

REGULATORY REQUIREMENTS

1. Plan Review
 - Pilot Study
 - Approval to Construct
 - Final Approval
2. Operator Certification
 - Water Treatment 1 (Typical)
3. Monitoring
 - Chlorine/CT
 - Turbidity
4. Reporting/Recordkeeping
 - Monthly Reporting (NTU, Chlorine, CT, etc.)

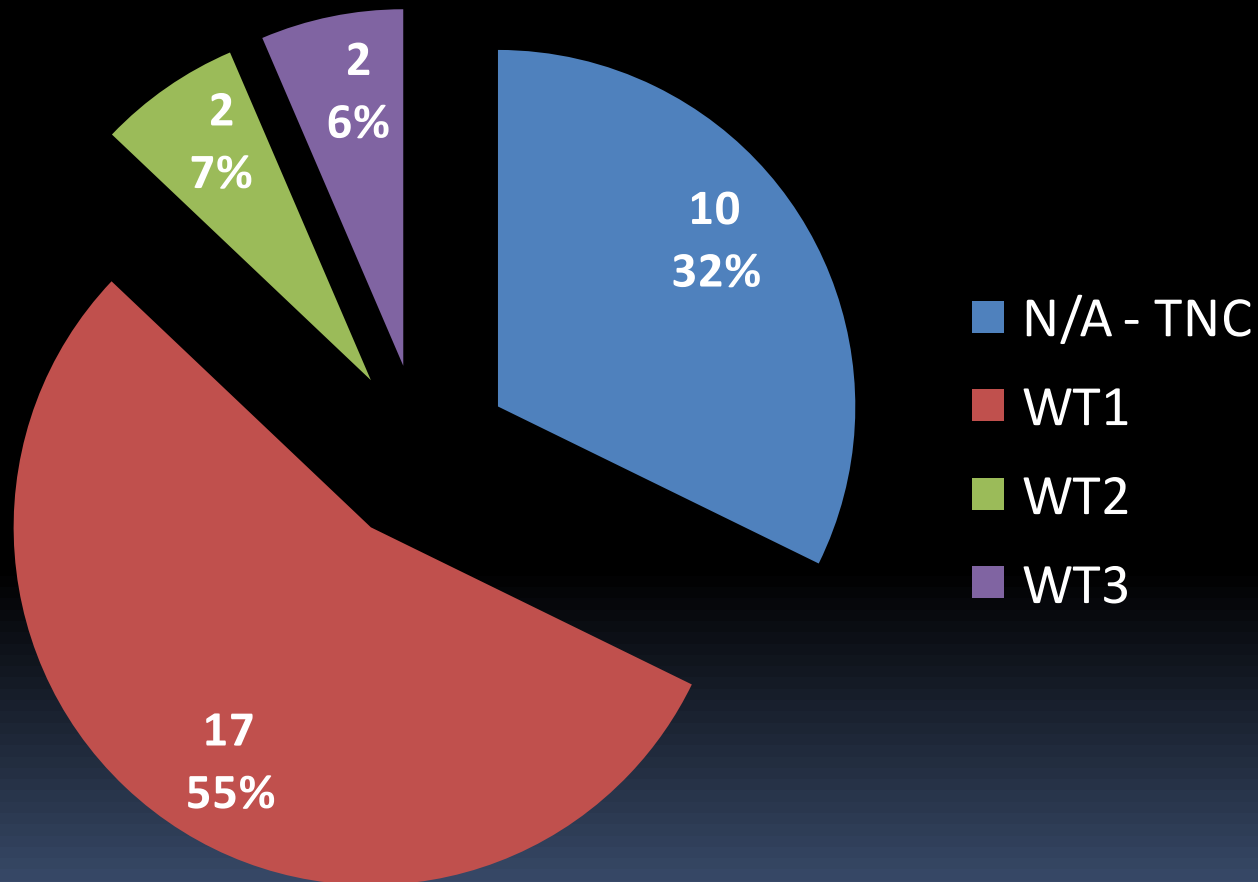
REGULATORY REQUIREMENTS

Plan Review – OAR 333-061-0050(4)(c)(C) & (E)

- (C) Pilot studies shall be conducted by the water supplier to demonstrate the effectiveness of any filtration method other than conventional filtration. Pilot study protocol shall be approved in advance by the Authority. Results of the pilot study shall be submitted to the Authority for review and approval.
- (E) All filtration systems shall be designed and operated so as to meet the requirements in OAR 333-061-0032(4) and (5) – i.e., meet turbidity limits and CT requirements. Design of the filtration system must be in keeping with accepted standard engineering references acknowledged by the Authority such as the Ten States Standards, technical reports by the International Reference Center for Community Water Supply and Sanitation (“IRC manual”), or publications from the World Health Organization (“WHO manual”).

REGULATORY REQUIREMENTS – OTHER

Operator Certification Level Required for Slow Sand Filtration Systems in Oregon



N/A - TNC = Transient Non-Community water systems that are required to have their operator(s) attend a 1-time only class (0.6 CEU class).

REGULATORY REQUIREMENTS

Surface Water Treatment Rule (SWTR), 1989

- 40 CFR 141.70 – 141.75 (applies to all SW and GWUDI systems a.k.a “Subpart H” systems)
- Required 3.0-log (99.9%) Giardia and 4-log (99.99%) virus removal/inactivation (filtration plus disinfection)
- Established turbidity limits (≤ 1 NTU in 95% of readings w/all ≤ 5 NTU)
- Established disinfectant residual requirements

Interim Enhanced Surface Water Treatment Rule (IESWTR), 1998

- 40 CFR 141.170 – 141.175
- Added 2.0-log cryptosporidium treatment requirements

Long-Term 1 Enhanced Treatment Water Rule (LT1), 2002

- 40 CFR 141.500 – 141.571
- Extended IESWTR requirements for systems < 10,000 pop

Long-Term 2 ESWTR (LT2), 2006

- 40 CFR 141.700 – 141.723 & 40 CFR 141.211, Appendix A to Subpart Q
- Additional *Cryptosporidium* treatment requirements depending upon source sampling and resultant bin classification (more treatment if higher than bin 2)
- Addressed uncovered finished water reservoirs

REGULATORY REQUIREMENTS –PATHOGEN RMVL

Applicability: PWSs that use SW or GWUDI that practice SSF, DE, or Alternative Filtration

Regulated Pathogen	99.99% (4-log) removal/inactivation of viruses (SWTR)
	99.9% (3-log) removal/inactivation of <i>Giardia lamblia</i> (SWTR)
	99% (2-log) removal of <i>Cryptosporidium</i> (IESWTR/LT1) (> 2-log if Bin 2 or higher under LT2)

Slow sand filtration is credited with removing:

- 2.0-log *Giardia* &
- 2-log *Cryptosporidium*

1.0-log Giardia inactivation is needed through disinfection, 0.5-log of which must be obtained after filtration.

