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TRACER STUDIES TO DETERMINE BAFFLING FACTOR

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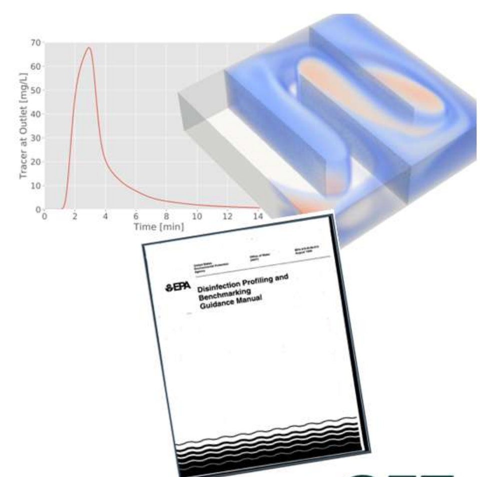
Presentation Outline

- What is a Tracer Study?
- Goal of Tracer Study
- Why do we need Tracer Studies?
- Development of Tracer Study Protocol
- Preparation is Key
- Execution of the Tracer Test
- Results and Report



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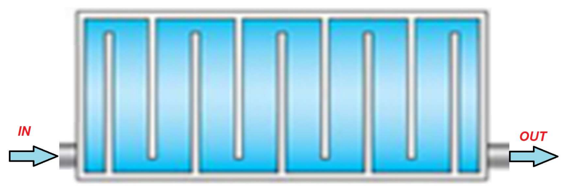
What is a Tracer Study?

- A test performed on a disinfection clearwell or contact tank to determine its baffling factor (BF).
- Results used to calculate the CT required for treatment operation
  - CT - the product of disinfectant concentration (C) and time (T) the disinfectant remains in contact with the water; used to measure the effectiveness of disinfection
- Test Consists of:
  - Addition of a known quantity of tracer chemical
  - Tracking and monitoring the tracer in one or more segments of a treatment process
- Constant and uninterrupted flow rate required

CT = C x T x BF

T = Theoretical Detention Time (V/Q)
V = Volume
Q = Flowrate
BF = Baffling Factor (0.0 – 1.0)



Chlorine Contact Basin

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Goal of Tracer Studies

- Determine contact time (T_{10}) for one or more segments of the treatment process
- What is T_{10}?
  - The time it takes for 10% of the tracer to pass through the segment being evaluated
  - The basis for determination of baffling factor/detention efficiency

$$T_{10} = T \times BF$$

T = Theoretical Detention Time (V/Q)
V = Volume
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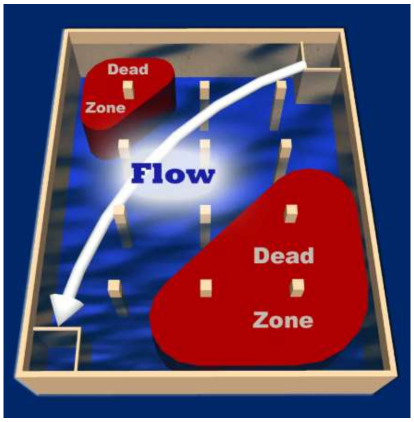
Goal of Tracer Studies

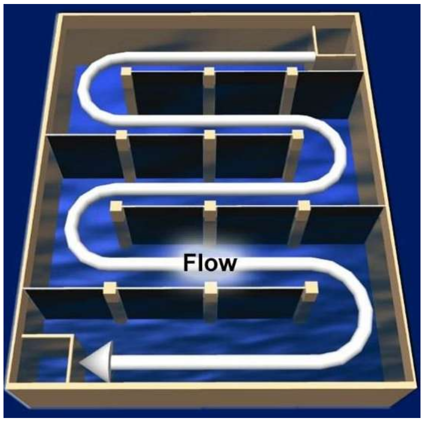
- What is Baffling Factor/Detention Efficiency?
  - Indicates the efficiency of water flow through a tank
  - Effective baffling optimizes tank design, ensures adequate mixing, and minimizes short-circuiting
  - Baffling factor closer to 1.0
    - Well distributed flow
    - Effective contact time between water and chemicals
  - Lower baffling factor suggests poor mixing, short-circuiting, inefficient contact time.

$$T_{10} = T \times BF$$

T = Theoretical Detention Time (V/Q)
V = Volume
Q = Flowrate
BF = Baffling Factor (0.0 – 1.0)

