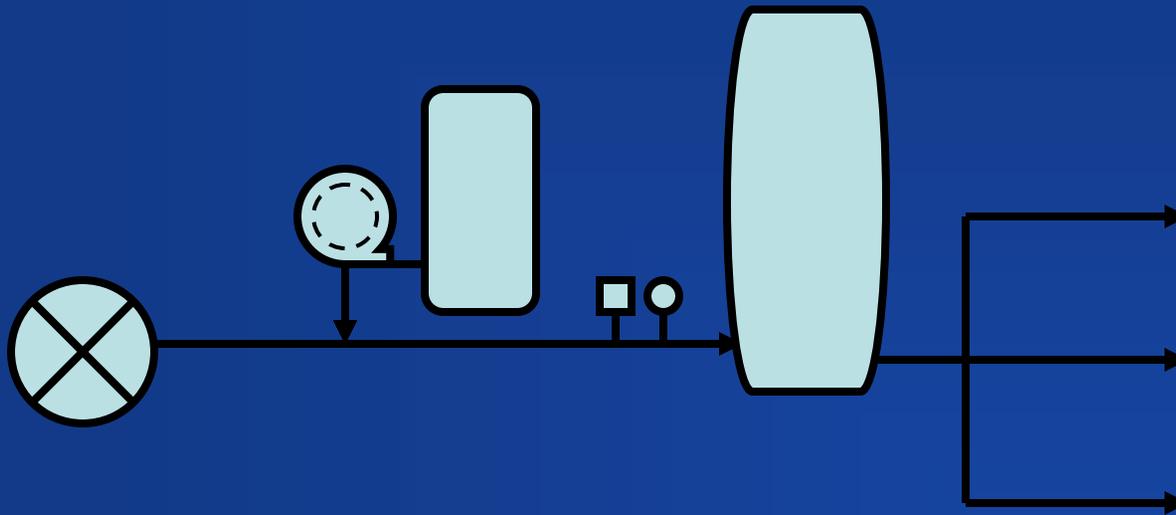


# DISINFECTION “CT” Groundwater Systems (Excluding GWUDI) Using Chlorine for Disinfection



John W. Czaja  
Sanitary Engineer 3  
Drinking Water Section  
Compliance – South Region 1

# Outline

- What is “CT” [mg-min/L]
- CT Requirements
  - Current
  - Ground Water Rule (GWR)
- First Customer/Consumer
- Contact Time (T) [min]
- Maximum flow (Q) [gpm]
- Baffle Factor (BF)
- Flow and Contact Time Relationships
- Monitoring Requirements

## Definition of CT: Section 19-13-B102 of the Regulations of Connecticut Agencies (RCSA)

(22) "CT" or "CT CALC" means the **product of the "residual disinfectant concentration" (C) in milligrams per liter (mg/l) determined before or at the first customer, and the corresponding "disinfectant contact time" (T) in minutes (i.e., "C" x "T").** If a public water system applies disinfectants at more than one point prior to the first customer, it shall determine the CT of each disinfectant sequence before or at the first customer to determine the total percent inactivation

## Definition of Disinfection Contact Time: Section 19-13-B102 of the Regulations of Connecticut Agencies (RCSA)

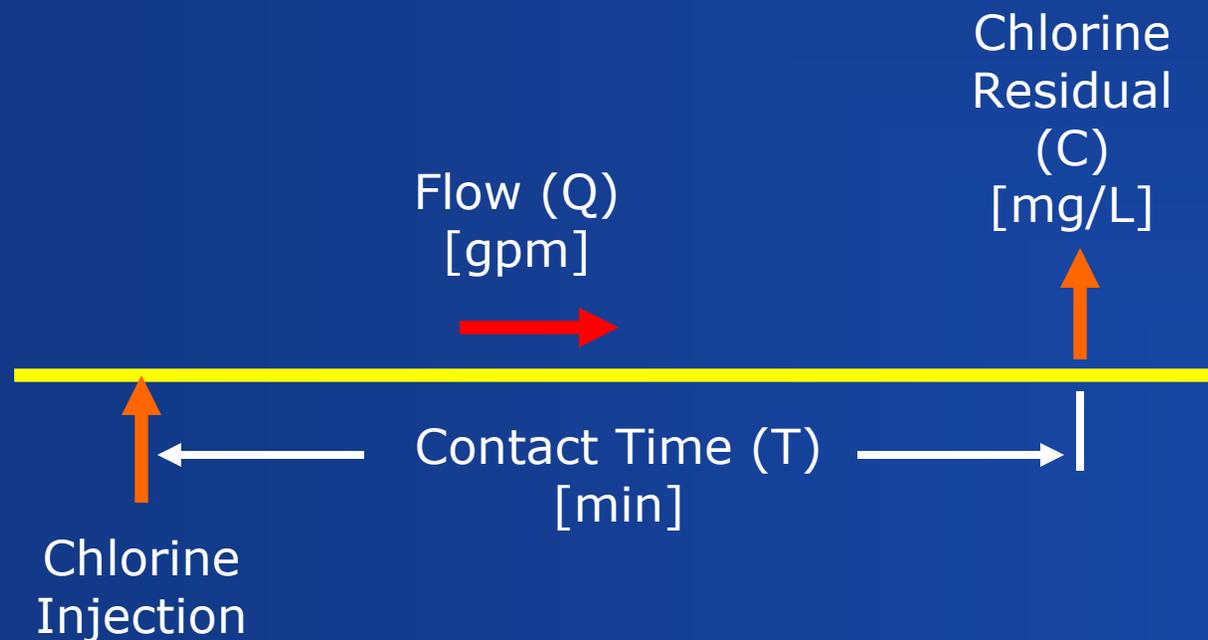
- (27) "Disinfectant contact time" ("T" in CT calculations) means the **time in minutes** that it takes for water to move **from the point of disinfectant application** or the previous point of disinfectant residual measurement to a point **before or at the point where residual disinfectant concentration ("C") is measured**;
- (A) Where only one "C" is measured (single application point), "T" is the time in minutes that it takes for water to move from the point of disinfectant application to a point before or at which residual disinfectant concentration ("C") is measured;
- (B) Where more than one "C", is measured (multiple application points), "T" is:
- (i) for the first measurement of "C", the time in minutes that it takes for water to move from the first point of disinfectant application to a point before or at the point where the first "C" is measured; and
  - (ii) for subsequent measurements of "C", the time in minutes that it takes for water to move from the previous "C" measurement point to the "C" measurement point for which the subsequent "T" is being calculated;
- (C) Disinfectant contact time in **pipelines** shall be calculated by dividing the **internal volume of the pipe by the maximum hourly flow rate through that pipe** (plug flow); and
- (D) Disinfectant contact time within **mixing basins, clearwells, and storage reservoirs** shall be **determined by tracer studies or an equivalent demonstration**;