REGULATORY REQUIREMENTS – TURBIDITY

Turbidity Limits		
Turbidity	Turbidity readings are to be monitored/recorded at the combined filter effluent (CFE) at a frequency of at least once every 4 hours*	95% of CFE turbidity readings ≤ 1 NTU (≤ 1.49 NTU) All CFE turbidity readings ≤ 5 NTU (≤ 5.49 NTU)

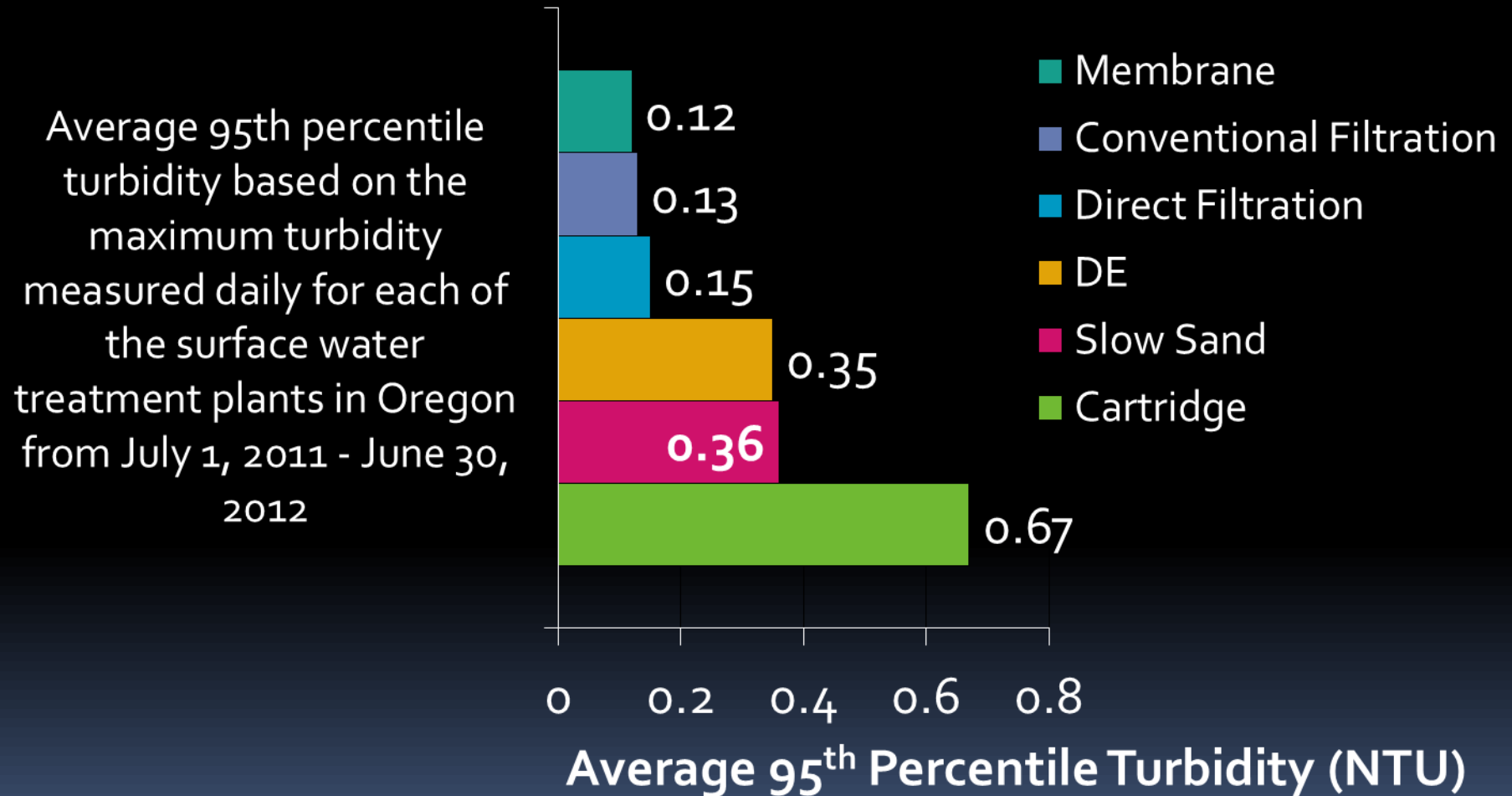
* Frequency may be reduced by the State to once per day.

REGULATORY REQUIREMENTS – NTU REPORTING

Turbidity Reporting

Turbidity reporting required within 10 days after the end of the month:	Total # of Monthly Measurements
	Number and percent less than or equal to 95 th percentile turbidity limit
	Date and Value Exceeding 5 NTU
Turbidity reporting required within 24 hours:	Exceedances of 5 NTU for CFE

SLOW SAND – ABLE TO MEET 1 NTU LIMIT

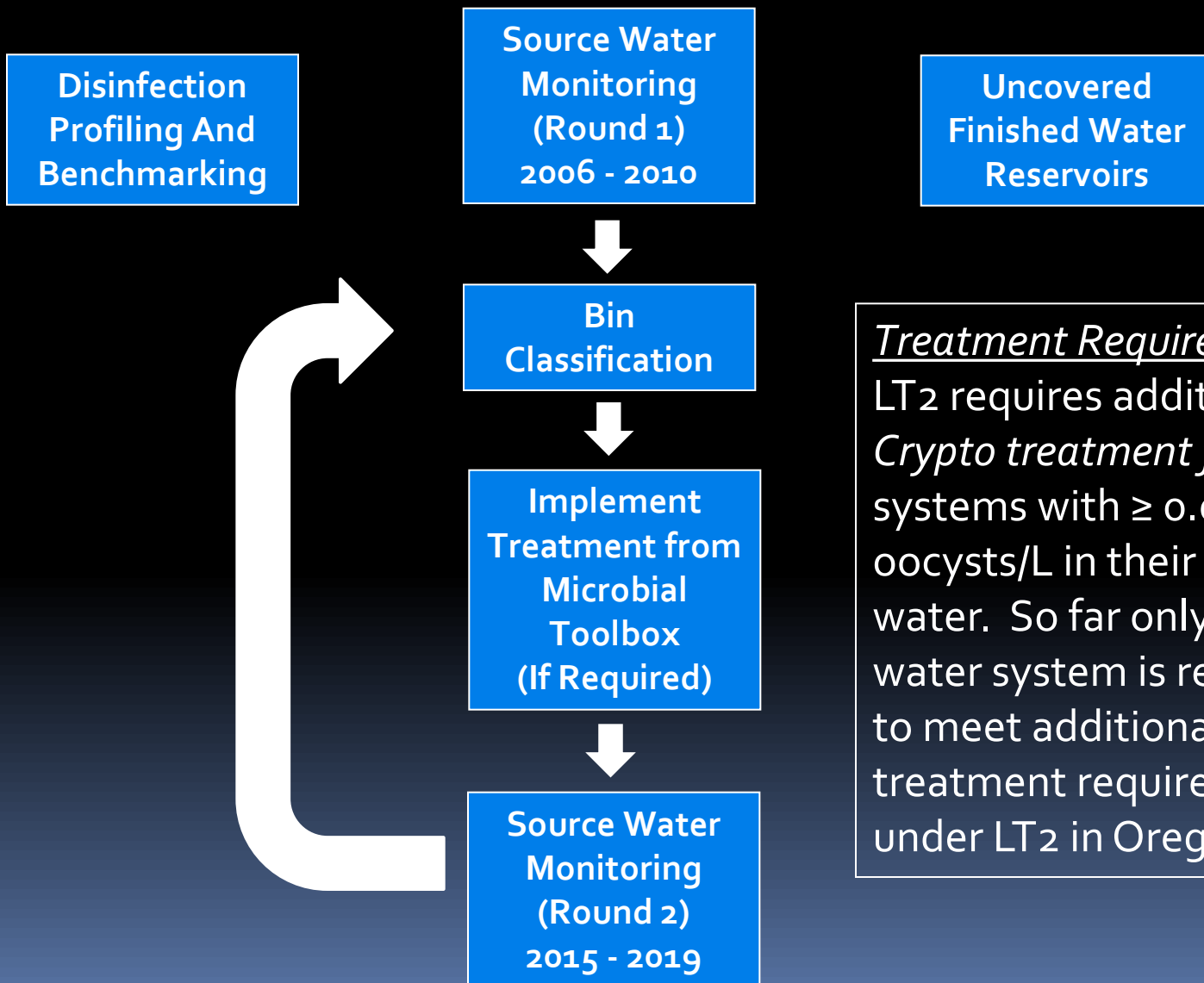


TURBIDIMETERS



- Turbidimeters
 - Online, portable or bench-top
 - Must be calibrated per manufacturer or at least quarterly with a primary standard
 - Formazin solution
 - StablCal® (stabilized formazin)
 - Secondary standards used for day-to-day check
 - Check is used to determine if calibration with a primary standard is necessary
 - Gelex
 - Manufacturer provided (e.g. Hach ICE-PIC)

LONG-TERM 2 ESWTR (LT2)



LONG-TERM 2 ESWTR (LT2)

40 CFR 141.701(c) Monitoring Schedule

Initial and second round monitoring must begin no later than the month beginning with the date listed in the table below.

