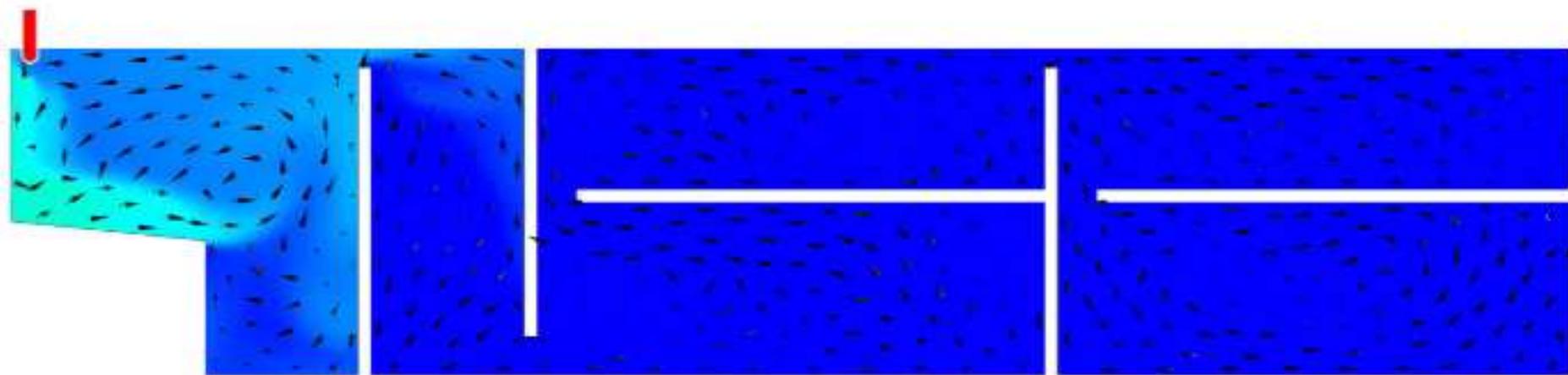
Examples – Pump Station Intake



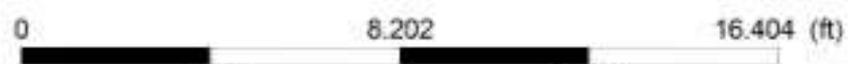


Examples – Chlorine Contact Basin