**CT = Chlorine Residual x Contact Time**

Chlorine Residual (C) – mg/L

Contact Time (T) – minutes (min)

CT = mg/L x min = mg-min/L



## Current Regulation For Chlorination of a Groundwater

### Section 19-13-B102(e)(7)(M) of the Regulations of Connecticut Agencies (RCSA)

- (M) **Where the water is chlorinated, at least daily tests shall be made for residual chlorine.** A system that uses a groundwater source under the direct influence of surface water, and that does not provide and operate treatment pursuant to section 19-13-B102(j)(2) of the Regulations of Connecticut State Agencies, shall disinfect in accordance with section 19-13-B102(j)(3)(B) of the Regulations of Connecticut State Agencies. **When groundwater source not under the direct influence of surface water is chlorinated, a free chlorine residual of at least 0.2 mg/L after ten (10) minutes contact, or the equivalent thereof, shall be used.**

## CT based on current regulation [Section 19-13-B102(e)(7)(M)]

$$CT = 0.2 \text{ mg/L} \times 10 \text{ min} = 2.0 \text{ mg-min/L}$$

or the equivalent

Example:

$$CT = 0.5 \text{ mg/L} \times 4 \text{ min} = 2.0 \text{ mg-min/L}$$

# CT Required Under GWR

- Average groundwater temperature in Connecticut is about 10 - 11 degrees Celsius.
- Using a temperature of 10 degrees C (50 degrees F) and assuming a pH range of 6.0 - 9.0
- The GWR requires 4-log inactivation of viruses

Minimum CT Required = 6.0 mg-min/L

DPH must approve minimum chlorine residual that must be maintained and set terms for the operation of water treatment plant

- Note that this is considerably higher than the current minimum CT required of 2.0 mg-min/L per Section 19-13-B102(e)(7)(M) of the RCSA (to be eliminated under proposed new state regulations)

# EPA CT Values

## 4-log Inactivation of Viruses

**Table 4-4. CT Values for Inactivation of Viruses by Free Chlorine, pH 6.0-9.0**

Degrees C	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
Inactivation (log)																										
2	5.8	5.3	4.9	4.4	4.0	3.8	3.6	3.4	3.2	3.0	2.8	2.6	2.4	2.2	2.0	1.8	1.6	1.4	1.2	1.0	1.0	1.0	1.0	1.0	1.0	1.0
3	8.7	8.0	7.3	6.7	6.0	5.6	5.2	4.8	4.4	4.0	3.8	3.6	3.4	3.2	3.0	2.8	2.6	2.4	2.2	2.0	1.8	1.6	1.4	1.2	1.0	1.0
4	11.6	10.7	9.8	8.9	8.0	7.6	7.2	6.8	6.4	6.0	5.6	5.2	4.8	4.4	4.0	3.8	3.6	3.4	3.2	3.0	2.8	2.6	2.4	2.2	2.0	2.0

CT values provided in the tables are modified by linear interpolation between 5°C increments.

**Table 4-5. CT Values for Inactivation of Viruses by Chlorine Dioxide, pH 6.0-9.0**

Degrees C	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
Inactivation (log)																										
2	8.4	7.7	7.0	6.3	5.6	5.3	5.0	4.8	4.5	4.2	3.9	3.6	3.4	3.1	2.8	2.7	2.5	2.4	2.2	2.1	2.0	1.8	1.7	1.5	1.4	1.4
3	25.6	23.5	21.4	19.2	17.1	16.2	15.4	14.5	13.7	12.8	12.0	11.1	10.3	9.4	8.6	8.2	7.7	7.3	6.8	6.4	6.0	5.6	5.1	4.7	4.3	4.3
4	50.1	45.9	41.8	37.6	33.4	31.7	30.1	28.4	26.8	25.1	23.4	21.7	20.1	18.4	16.7	15.9	15.0	14.2	13.3	12.5	11.7	10.9	10.0	9.2	8.4	8.4

CT values provided in the tables are modified by linear interpolation between 5°C increments.