Schedule	Systems that serve...	1 st Round	2 nd Round
1	At least 100,000 people*	October 1, 2006	April 1, 2015
2	From 50,000 to 99,999 people*	April 1, 2007	October 1, 2015
3	From 10,000 to 49,999 people*	April 1, 2008	October 1, 2016
4 (<i>E. coli</i>)	Fewer than 10,000, not a wholesale system, and monitors for <i>E. coli</i> ^a	October 1, 2008	October 1, 2017
4 (<i>Crypto</i>)	Fewer than 10,000, not a wholesale system, and monitors for <i>Cryptosporidium</i> ^b	April 1, 2010	April 1, 2019

*Also applies to wholesalers in a combined distribution system (CDS) that contains a schedule 1, 2, or 3 system

^a Applies only to filtered systems.

^b Applies to filtered systems that meet the conditions of paragraph (a)(4) of §141.701 and unfiltered systems.

LONG-TERM 2 ESWTR (LT2)

Filtered System Additional *Cryptosporidium* Treatment Requirements

(based on their bin classification as determined under § 141.710
and according to the schedule in § 141.713)

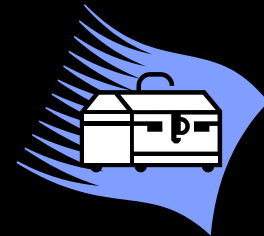
bin	Conventional Filtration (including softening), Slow Sand, or Diatomaceous Earth	Direct filtration	Alternative filtration technologies
Bin 1	No Additional Treatment		
Bin 2	1-log treatment	1.5-log treatment	RMVL + Inactivation $\geq 4.0\text{-log}^1$
Bin 3	2-log treatment	2.5-log treatment	RMVL + Inactivation $\geq 5.0\text{-log}^2$
Bin 4	2.5-log treatment	3-log treatment	RMVL + Inactivation $\geq 5.5\text{-log}^3$

¹As determined by the State such that the total *Cryptosporidium* removal and inactivation is at least 4.0-log.

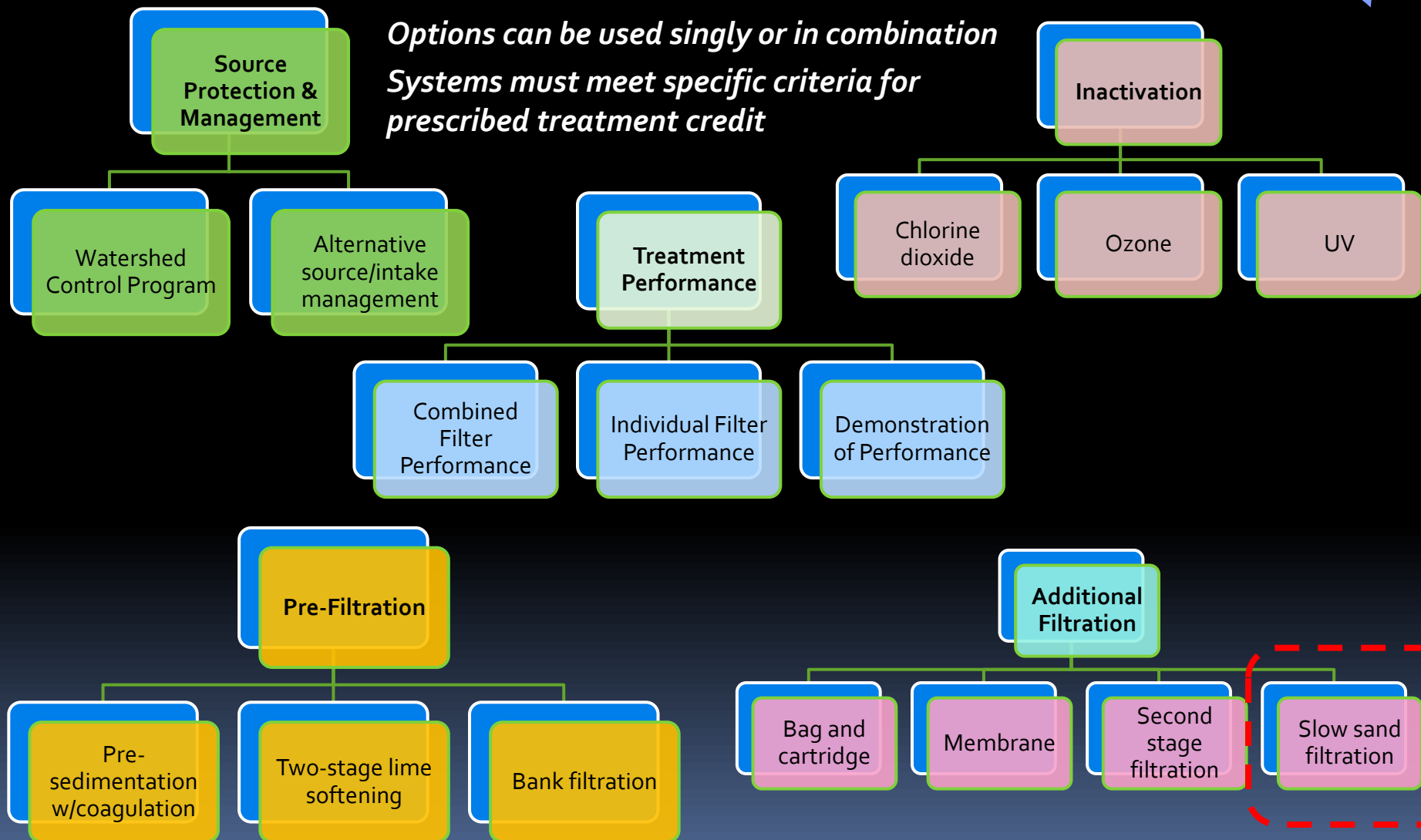
²As determined by the State such that the total *Cryptosporidium* removal and inactivation is at least 5.0-log.

³As determined by the State such that the total *Cryptosporidium* removal and inactivation is at least 5.5-log.

LONG-TERM 2 ESWTR (LT2)



Microbial Toolbox Treatment Options



REGULATORY REQUIREMENTS – DISINFECTION

Entry Point Chlorine Residual

Entry Point Residual
Disinfection
Concentration

(for free chlorine
measured prior to or at
the first customer each
day of operation)

Residual disinfectant concentration cannot be < 0.2 mg/l for more than 4 hours based on continuous monitoring (> 3,300 pop) or less frequent monitoring as allowed by the state.
(SWTR)

(contact your state regulator if using a disinfectant other than chlorine or are planning to switch disinfectants)

No two consecutive daily samples should exceed 4.0 mg/l (DBPR)

Where chlorine is used as the disinfectant, the measurement of residual chlorine shall be by the DPD or other EPA-approved method in accordance with Standard Methods for the Examination of Water and Waste-water, and shall measure the free chlorine residual or total chlorine residual as applicable

REGULATORY REQUIREMENTS – DISINFECTION

Distribution System Chlorine Residual

Distribution System Residual
Disinfection Concentration

(for free chlorine
measured with coliform samples)

(contact your state regulator if
using a disinfectant other than
chlorine or are planning to switch
disinfectants)

Residual disinfectant concentration
cannot be undetectable in greater than
5% of samples in a month, for any 2
consecutive months.