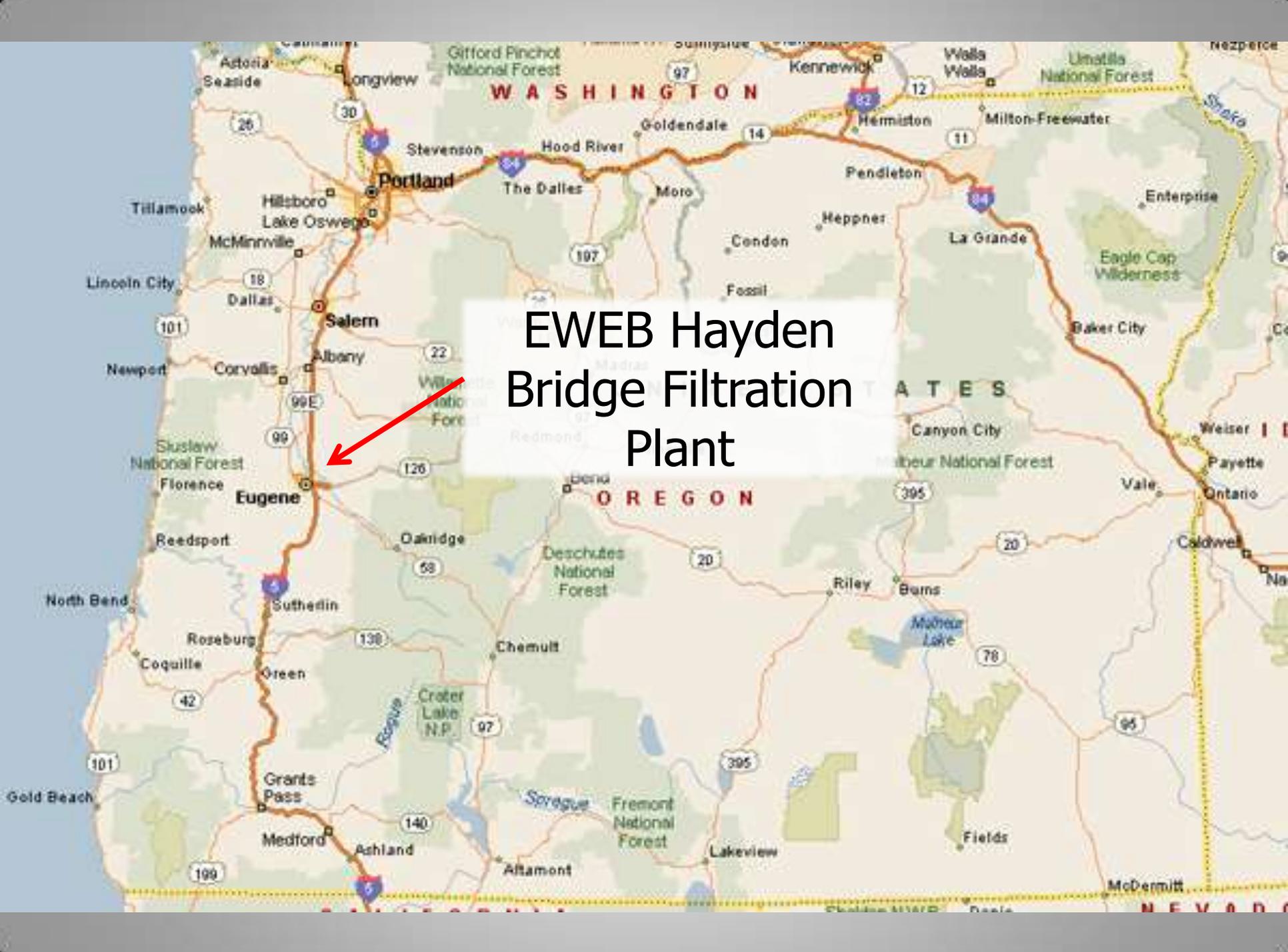


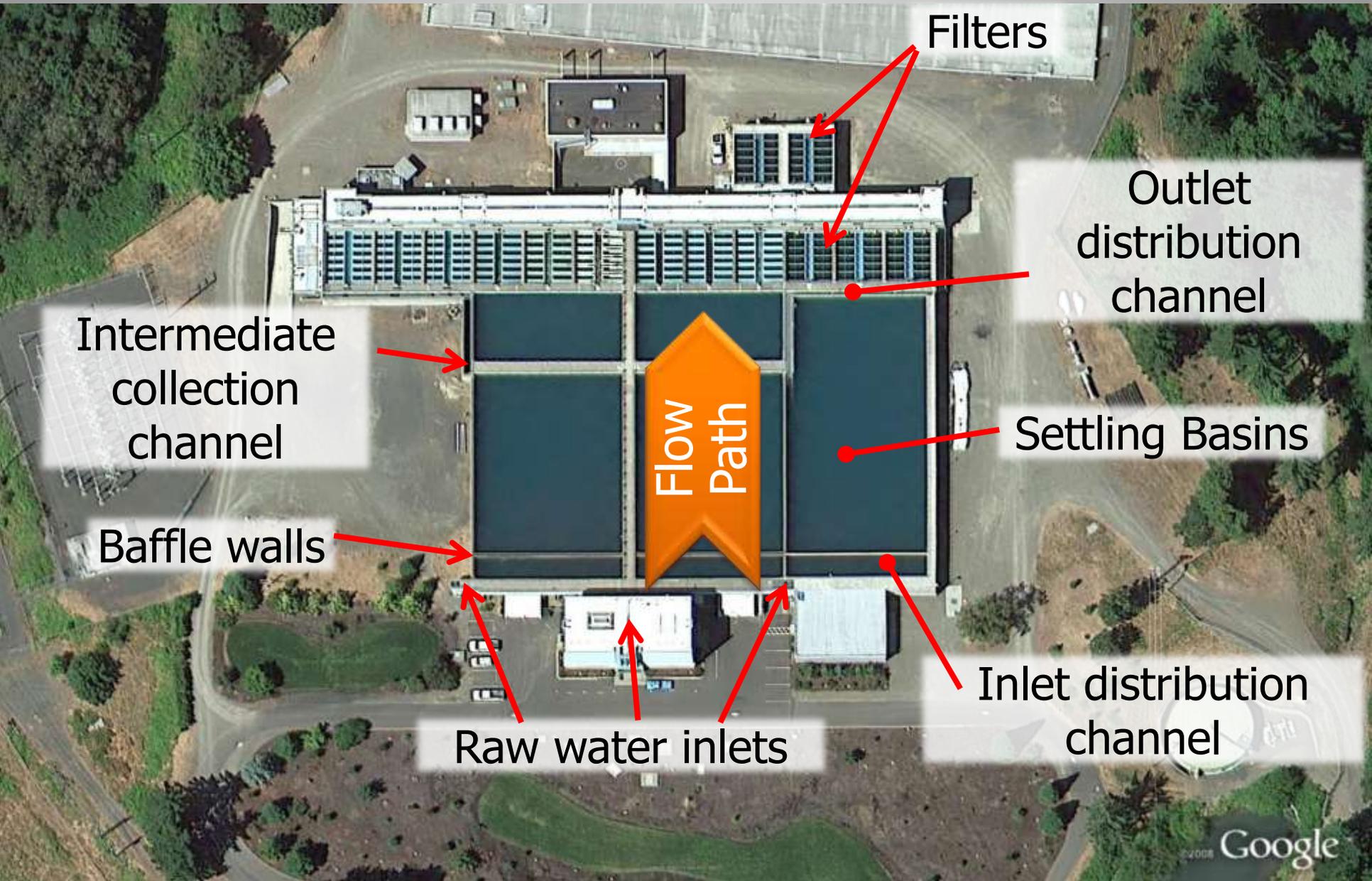


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EWEB Hayden
Bridge Filtration
Plant