**Table 4-6. CT Values for Inactivation of Viruses by Ozone**

Degrees C	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
Inactivation (log)																										
2	0.90	0.83	0.75	0.68	0.60	0.58	0.56	0.54	0.52	0.50	0.46	0.42	0.38	0.34	0.30	0.29	0.28	0.27	0.26	0.25	0.23	0.21	0.19	0.17	0.15	0.15
3	1.40	1.28	1.15	1.03	0.90	0.88	0.86	0.84	0.82	0.80	0.74	0.68	0.62	0.56	0.50	0.48	0.46	0.44	0.42	0.40	0.37	0.34	0.31	0.28	0.25	0.25
4	1.80	1.65	1.50	1.35	1.20	1.16	1.12	1.08	1.04	1.00	0.92	0.84	0.76	0.68	0.60	0.58	0.56	0.54	0.52	0.50	0.46	0.42	0.38	0.34	0.30	0.30

CT values provided in the tables are modified by linear interpolation between 5°C increments.

## First Customer/Consumer (Guidance)

The first customer is the location (i.e., residential, commercial, industrial building, treatment facility, etc.,) where water is first consumed or provided. **No CT will be given for a service line** since a service line is not under the control of a PWS and the flow rate in the service line is not uniform. **CT needs to be determined from the point of chlorine injection up to a first service tap, connection, or tee on a system with distribution mains.** On a small system without a distribution system, CT is to be determined from the point of chlorine injection up to a location in the plumbing system before or at any tee or split.

# Contact Time

Contact Time (T) component may be a little more difficult to understand and determine.

- T is typically achieved in pipes and storage facilities.
- In general, contact time (T) can be calculated by the following formula:

$$T = V/Q$$

T = minutes (min)

V = volume of water in pipe or tank (gallons)

Q = maximum flow of facility (gallons per minute – gpm)

## Contact Time (T): Using a Pipe (Calculations)



$$V \text{ (ft}^3\text{)} = A \times L = (\pi \times d^2)/4 \times L = 0.785 \times d^2 \times L$$
$$\text{ft}^3 \times 7.48 \text{ gallons/ft}^3 = \text{gallons}$$

Therefore:

$$V \text{ (gallons)} = (0.785 \times d^2) \times L \times 7.48$$

and

$$T = [(0.785 \times d^2) \times L \times 7.48]/Q$$

T = minutes (min)

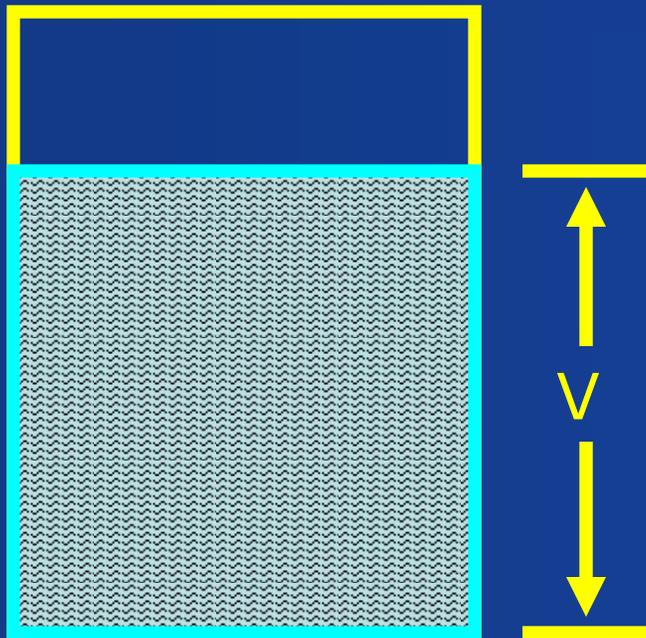
d = diameter (feet)

L = length of pipe (feet)

Q = maximum flow of facility (gallons per minute – gpm)

## Contact Time (T): Tank Volume Used for CT

V = volume of water in tank at lowest normal operating level  
NOT total/gross volume