(SWTR)

Not to exceed 4.0 mg/l MRDL*
(DBPR)

**The maximum residual disinfectant level (MRDL) is regulated under the Disinfection By-Products Rules (DBPR). Compliance is based upon chlorine residuals taken at the same location and frequency as that required for total coliform monitoring in the distribution system. The running annual average of monthly averages of samples, computed quarterly, must be ≤ 4.0 mg/l.*

REGULATORY REQUIREMENTS – CL2 REPORTING

Additional Distribution Residuals Monitoring 2x per week

Distribution (records to be kept by the water system for at least 2 years)	All public water systems that add a disinfectant to the water supply at any point in the treatment process, or deliver water in which a disinfectant has been added to the water supply, must maintain a detectable disinfectant residual throughout the distribution system and shall measure and record the residual at one or more representative points at a frequency that is sufficient to detect variations in chlorine demand and changes in water flow but in no case less often than twice per week.
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REGULATORY REQUIREMENTS – CL2 REPORTING

Chlorine Residual Reporting Required (within 10 days after the end of the month)

Entry Point (reported with turbidity)	Lowest daily value for each day, the date and duration when residual disinfectant was < 0.2 mg/l, and when State was notified of events where residual disinfectant was < 0.2 mg/l.
Distribution (reported with coliform sample results)	Number of residual disinfectant or HPC measurements taken in the month resulting in no more than 5% of the measurements as being undetectable in any 2 consecutive months.

CHLORINE ANALYZERS

- Chlorine analyzers
 - Handheld (HACH Colorimeter shown)
 - Follow manufacturer's instructions
 - Online
 - Check calibration against a handheld that has been calibrated
 - At least weekly
 - Follow manufacturer's instructions if out of calibration



REGULATORY REQUIREMENTS – OTHER

Other SWTR/IESWTR/LT₁ Requirements

Disinfection Profiling & Benchmarking	Systems must profile inactivation levels and generate a benchmark, if required due to disinfection changes (IESWTR & LT1)
Water System Surveys (State Requirement)	CWS: Every 3 years NCWS: Every 5 years (IESWTR & LT1)
Finished Water Reservoirs	New (post-1989) reservoirs must be covered under SWTR. Pre-SWTR reservoirs must be covered (or have additional treatment) under LT2
Operator Certification	Operated by Qualified Personnel as Specified by State (SWTR)

(CWS) Community Water System (NCWS) Non-community Water System

Cyanotoxin Monitoring (OAR 333-061-0510 to -0580)

Healthoregon.org/dwcyanotoxins

Who does this apply to?	Affects systems who have sources susceptible to cyanobacteria blooms (not everyone). See list systems and specific rule requirements on-line at www.healthoregon.org/dwcyanotoxins
What is required?	Raw water (intake) sampling for total microcystin and Cylindrospermopsin toxins every 2 weeks from May 1 st – October 31 st each year
What happens if detected?	<ol style="list-style-type: none"> 1. Notify your regulator 2. <u>If any toxins are greater than or equal to 0.3 µg/L in raw water or if there is a recreational use health advisory* upstream</u> of the intake, sample raw and entry point weekly with the first EP sample taken within 1 business day. Weekly sampling continues until non-detect at EP and less than 0.3 µg/L in raw water in two consecutive samples. 3. <u>If detected at EP</u>, sample EP daily and optimize treatment for toxin removal. 4. <u>If above Health Advisory Level (HAL) at EP</u>, take confirmation sample within 24-hrs & monitor EP daily. 5. <u>If confirmation sample is above the HAL</u>, issue Do-Not-Drink Advisory 6. Advisory may only be lifted if 2 consecutive daily EP samples taken a minimum of 24-hrs apart are ≤ HAL and two consecutive daily sets of distribution samples taken a minimum of 24 hours apart are ≤ HAL <p>"Recreational use health advisory" means a health advisory issued by the Oregon Health Authority for a water body when cyanotoxins are determined to be above any recreational use advisory levels.</p>
What are the DW Health Advisory Levels (HALs)?	<ul style="list-style-type: none"> • Total Microcystins: 0.3 µg/L for vulnerable people; 1.6 µg/L for all persons • Cylindrospermopsin: 0.7 µg/L for vulnerable people; 3 µg/L for all persons <p>"Vulnerable people" means infants, children under the age of six, pregnant women, nursing mothers, those with pre-existing liver conditions, and those receiving dialysis treatment.</p>

REVIEW

- 2.0-log *Cryptosporidium* removal is required (and credited) for slow sand filtration.
- Surface Water Treatment Rule (SWTR) requires 3-log reduction of *Giardia* using a combination of disinfection and filtration and 4.0-log reduction of viruses.
- At least 2.0 -log *Giardia* removal is credited for slow sand filtration (per 1991 USEPA SWTR Manual)
- 1.0-log *Giardia* inactivation must be achieved through disinfection (0.5-log must be after filtration). 1.0-log reduction of viruses must also be achieved after filtration.

REPORTING FORMS

There are 4 forms:

- Conventional/Direct
- Slow Sand / Membrane / DE / Unfiltered
- Cartridge
- UV (if used for *Giardia credit*)

Must use correct form because each has questions that must be answered that are specific to the filtration type

REPORTING FORMS – CFE TURBIDITY

OHA - Drinking Water Program – Turbidity Monitoring Report Form County:
Slow Sand, Membrane, Diatomaceous Earth Filtration, or Unfiltered Systems

System Name:		ID #:		WTP-:		Month/Year:	
DAY	12 AM [NTU]	4 AM [NTU]	8 AM [NTU]	NOON [NTU]	4 PM [NTU]	8 PM [NTU]	Highest Reading of the Day ¹ [NTU]
1			0.34				0.50
2			0.24				0.66
3			0.44				
4							
5							
6							
7							
8							
9							
10							

Notify the State if NTU > 1 NTU.
 Notify the State within 24-hrs if turbidity > 5 NTU
 (includes after hours)
 Public Health After Hours Duty Officer:
 Cell (971) 246-1789
 Pager (503) 938-6790
 Oregon Emergency Response System:
 1-800-452-0311

- Chose time closest to when daily turbidity is measured and enter result(s)
- Enter highest turbidity of all measurements for the day (e.g., on-line instrument or highest of multiple daily grab samples)

REPORTING FORMS – MONTHLY SUMMARY – TURBIDITY

Slow Sand/Membrane/DE Filtration/Unfiltered

95% of daily turbidity readings \leq 1 NTU? ² **Yes** / No
All daily turbidity readings \leq 5 NTU? **Yes** / No

- Based on the results entered for the month, circle “yes” or “no” to the two questions at the bottom of the form.

REPORTING FORMS – PEAK HOUR DEMAND FLOW

OHA - Drinking Water Program – Surface Water Quality Data Form

System Name:

ID #:

WTP-:

Month/Year:

Date / Time	Minimum Cl ₂ Residual at 1 st User (C) ³	Contact Time (T)	Actual CT	Temp	pH	Required CT	CT Met? ³	Peak Hourly Demand Flow
	[ppm or mg/L]	[minutes]	C X T	[° C]		Use tables	Yes / No	[GPM]
1 / 9 AM								1,000
2 /								
3 /								
4 /								
5 /								
6 /								
7 /								
8 /								
9 /								
10 /								

- Enter the peak hourly demand (PHD) flow and the time that the PHD flow occurred.
- This flow should not exceed 10% above the peak flows replicated at the time of the last tracer study.