Filters

Outlet distribution channel

Intermediate collection channel

Settling Basins

Baffle walls

Inlet distribution channel

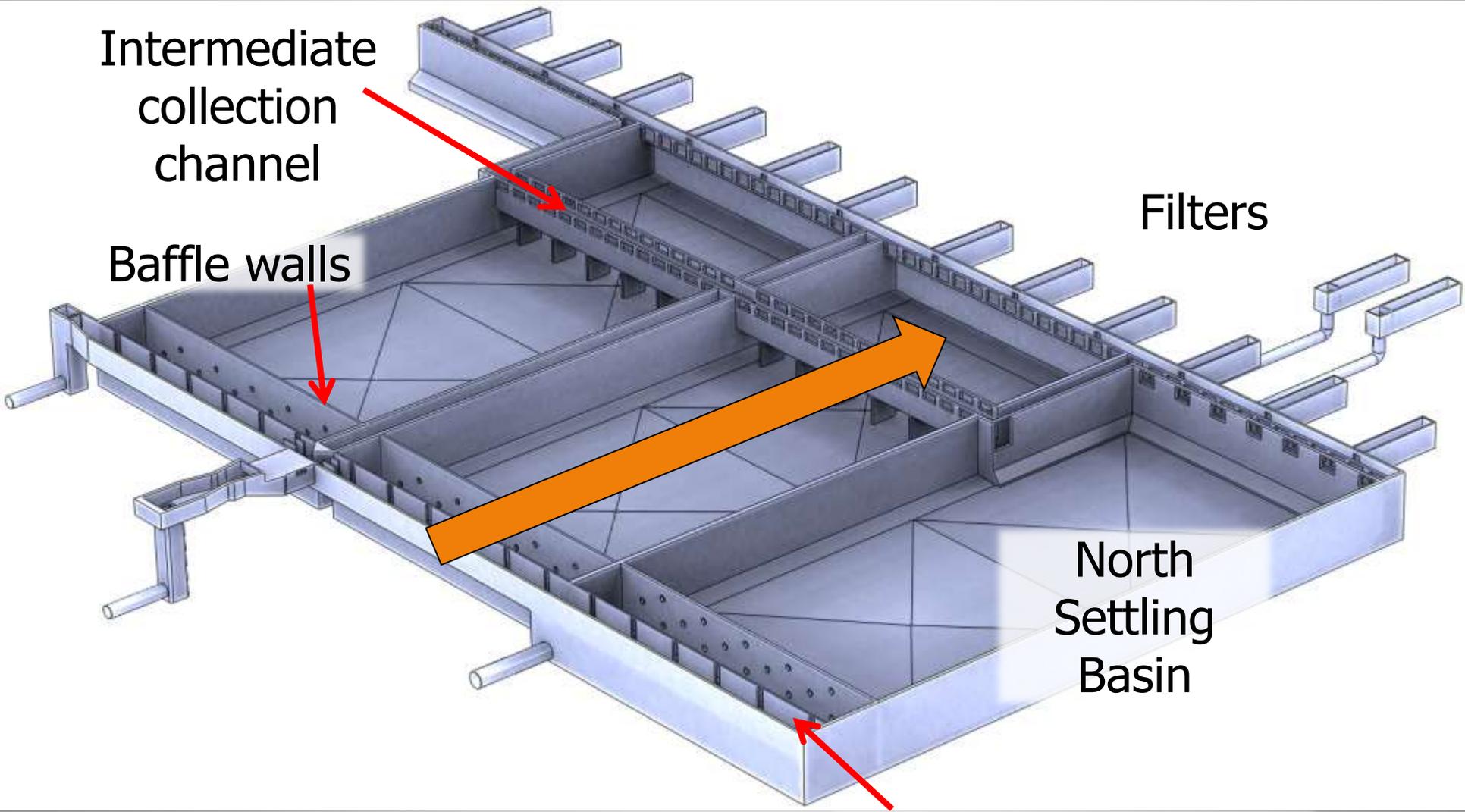
Flow Path

Raw water inlets