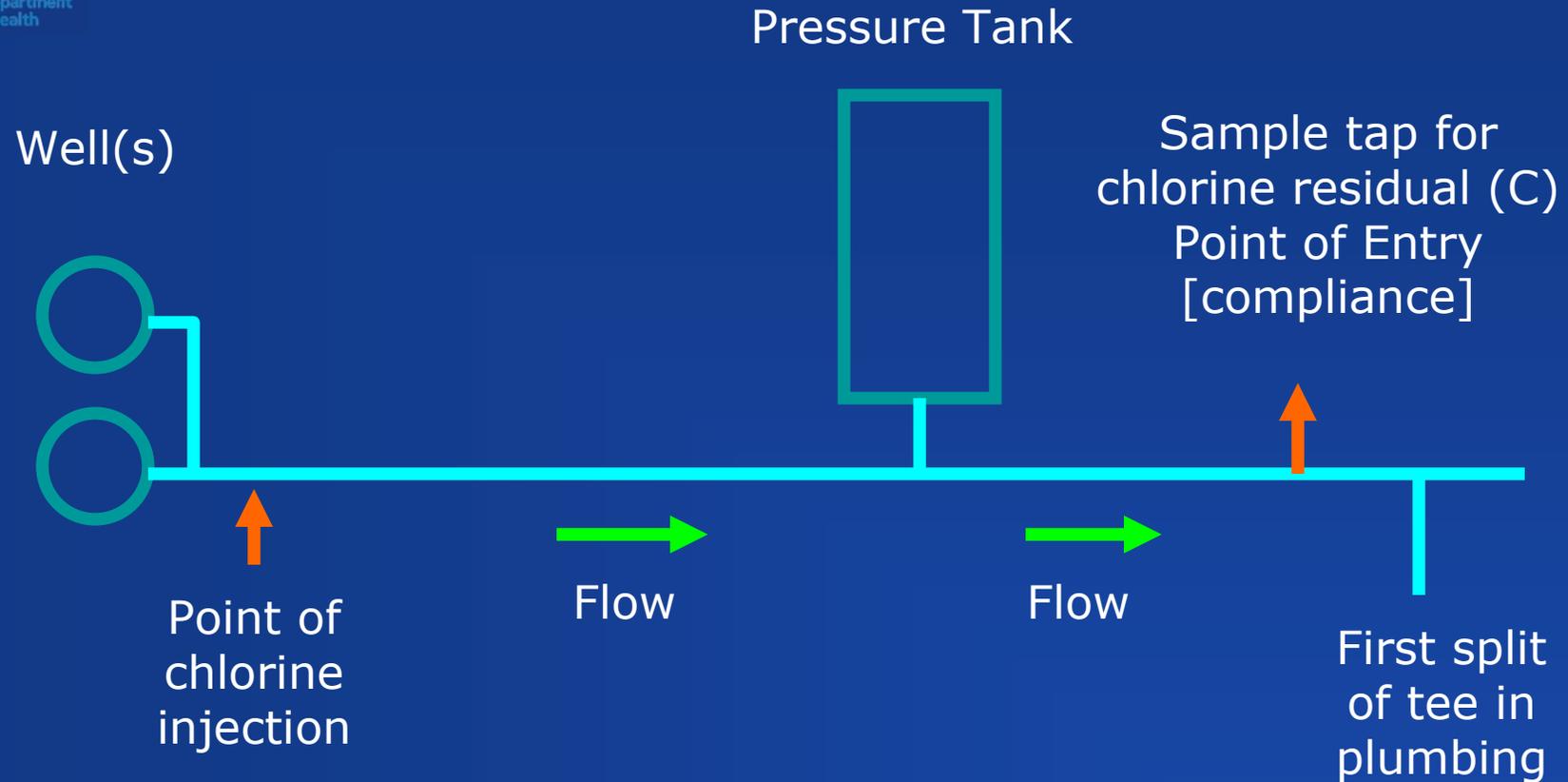


Atmospheric Tank – volume of water in tank at which level well(s) come on to re-fill tank (i.e. float switch, level probe, pressure sensor, etc.)

Pressure or  
Hydropneumatic Tank – volume of water in tank at which level well(s) or booster pump come on to re-fill tank (i.e. pressure switch, level probe, etc.)