REPORTING FORMS – PEAK HOUR DEMAND FLOW

OHA - Drinking Water Program – Surface Water Quality Data Form								
System Name:		ID #:		WTP-:		Month/Year:		
Date / Time	Minimum Cl ₂ Residual at 1 st User (C) ³	Contact Time (T)	Actual CT	Temp	pH	Required CT	CT Met? ³	Peak Hourly Demand Flow
	[ppm or mg/L]	[minutes]	C X T	[° C]		Use tables	Yes / No	[GPM]
1 / 9 AM								1,000
2 /								
3 /								
4 /								
5 /								
6 /								
7 /								
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9 /								
10 /								

Peak Hour Demand Flow:

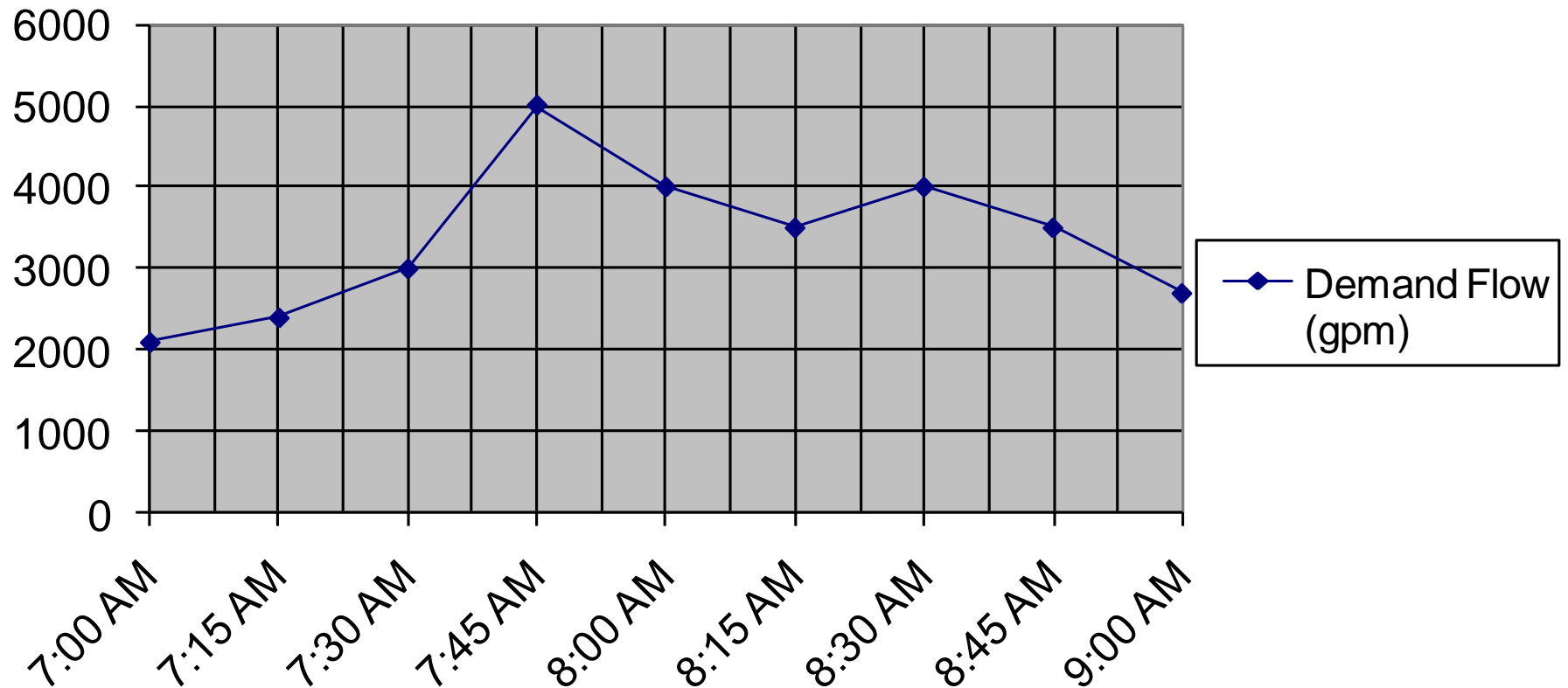
- The greatest volume of water passing through the system during any one hour in a consecutive 24 hr period
- Not the same as Peak Instantaneous Flow
- Report demand flow: flow leaving the clear well, not plant flow (in most cases)

- On a daily basis, use the best available operational data to identify the

- Spot check throughout the day to determine

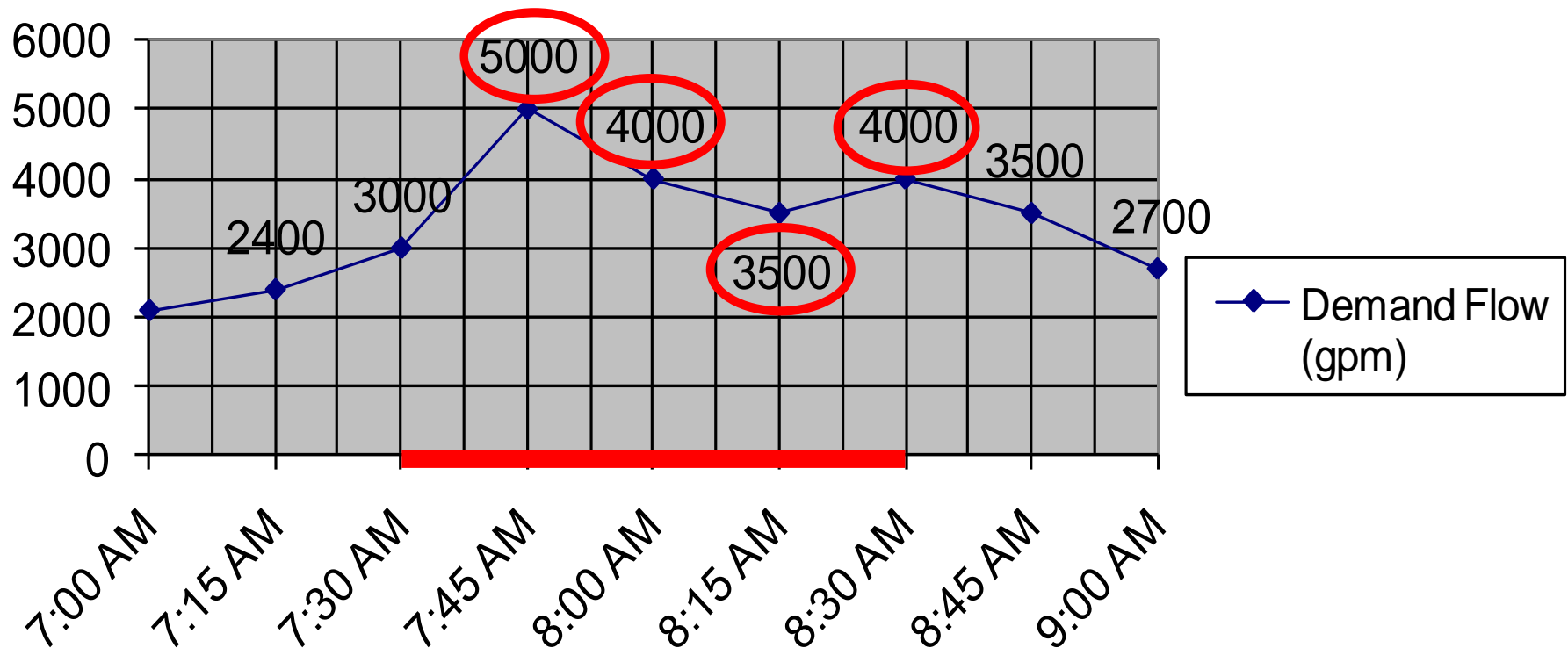
1
2
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11
12