Baffling Factor/Detention Efficiency





Baffling Factor/Detention Efficiency

EPA SWTR Disinfection Benchmark: Baffling Classifications

Baffling Condition	T10/T	Baffling Description
Unbaffled (mixed flow)	0.1	None, agitated basin, very low length to width ratio, high inlet and outlet flow velocities. Can be approximately achieved in flash mix tank
Poor	0.3	Single or multiple unbaffled inlets and outlets, no intra-basin baffles
Average	0.5	Baffled inlet or outlet with some intra-basin baffles
Superior	0.7	Perforated inlet baffle, serpentine or perforated intra-basin baffles, outlet weir or perforated launders
Perfect (plug flow)	1.0	Very high length to width ratio (pipeline flow), perforated inlet, outlet, and intra-basin baffles

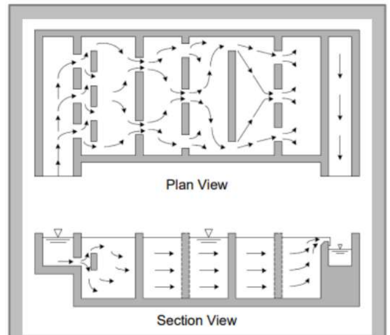


Figure 3: Example of superior baffling conditions of a rectangular clearwell (obtained from US EPA, 2003)

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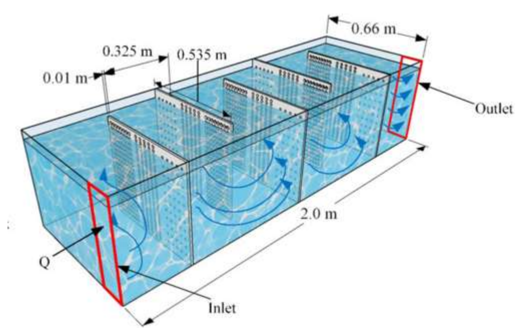
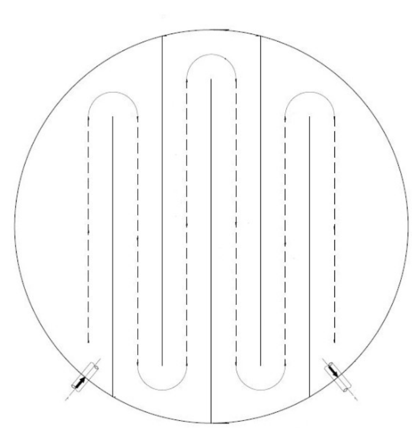
Baffling Factor/Detention Efficiency





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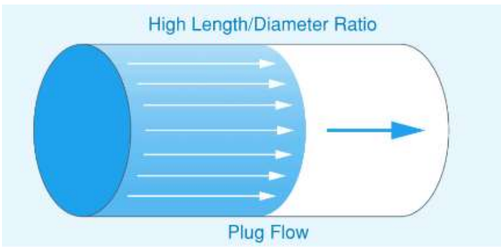
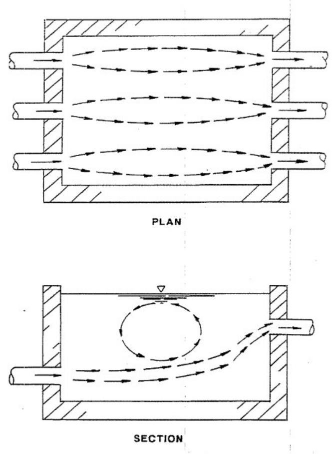
Baffling Factor/Detention Efficiency





Why do we need Tracer Studies?

- Ensure the treatment process is as efficient as possible
- Understand the impact of flow rates and characteristics
- Ensure Regulatory Compliance
  - Achieve required log-reductions for Giardia, viruses, and/or Cryptosporidium
    - Log-inactivation calcs are impacted by pH, temperature, Cl_2 residual, and Baffling Factor
- Minimize/manage DBPs
  - Can't just increase disinfectant concentration
- Often required as part of PA DEP Filter Plant Performance Evaluation (FPPE)
- Often a Permit Condition to validate basis of design for new or upgraded facilities

Development of Tracer Study Protocol

- Tracer Chemical (Salt; Fluoride – pros/cons)
- Operating Conditions for Test(s)
  - Flow rate (at least 91% of Max. Q if only running at one Q)
  - Clearwell level
  - Plant conditions - open/closed valves
- Test Type – Step-dose vs. Slug Dose
- Target Tracer Concentration - Background sampling for tracer concentration
  - Concentration adequate to clearly measure T_{10} (consider equipment and/or lab MDL)
- Tracer Injection Point
  - As close as possible to chlorine injection location; good mixing
- Sampling Location and Frequency
  - Monitor end point of segment being evaluated
  - Grab samples with hand-held instrument; continuous measuring device; grab samples to lab
- Regulatory Approval Requirements (can vary by state)