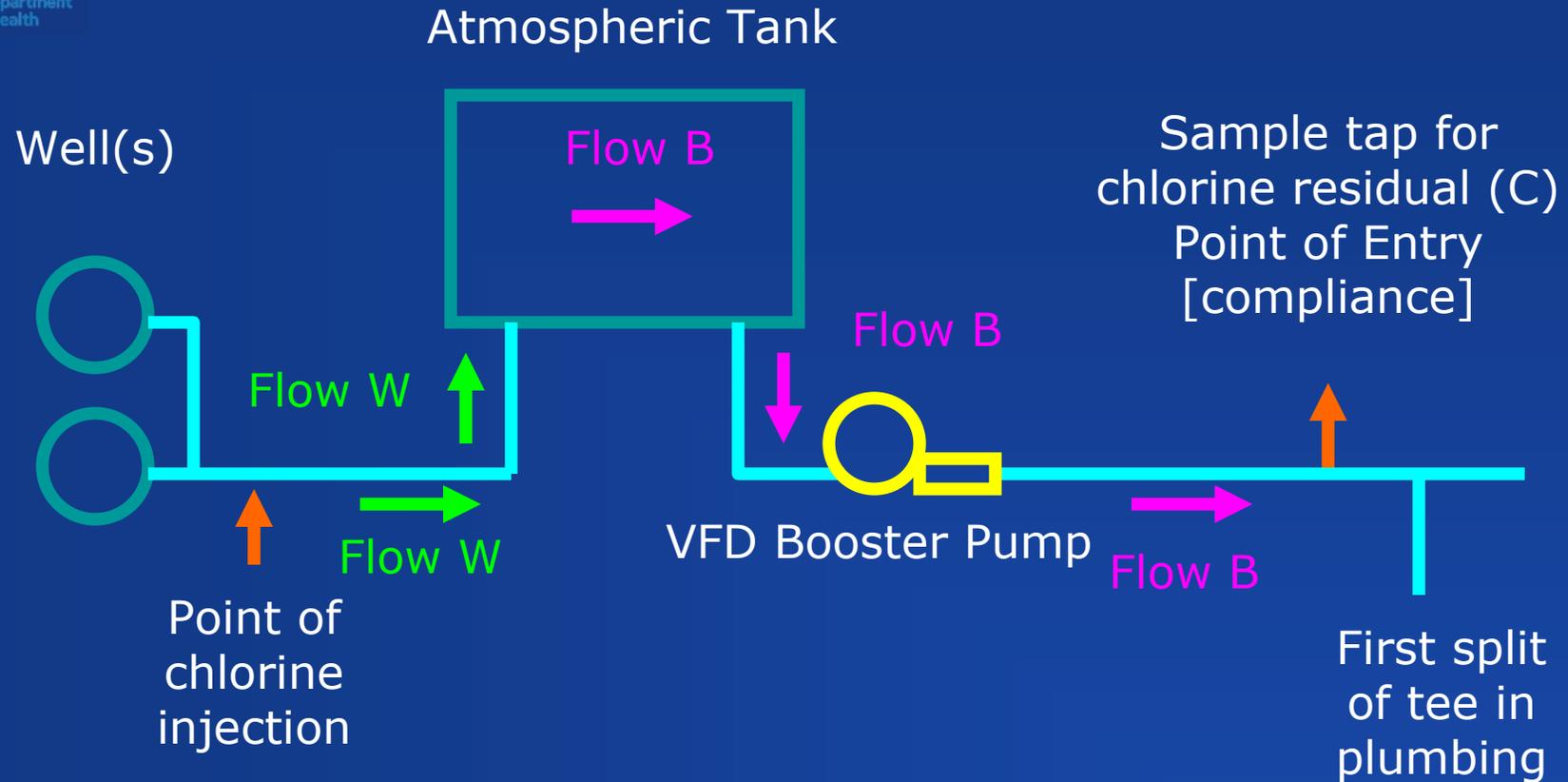
$$T = V/Q$$

## Flow (Q): Using a Pipe (Small System)



Flow = maximum flow of well(s)

## Flow (Q): Using a Pipes and Tank (Small System)



Flow W = maximum flow of well(s)

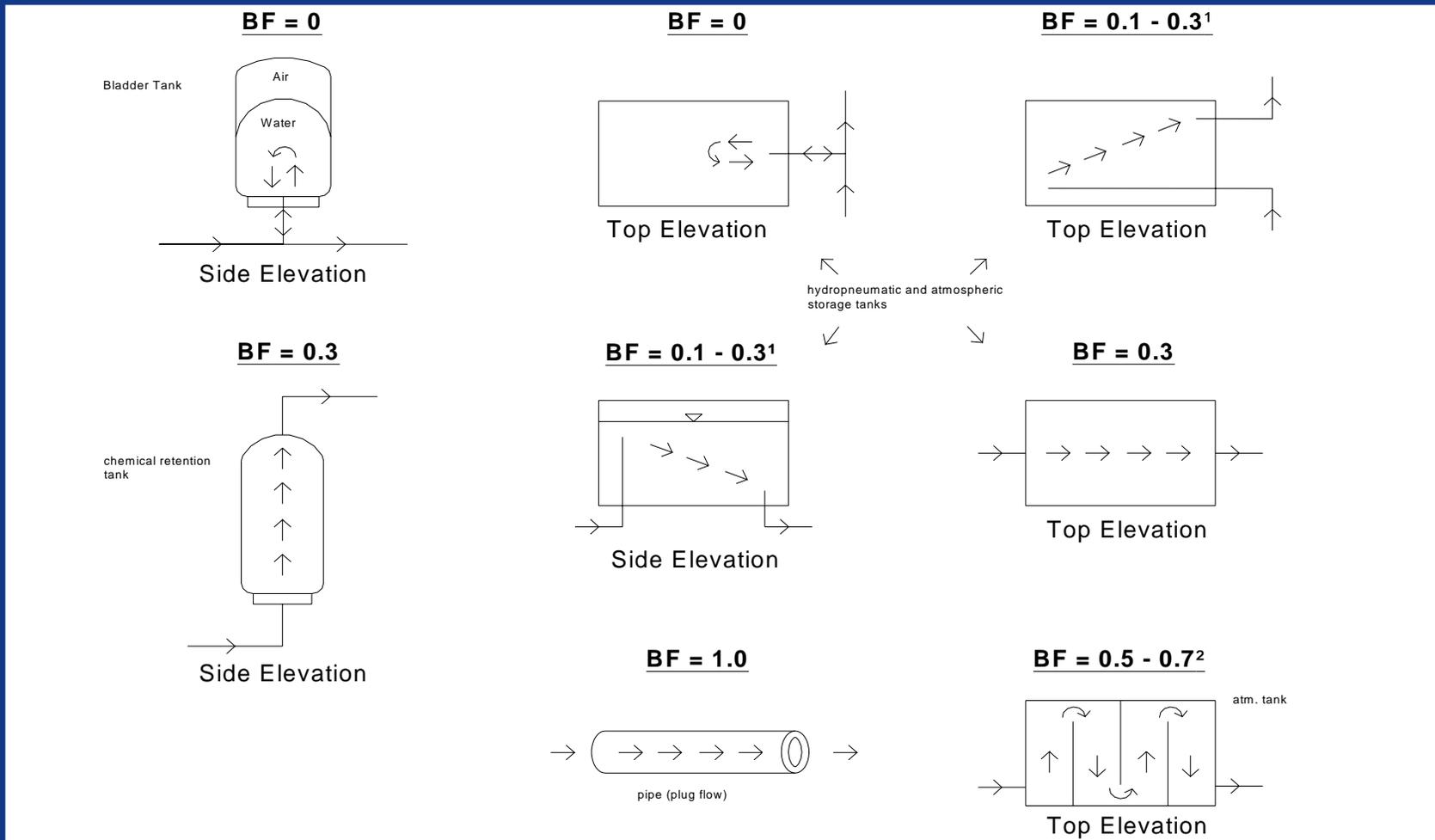
Flow B = maximum flow of booster pump(s)