REPORTING FORMS – PEAK HOUR DEMAND FLOW



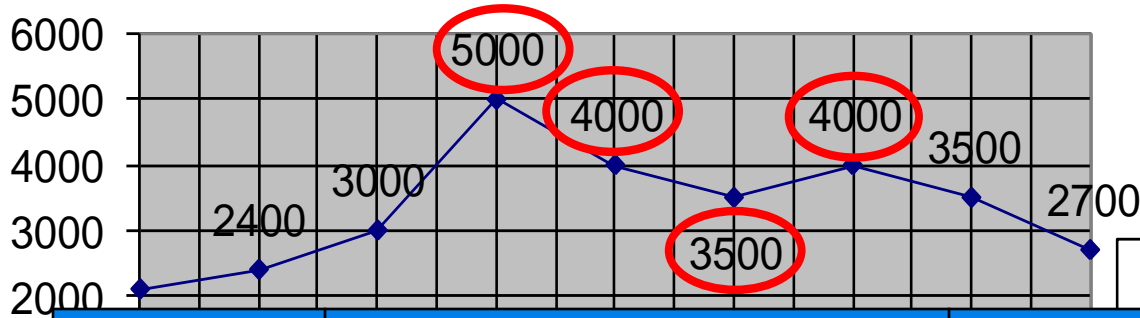
Here is an example chart, meant to represent continuous readings that shows demand flow out of a reservoir used for contact time. What would you say the peak hourly demand flow is?

REPORTING FORMS – PEAK HOUR DEMAND FLOW



Again, the peak hourly demand flow is the hour within the 24-hr period of the highest demand flow. The red line represents the span of 1 hour: **7:30 am to 8:30 am** – the **peak hour**. The avg. of the 4 data points equals **4,125 gpm** - the **peak hourly demand flow**.

REPORTING FORMS – PEAK HOUR DEMAND FLOW



Think of it like a running hourly average of demand flow measurements.

Time	Demand Flow (gpm)	Running Hourly Average (gpm)
7:00 AM	2,000	
7:15 AM	2,400	
7:30 AM	3,000	
7:45 AM	5,000	3,100
8:00 AM	4,000	3,600
8:15 AM	3,500	3,875
8:30 AM	4,000	4,125
8:45 AM	3,500	3,750
9:00 AM	2,700	3,425

REPORTING FORMS – CHLORINE & CONTACT TIME

OHA - Drinking Water Program – Surface Water Quality Data Form

System Name:

ID #:

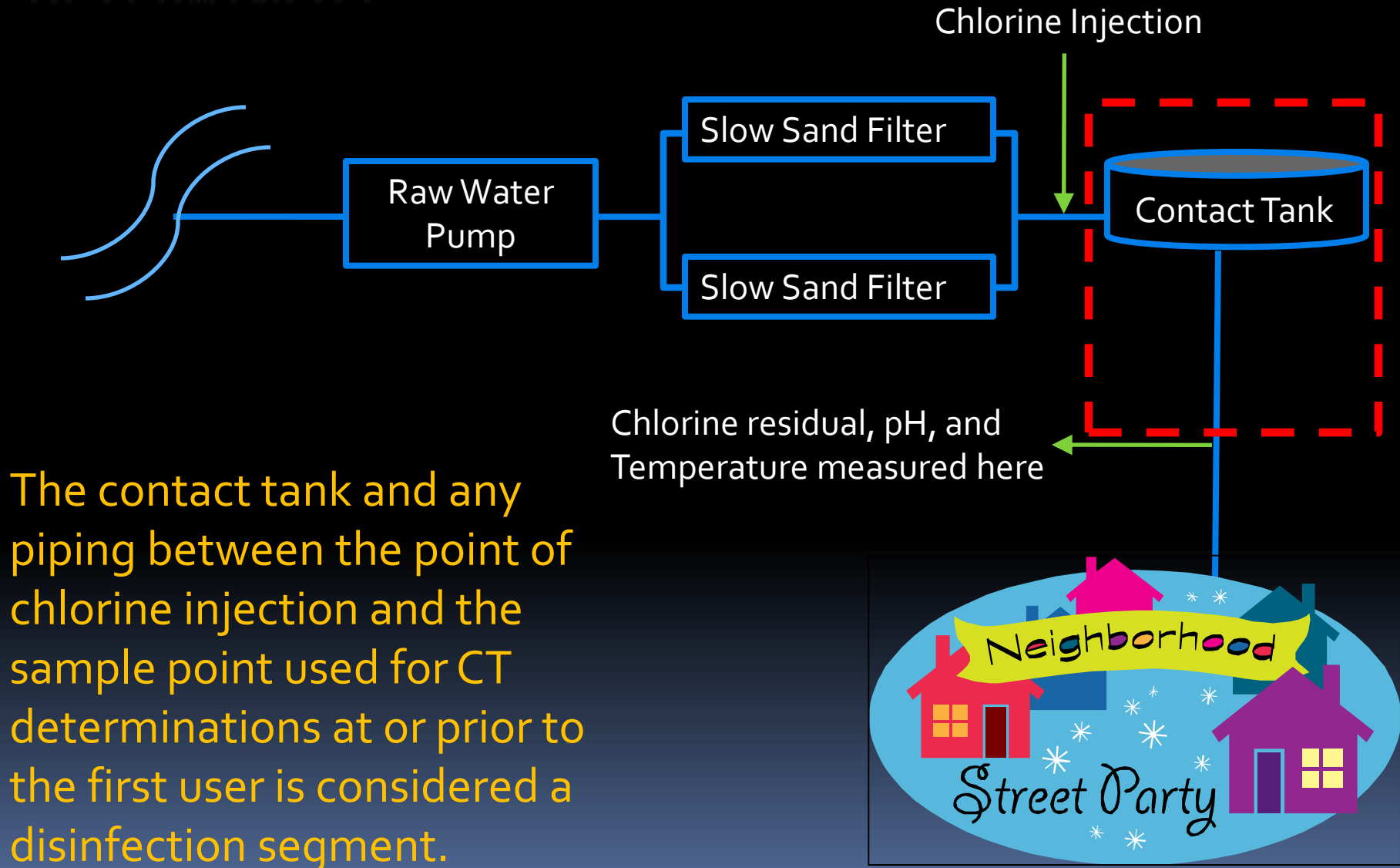
WTP-:

Month/Year:

Date / Time	Minimum Cl ₂ Residual at 1 st User (C) ³	Contact Time (T)	Actual CT	Temp	pH	Required CT	CT Met? ³	Peak Hourly Demand Flow
	[ppm or mg/L]	[minutes]	C X T	[° C]		Use tables	Yes / No	[GPM]
1 / 9 AM	???	???						1,000
2 /								
3 /								
4 /								
5 /								
6 /								
7 /								
8 /								
9 /								
10 /								

- The minimum chlorine residual is measured at the end of the disinfection segment.
- Contact time is the time that the disinfectant is in contact with the water within the disinfection segment.

HOW IS THE DISINFECTION SEGMENT DETERMINED?



HOW IS CONTACT TIME DETERMINED?

- Tracer studies are used to determine contact time (T) which is used in calculating CT achieved, where

$CT = \text{chlorine Concentration} \times \text{contact Time}.$

- Contact time is the time that chlorine is in contact with the water from the point of injection to the point where it is measured (sometimes referred to as the “CT segment”)
 - May be at or before the 1st user
 - May be more than one CT segment
- Tracer studies are often conducted to simulate a worst-case scenario where peak hour demand flows are high and reservoir levels are low. This gives a conservative (i.e. lower) contact time than would normally be expected.