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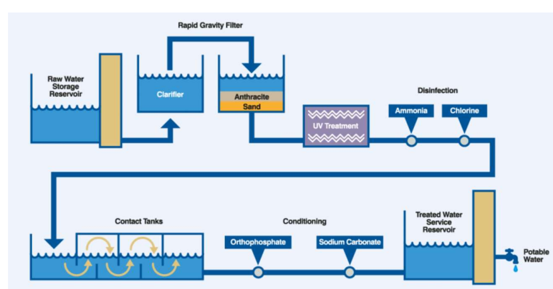
Preparation for the Tracer Test

- Site Visit
  - Meet with Operators – review treatment process, test protocol
    - Potential impacts of other chemicals
  - Identify injection, monitoring, and sample points
    - Existing taps in place? Fittings/tubing needed?
  - Adequate space for tracer equipment setup
  - Distance from injection/monitoring pts. to sampling pts.
  - Anything to be isolated during test?
    - Valve exercising or evaluation needed?
  - Power needed/available
    - Tracer feed pump
    - Charging of equipment



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Preparation for the Tracer Test

- Anticipated length of test
  - Operator presence/availability throughout test
- Ability to maintain required flow rate and clearwell level throughout test
  - May need to schedule test during period of high demand
  - Lower finished water storage tank(s) in advance
- Public Notification required?
- Calculate, calculate, calculate
  - Tracer quantity/volume required (mixing tank; access to plant water)
  - Anticipated T_{10}
- Equipment Calibration – know your equipment
- Supply list - Sample bottles, DI water, labels, sharpies, clipboard, extension cords, gloves, etc.
- Set up the day before whenever possible!

Execution of the Tracer Test

- Minimum of two people needed
- Verify with Operators:
  - SCADA can be used for flow rate and clearwell level data
  - Operating conditions (flow, clearwell level, valve status)
- Synchronize timing devices
- Monitor background tracer concentration at least 30 minutes prior to start
- Sampling frequency
  - Most frequent at startup and near $T_{10,}$ immediately following T_{10}
  - Grab samples for backup, even if using continuous monitoring equipment
  - Consider calibration verification during test
- Manually record results for backup
- Run test to 100% of tracer concentration, if feasible

What Could Possibly Go Wrong?

- Equipment/Instrument Issues
  - Instrument Calibration
  - Batteries
  - Probe returning unrealistic results
  - Probes measuring slightly differently
  - Pump, tubing, fittings, etc.
- Inadequate Sampling
  - Inadequate frequency
  - Inappropriate timing (too early/too late)
- Other chemicals or parameters impact tracer concentration
  - pH
  - Temperature
- Operational Issues
  - Changes in plant flowrate/clearwell level
  - Changes in tracer injection
  - Leaking valves
- Tracer solution mixing/strength
  - Dry chemical difficult to dissolve

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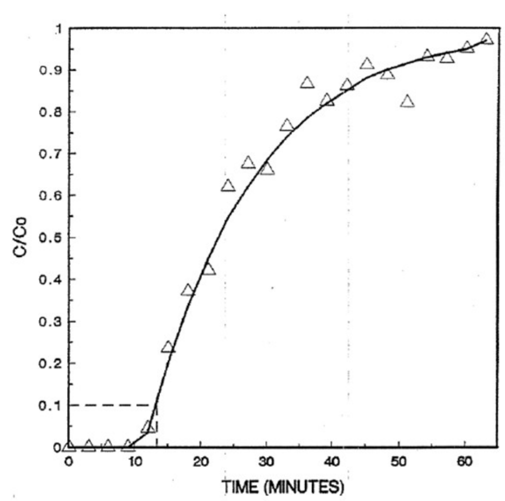
Analysis of Results

- Sampling Results
  - Migration of data from instruments
  - Modification of data (if necessary)
  - Lab analysis of grab samples
  - Review of SCADA data
- Analysis of Data
  - Plotting of Data
  - Comparison of instrument sampling and lab analysis
  - Determination of T_{10}
  - Determination of BF



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Tracer Study Results and Report

- Tracer Study Final Report Requirements
  1. Provide the complete set of results from the Tracer Study
  2. Provide schematic diagram of the disinfection segment(s) being analyzed showing where all monitoring took place during the study.
  3. Provide a list of the water levels and volumes of each disinfection segment being analyzed during the study.
  4. Provide the graphical analysis method calculations and results for T_{10} including C/C_0 versus Time graph.

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Q&A

Thank You!

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