# Baffle Factor (BF)

- A BF has no units, is a number of  $\leq 1.0$  and is used adjust/correct CT calculations
- Pipes have uniform flow (plug flow) therefore a BF of 1.0
- Flow through a tank is not uniform and short circuiting occurs resulting in a BF of less than 1.0 therefore reducing CT
- Bladder tanks and atmospheric or hydropneumatic tanks with a single inlet and outlet pipe are given a BF = 0 therefore no CT since during a pump operation (well or booster pump) some or all of the water is bypassing a tank
- BF can be determined by a tracer study however estimate BF are provided for use (DPH guidance document)

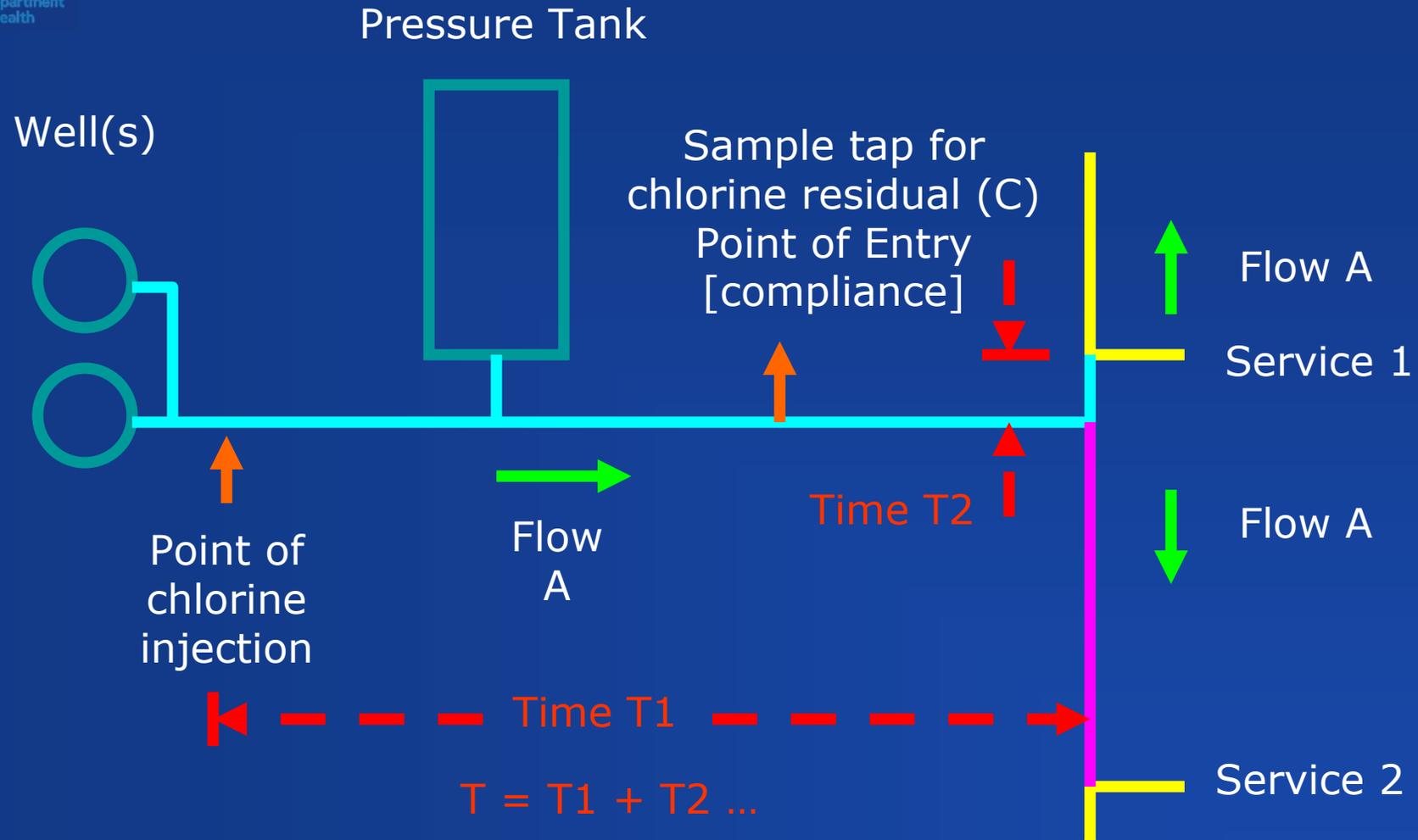
**Volume of Tank X BF = Volume available for CT**

# Baffle Factor (BF)



1 The recommended BF for tank configurations with separate inlets and outlets is 0.1 if the inlet pipe is not extended in the tank and up to 0.3 if the inlet pipe is extended as far in the tank as possible.