Observed short circuiting

I.e. low T_{10}



Intermediate collection channel

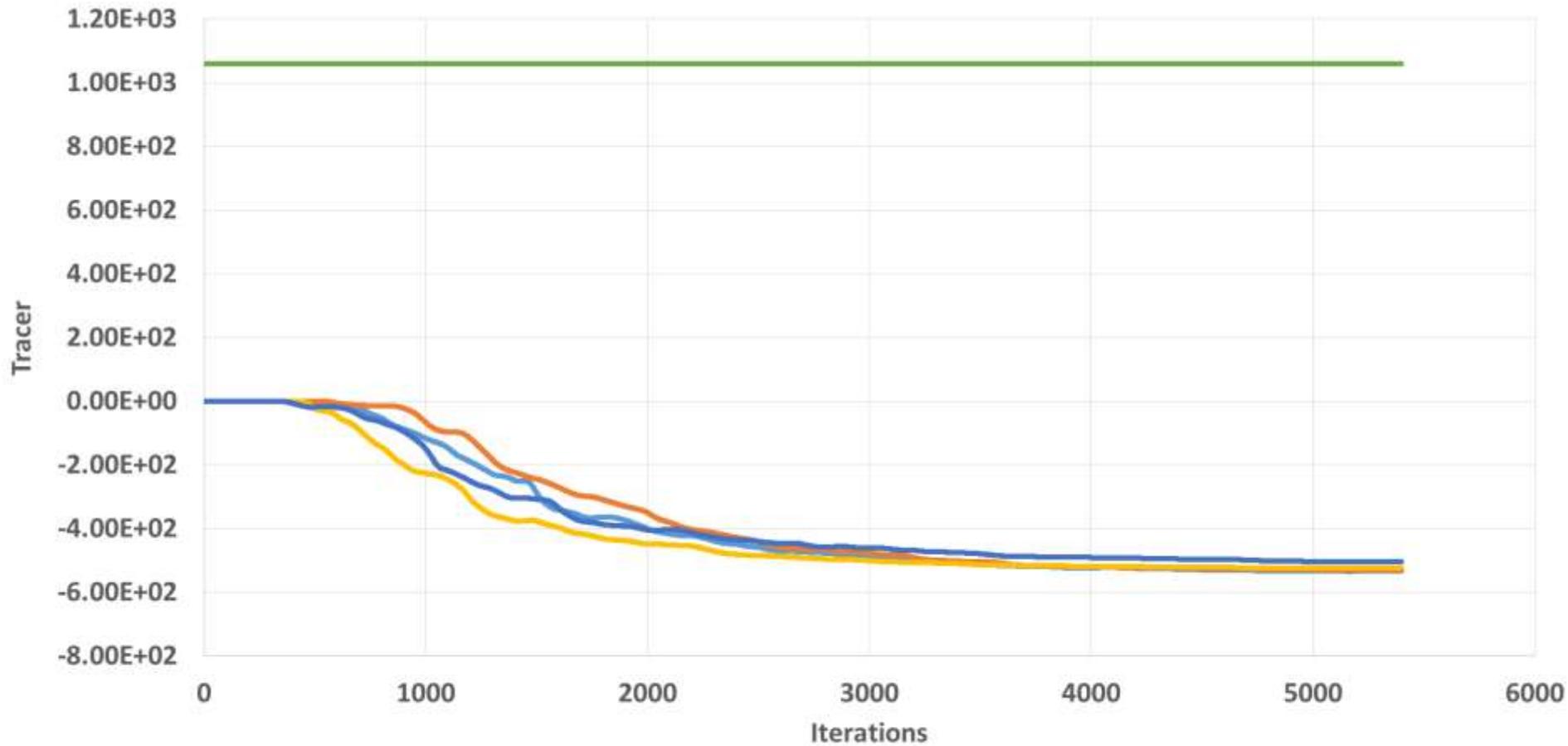
Baffle walls

Filters

North Settling Basin

Inlet distribution channel

CFD Residual