HOW IS CONTACT TIME DETERMINED?

- The more efficient the mixing is in a reservoir or tank, the more contact time is available for disinfection.
- Estimates of contact time based on tank or reservoir design are not allowed for calculating CT's for surface water!



WHAT AFFECTS MIXING EFFICIENCY?

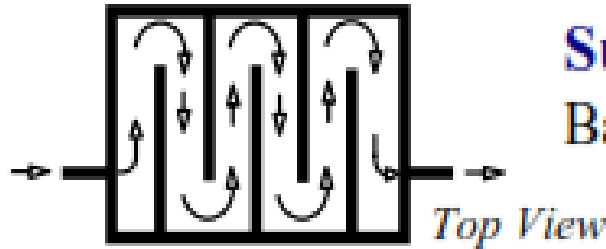
Mixing efficiency improves with high flow path length to width ratios, found in pipelines and simulated in tanks with the use of baffles (hence the term baffling efficiency or factor).



Perfect Circulation

Baffling Efficiency = 100%

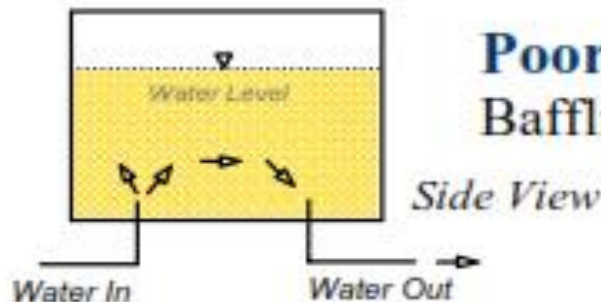
Plug flow through a length of pipe



Superior Circulation

Baffling Efficiency = 70%

Top View



Poor Circulation

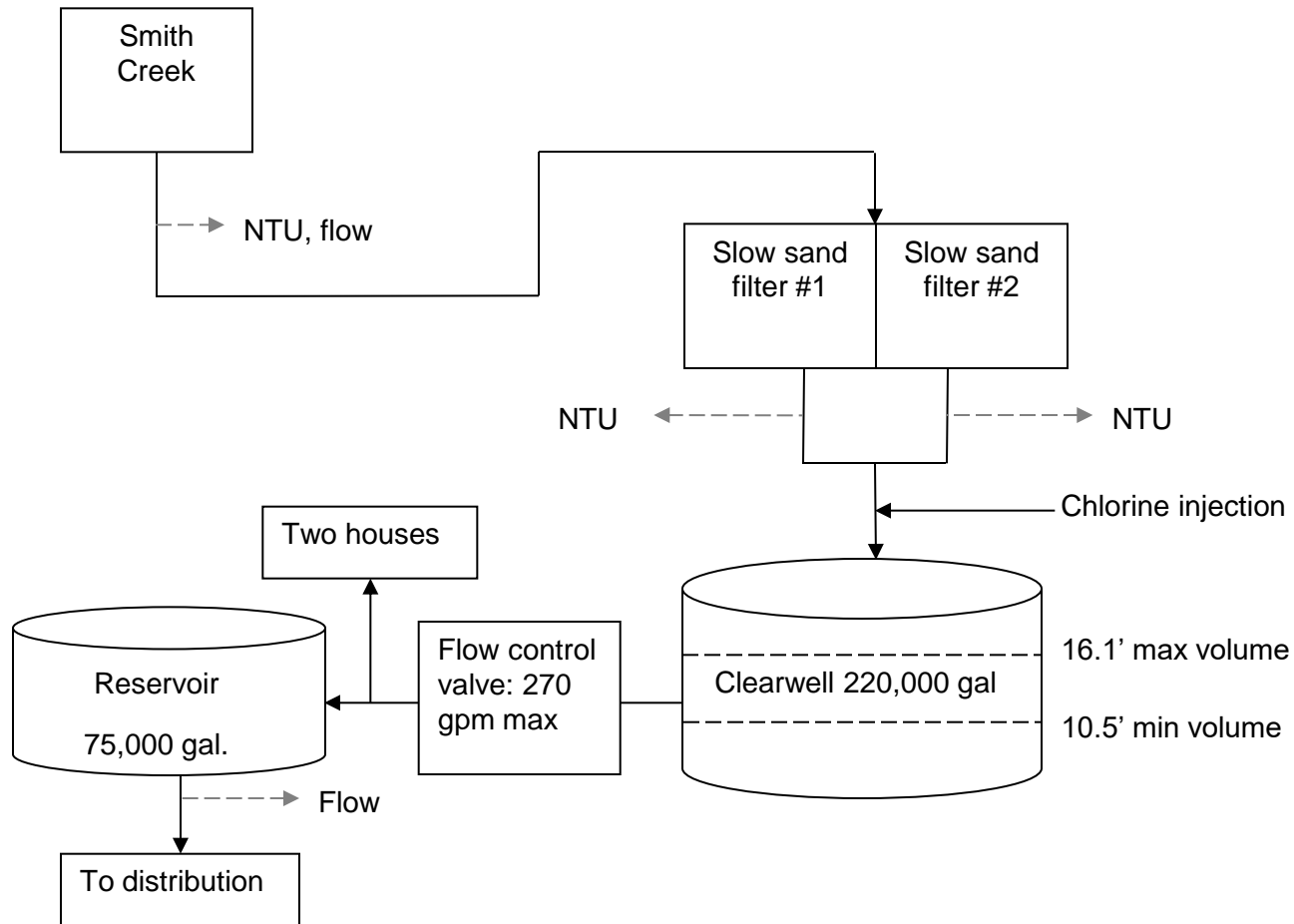
Baffling Efficiency = 5-10%

Side View

Example: Tracer studies

Directions: Look at the diagram and answer the questions.