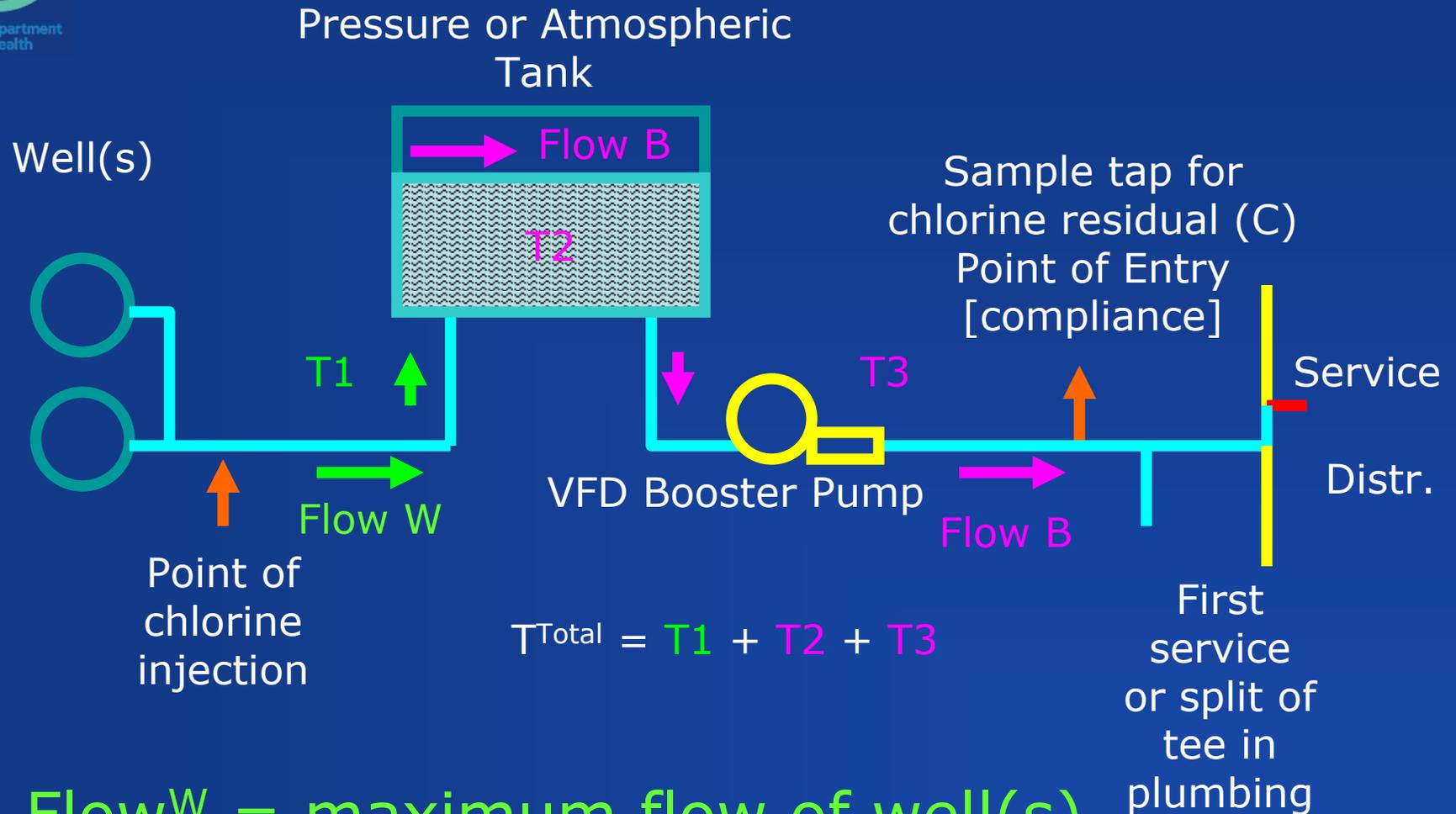
# Flow and Contact Time: Using a Pipe (Small System – Distr. System)



Flow = maximum flow of well or wells

- Use Flow A in either direction

# Flow and Contact Time: Using a Pipes and Tank



Flow<sup>W</sup> = maximum flow of well(s)

Flow<sup>B</sup> = maximum flow of booster pump(s)

# CT Calculations (Summary)

$$\begin{aligned}\text{Tank: CT} &= C \times T \\ &= C \times V/Q \times BF\end{aligned}$$

$$\begin{aligned}\text{Pipe: CT} &= C \times T \\ &= C \times [(0.785 \times d^2) \times L \times 7.48]/Q\end{aligned}$$

Or

$$CT = C \times (T_{\text{Tank}} + T_{\text{Pipe}} + T \times \dots)$$

T = minutes (min)

V = volume of water in pipe or tank (gallons)

Q = maximum flow of facility (gallons per minute – gpm)

BF = baffle factor

d = diameter of the pipe (feet)

L = length of pipe (feet)

# CT Considerations – 4-log Disinfection

## First Customer and Compliance Sample Location

Chlorine residual has to be a **minimum of 0.2 mg/L** or greater at the compliance sample location

**Two** CT calculations are needed:

1. First Customer/Consumer
2. Sample location (tap or analyzer)

If inadequate CT at first service or sample location:

- Increase contact time (i.e. add contact tank, modify inlet outlet on tank, add pipe, flow restrictor, etc.)
- Maintain a higher minimum chlorine residual

If PWS has more than adequate CT to a first customer, a minimum contact time based on chlorine residual level to be maintained is needed at sample location.