Tracer Boundary Flow on N2

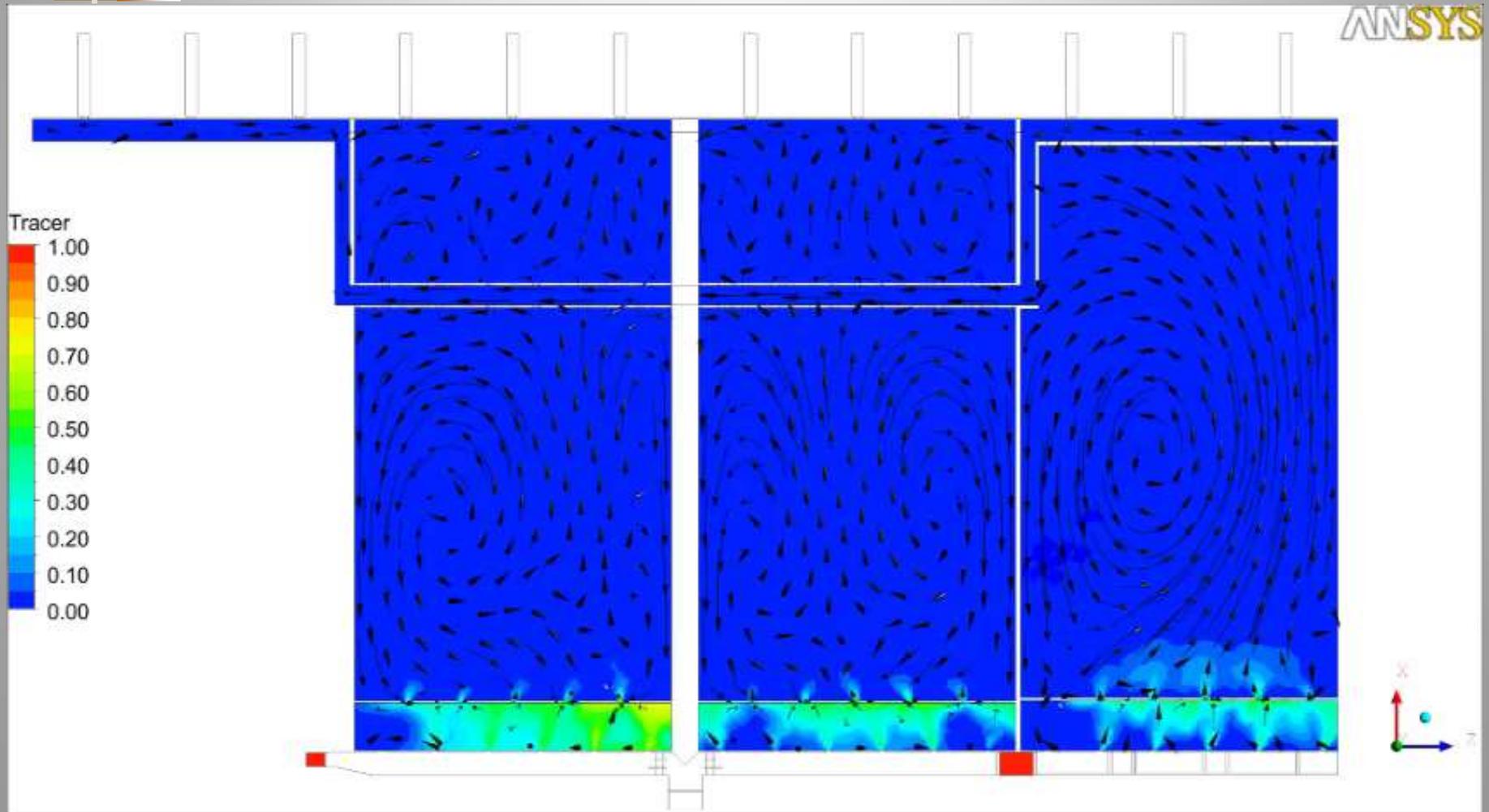
Tracer Boundary Flow on N6

Tracer Boundary Flow on S1

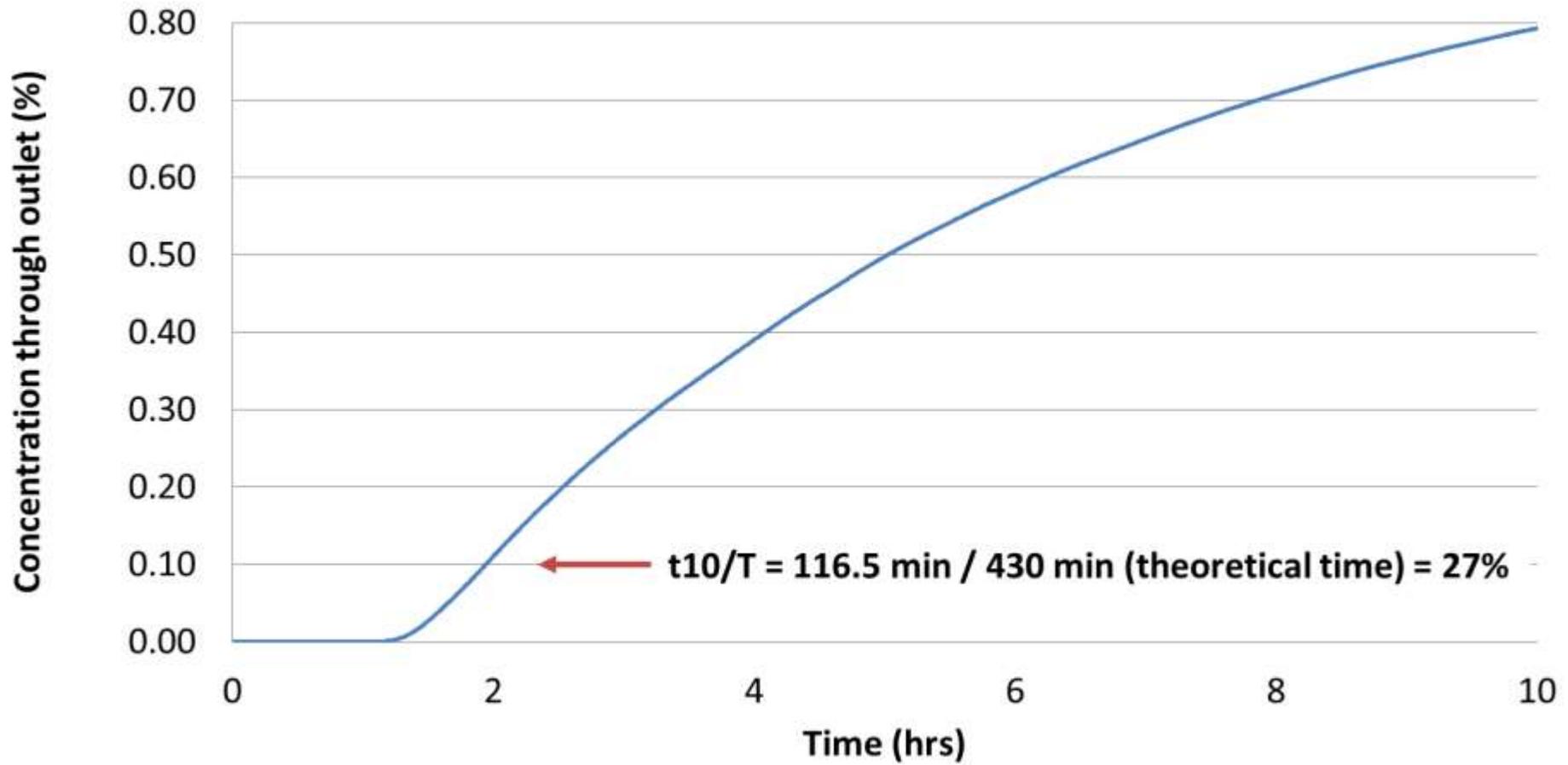
Tracer Boundary Flow on S5

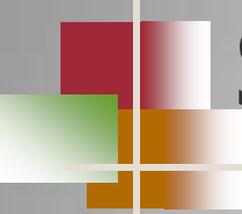