<u>CT = 6 mg-min/L</u>	
0.2 mg/L	30 min
0.3 mg/L	20 min
0.4 mg/L	15 min

# Chlorine Residual Monitoring

Current Regulations Section 19-13-B102 of RCSA:

- Sample Tap - daily test taken and reported
- Continuous Analyzer – daily result reported

**Proposed Ground Water Rule (GWR):**

System serving 3,300 or fewer people

- Daily grab sample or can continuously monitor

System serving greater than 3,300 people

- Continuously monitor (i.e. analyzer with means to record)
- If there is a failure in the continuous monitoring equipment, grab sampling every four hours must be conducted until the continuous chlorine analyzer is returned to service. The system must resume continuous residual disinfectant monitoring within 14 days following a failure of the continuous monitoring equipment.



## Ground Water Rule Compliance Monitoring Requirements Systems Providing 4-log Treatment of Viruses with Chemical Disinfection

### MONITORING REQUIREMENTS

System Size	Monitor What, Where & When	Public Notification
>3,300 People	<ol style="list-style-type: none"> <li>1. <b>Notify your state</b> that you provide 4-log treatment of viruses and wish to conduct compliance monitoring.</li> <li>2. <b>Contact your state</b> to determine the minimum disinfectant residual concentration and record here: <input type="text"/></li> <li>3. Monitor disinfectant residual concentration <b>continuously</b> at or before the first customer.</li> <li>4. Record the lowest disinfectant residual concentration each day that water from the ground water source is served to the public.</li> </ol>	<p>If continuous monitoring equipment fails:</p> <ol style="list-style-type: none"> <li>1. You must conduct grab sampling <b>every 4 hours</b> until the continuous monitoring equipment is returned to service.</li> <li>2. You must resume continuous disinfectant residual monitoring within 14 days.</li> </ol>
≤3,300 People	<ol style="list-style-type: none"> <li>1. <b>Notify your state</b> that you provide 4-log treatment of viruses and wish to conduct compliance monitoring.</li> <li>2. <b>Contact your state</b> to determine the minimum disinfectant residual concentration and record here: <input type="text"/></li> <li>3. Monitor disinfectant residual concentration at or before the first customer.</li> <li>4. Take grab samples on a daily basis during peak flow (or at another time specified by the state).</li> <li>5. If you choose to monitor <b>continuously</b> you must meet all the monitoring requirements for systems serving &gt;3,300 people.</li> </ol>	<p>If any daily grab sample is less than the minimum disinfectant residual concentration:</p> <ol style="list-style-type: none"> <li>1. You must take samples <b>every 4 hours</b> until the residual meets or exceeds the minimum disinfectant residual concentration.</li> </ol>

### CORRECTIVE ACTION

If the state identifies a significant deficiency at your system, take corrective action.

- A significant deficiency may be identified during a sanitary survey or at any other time.
- You are required to provide the state with information requested to complete a sanitary survey.

**Within 30 days of notification:**

- You must **consult with your state** to determine a corrective action unless the state specifies a corrective action.

**Within 120 days of notification:**

- You must complete corrective action; or,
- You must be in compliance with state-approved corrective action plan and schedule.

If you fail to take corrective action, you will incur a treatment technique violation and must notify the public with a **Tier 2 PN**.<sup>3</sup>

- **Community water systems:** If you have not corrected the significant deficiency before the end of the calendar year, you must notify the public with a **Special Notice in your next CCR** and repeat annually until the significant deficiency has been addressed.
- **Noncommunity water systems:** If you have not corrected the significant deficiency within 12 months, you must notify the public with a **Special Notice** and repeat annually until the significant deficiency has been addressed.

Footnote 1: For this violation you must notify the state within 48 hours of the violation and provide a Tier 3 PN to the public within 1 year (potentially in CCR).

Footnote 2: For this violation you must notify the state as soon as possible but no later than the end of the next business day of the violation and provide a Tier 2 PN to the public within 30 days.

Footnote 3: For this violation you must notify the state within 48 hours of the violation and provide a Tier 2 PN to the public within 30 days.

The term "state" is used to refer to all types of primacy agencies including states, U.S. territories, Indian tribes, and EPA.

If your system decides to discontinue 4-log treatment of viruses, you must get state approval and meet triggered source water monitoring requirements. *These requirements are covered in a separate placard.*

State/Primacy Agency Contact (name and phone number): \_\_\_\_\_ Office of Water (4606M) EPA 816-F-10-060 www.epa.gov/safewater April 2010



## Department Approval Necessary

- Any addition of treatment
- 4-log inactivation of viruses under the GWR

Submit with a General Application form (DPH web site)

## References

Guidelines on DPH web site:

<http://www.ct.gov/dph/publicdrinkingwater>

- LIQUID CHEMICAL FEED SYSTEM DESIGN AND INSTALLATION GUIDELINES
- TECHNICAL GUIDELINES FOR DETERMINING DISINFECTION "CT" WHEN USING CHLORINE FOR DISINFECTION OF GROUNDWATER SOURCES OF SUPPLY

US EPA: Guidance

<http://water.epa.gov/lawsregs/rulesregs/sdwa/gwr/compliancehelp.cfm>



# Thank You

## Presenter Information:

John W. Czaja, Sanitary Engineer 3

Connecticut Department of Public Health

Drinking Water Section

410 Capitol Avenue, MS#51WAT

P.O. Box 340308

Hartford, CT 06134

Email: [john.czaja@ct.gov](mailto:john.czaja@ct.gov)

Phone: 860-509-7333

Fax: 860-509-7359