Tracer Boundary Flow on SouthRiser

Preliminary Results



Sc8

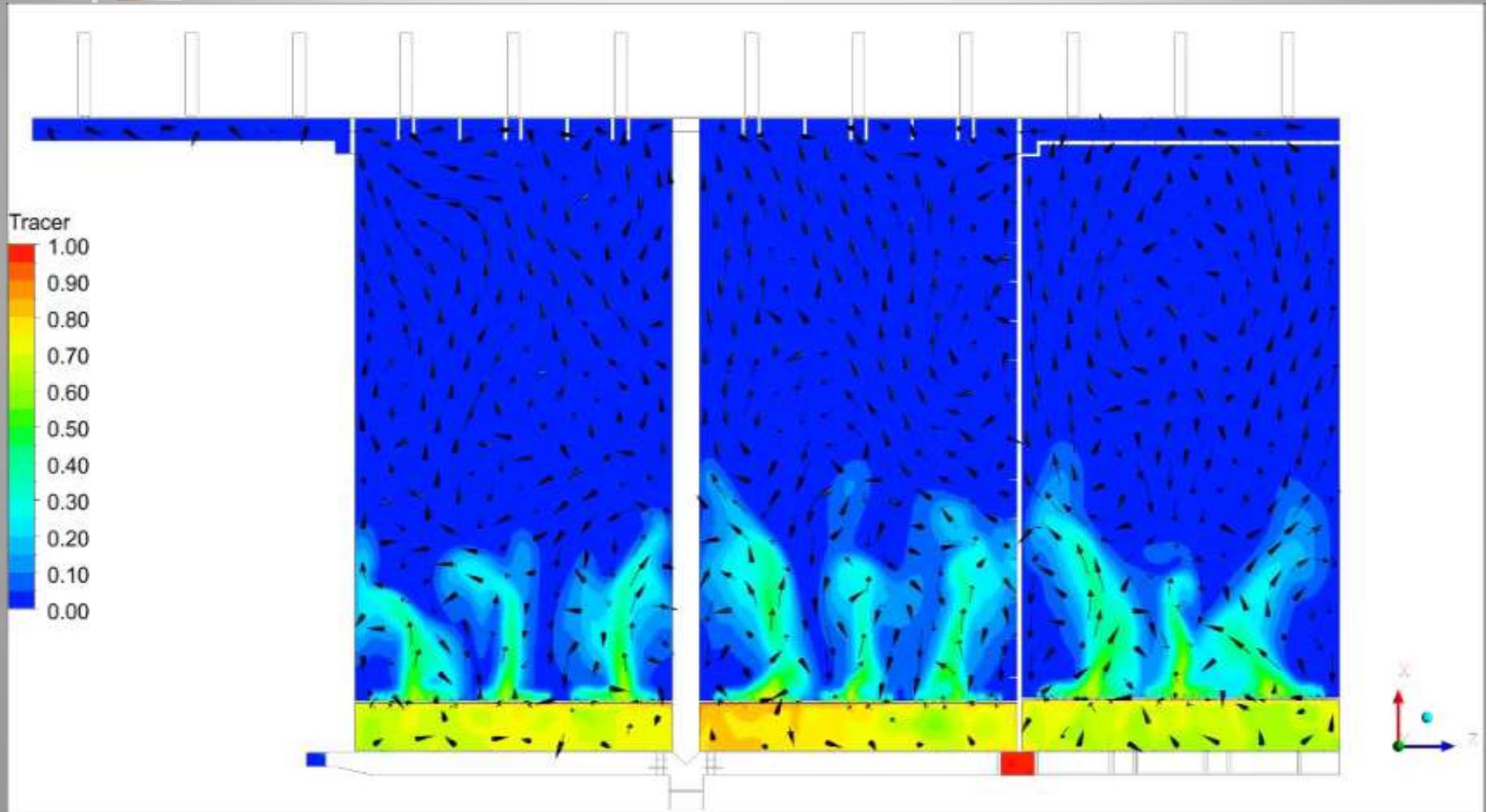




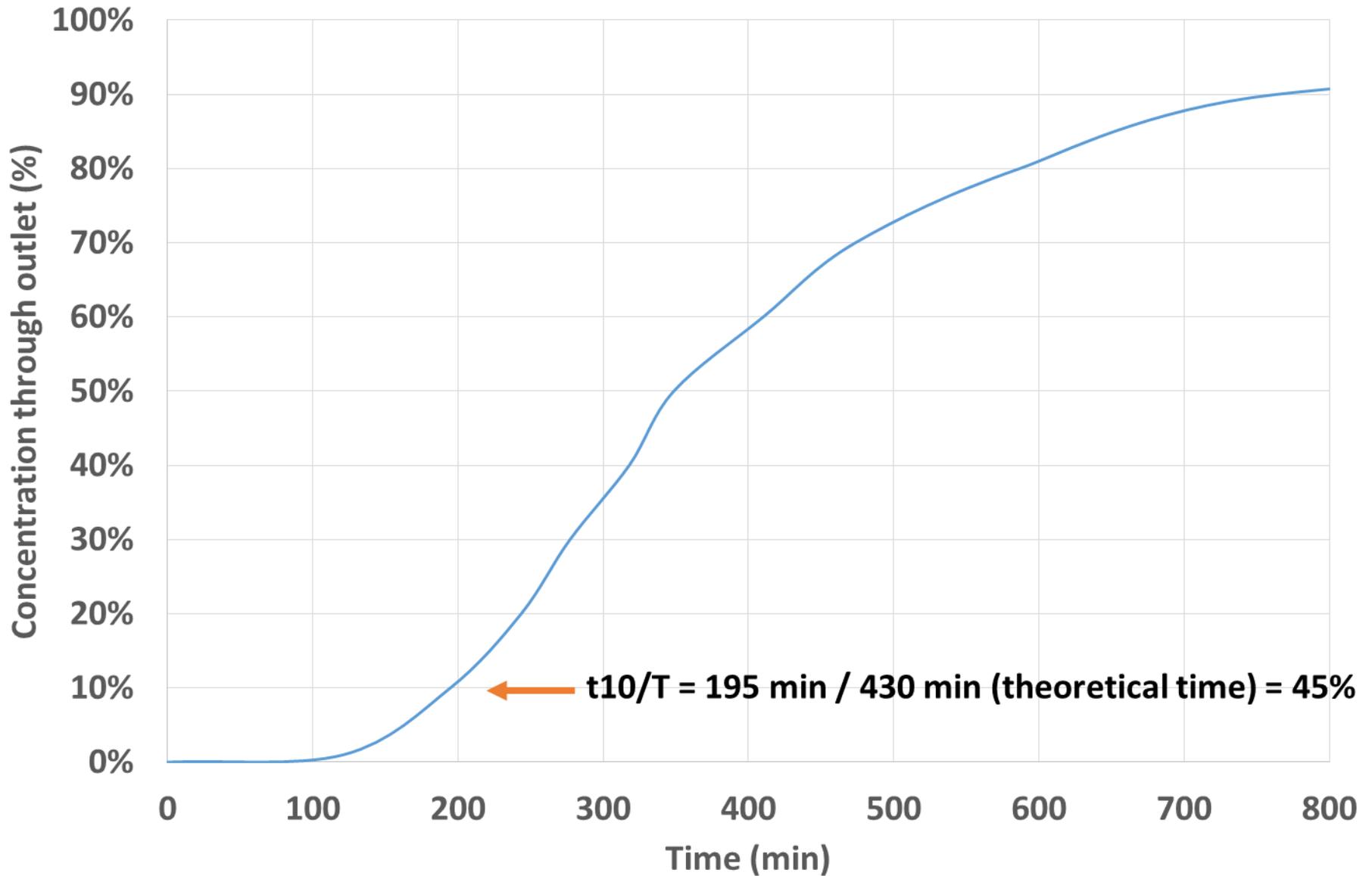
Solution

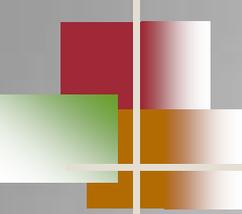
- A variety of ideas were tested
 - Monitoring the T_{10} allowed us to evaluate the overall short-circuiting of each idea.
- Force higher head loss and more even distribution across the basins.

Final Results



Outlet Concentration vs Time

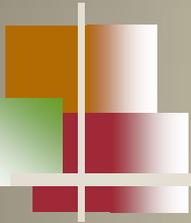




Conclusions

- Calculating T_{10} can be used to quantify the reduction in short-circuiting.
- CFD is an effective tool to estimate T_{10} over a wide variety of scenarios and conditions.
- Using CFD can help evaluate the quality of your design or improve an existing structure.

Questions?

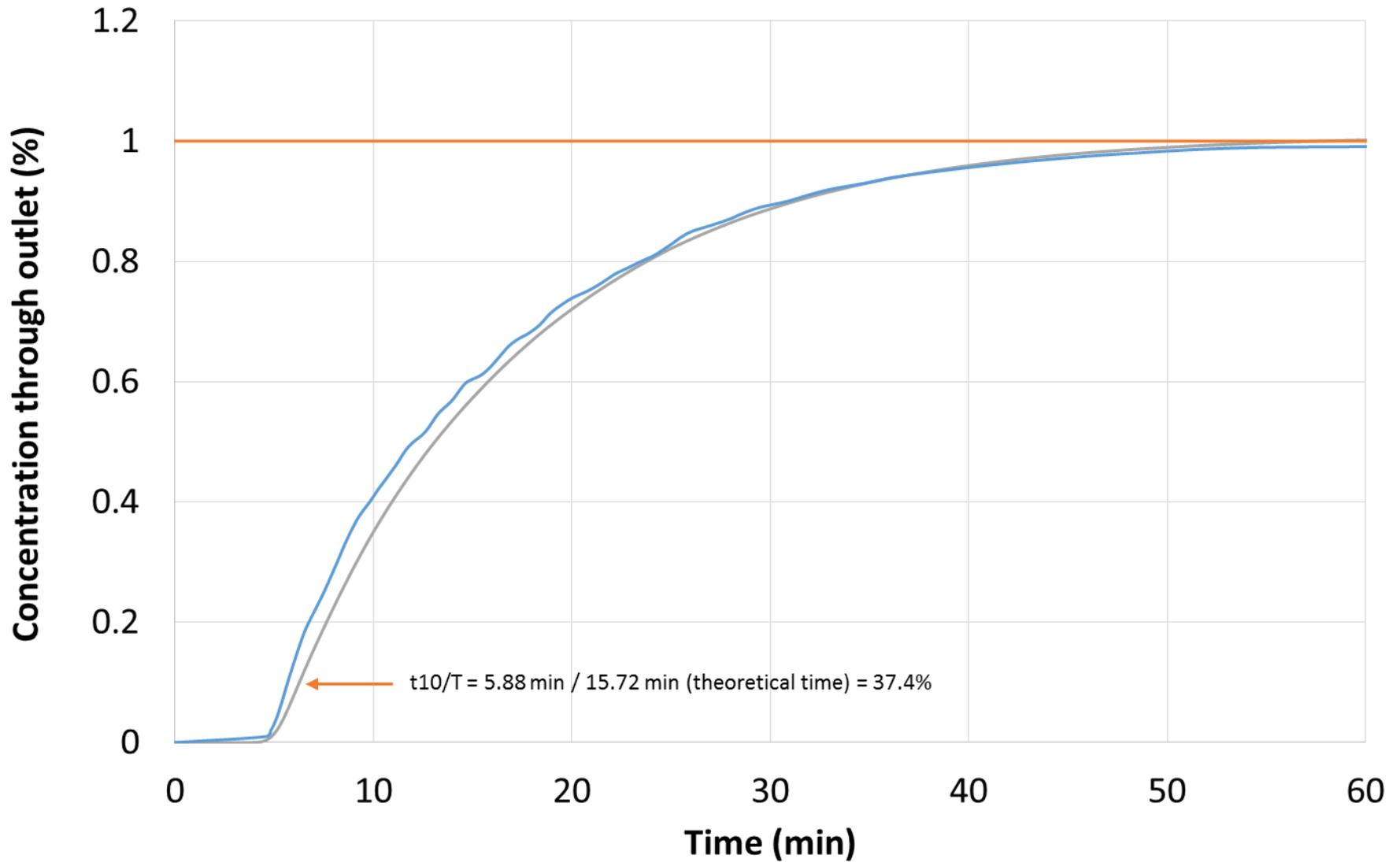


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Plug vs Constant Tracer vs Time



— Plug Tracer

— Constant Tracer Inflow

— Constant Tracer Outflow

$t_{10}/T = 5.88 \text{ min} / 15.72 \text{ min (theoretical time)} = 37.4\%$