Figure 1: Water Treatment Plant



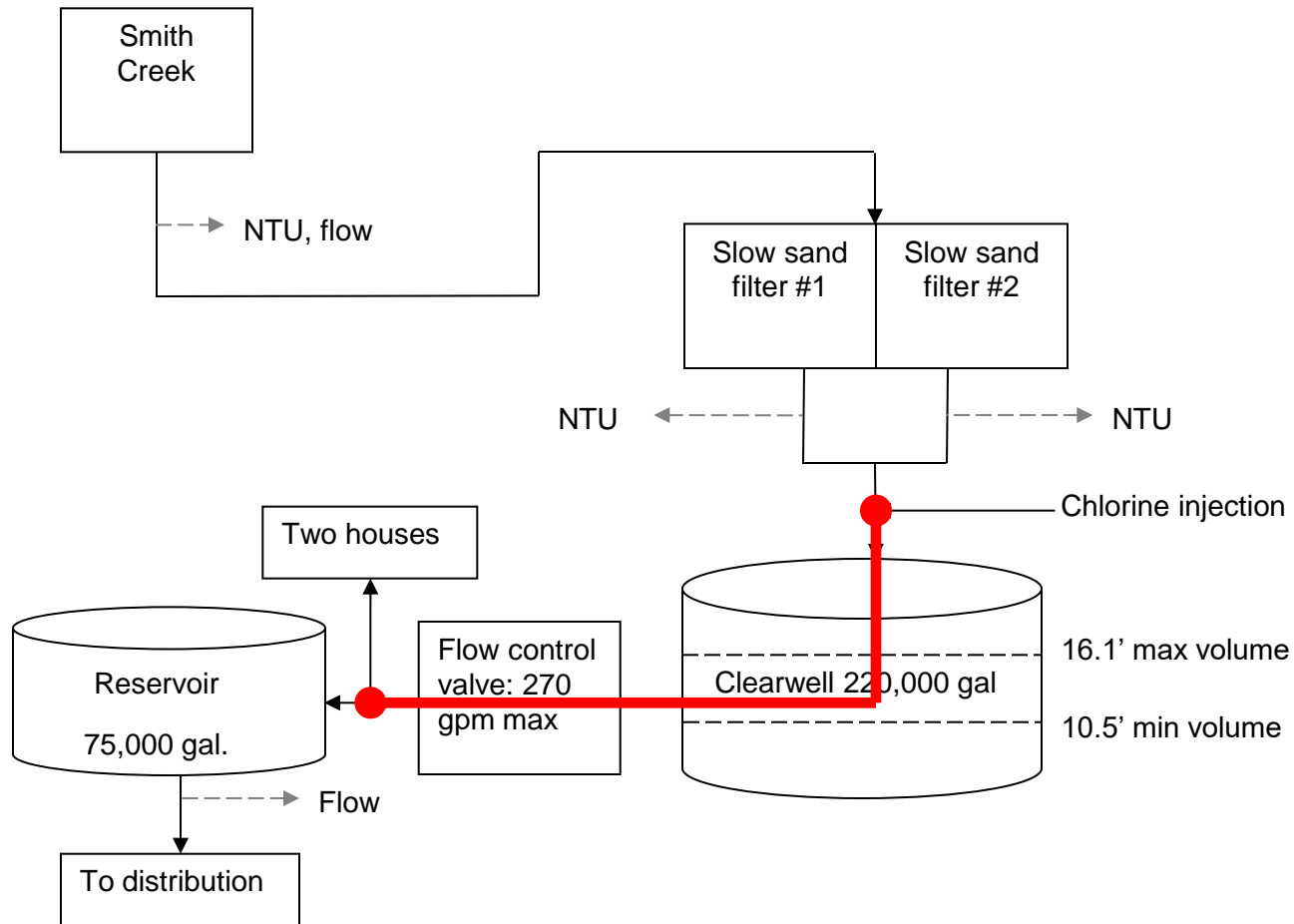
Questions:

- If this was your treatment plant, highlight the part of the plant where you might conduct a tracer study.
- In a “worst-case scenario” tracer study, what would the flow rate be? _____
- In a “worst-case scenario” tracer study, what would the clearwell level be? _____

Example: Tracer studies - Answer

Directions: Look at the diagram and answer the questions.

Figure 1: Water Treatment Plant



Questions:

- If this was your treatment plant, highlight the part of the plant where you might conduct a tracer study.
- In a “worst-case scenario” tracer study, what would the flow rate be? **270 gpm**
- In a “worst-case scenario” tracer study, what would the clearwell level be? **10.5 feet**

DO I REPORT CONTACT TIME?

- Use the time T from the tracer study on the monthly reporting form in the “Contact time (min)” column
 - Use the smallest T (highest flow) if the tracer study was done at multiple flow rates
- This may not be your exact time, but it represents your worst case (as long as the peak flow is less and clearwell volume is more than they were at the time of the tracer study)

REPORTING FORMS – CHLORINE & CONTACT TIME

OHA - Drinking Water Program – Surface Water Quality Data Form

System Name:

ID #:

WTP-:

Month/Year:

Date / Time	Minimum Cl ₂ Residual at 1 st User (C) ³	Contact Time (T)	Actual CT	Temp	pH	Required CT	CT Met? ³	Peak Hourly Demand Flow
	[ppm or mg/L]	[minutes]	C X T	[° C]		Use tables	Yes / No	[GPM]
1 / 9 AM	0.6	100						1,000
2 /								
3 /								
4 /								
5 /								
6 /								
7 /								
8 /								
9 /								
10 /								

Notify the State within 24-hrs if chlorine residual < 0.2 mg/l

Public Health After Hours Duty Officer:
Cell (971) 246-1789
Pager (503) 938-6790

Oregon Emergency Response System:
1-800-452-0311

- Enter the minimum chlorine residual at or before the first user.
- Enter the contact time (based either on the tracer study or determined from clearwell volume(s) and the peak hourly demand flow).

CAN I USE A BAFFLING FACTOR?

- As an alternative to using the tracer study contact time, you can use the results of the tracer study to determine the baffling factor of the clearwell
 - $\text{Baffling factor (\%)} = \frac{\text{Time (min)} \times \text{Flow During Tracer Study (gpm)}}{\text{Clearwell Volume During Tracer Study (gal)}}$
- T can be adjusted based on flow (at flow < 110% of tracer study flow) with the following equation:
 - $T = \frac{\text{Current clearwell Volume (gal)} \times \text{Baffling Factor (\%)}}{\text{Peak Hourly Demand Flow (gpm)}}$
- Contact the state for guidance on using baffling factors.

REPORTING FORMS – ACTUAL CT

OHA - Drinking Water Program – Surface Water Quality Data Form

System Name:

ID #:

WTP-:

Month/Year:

Date / Time	Minimum Cl ₂ Residual at 1 st User (C) ³	Contact Time (T)	Actual CT	Temp	pH	Required CT	CT Met? ³	Peak Hourly Demand Flow
	[ppm or mg/L]	[minutes]	C X T	[° C]		Use tables	Yes / No	[GPM]
1 / 9 AM	0.6	100	60					1,000
2 /								
3 /								
4 /								
5 /								
6 /								
7 /								
8 /								
9 /								
10 /								

- Enter the actual CT achieved that day:

$$\text{Actual CT} = \text{Chlorine Concentration (mg/l)} \times \text{Contact Time (min)}$$
- Do not confuse “CT” and “Contact Time”

REPORTING FORMS – TEMPERATURE & PH

OHA - Drinking Water Program – Surface Water Quality Data Form

System Name:

ID #:

WTP-:

Month/Year:

Date / Time	Minimum Cl ₂ Residual at 1 st User (C) ³	Contact Time (T)	Actual CT	Temp	pH	Required CT	CT Met? ³	Peak Hourly Demand Flow
	[ppm or mg/L]	[minutes]	C X T	[° C]		Use tables	Yes / No	[GPM]
1 / 9 AM	0.6	100	60	12	6.8			1,000
2 /								
3 /								
4 /								
5 /								
6 /								
7 /								
8 /								
9 /								
10 /								

- Enter the finished water temperature (°C) and pH measured at or prior to the first customer and after any storage (tank, reservoir, or pipeline) used for contact time.

REPORTING FORMS – REQUIRED CT

OHA - Drinking Water Program – Surface Water Quality Data Form

System Name:

ID #:

WTP-:

Month/Year:

Date / Time	Minimum Cl ₂ Residual at 1 st User (C) ³	Contact Time (T)	Actual CT	Temp	pH	Required CT	CT Met? ³	Peak Hourly Demand Flow
	[ppm or mg/L]	[minutes]	C X T	[° C]		Use tables	Yes / No	[GPM]
1 / 9 AM	0.6	100	60	12	6.8			1,000
2 /								
3 /								
4 /								
5 /								
6 /								
7 /								
8 /								
9 /								
10 /								

Actual CT must be \geq Required CT. To determine required CT:

1. Use USEPA CT tables or
2. Regression Equations (Use 1 of 2 equations –depends on °C)

HOW IS REQUIRED CT CALCULATED?

- We use the EPA tables (or “regression equations”) to determine the CT required to inactivate *Giardia* (CT_{required})
 - 1-log inactivation of *Giardia* using chlorine results in at least 4.0-log inactivation of viruses.
 - To determine CT, we need to know pH, temperature, and free chlorine residual at or before the first user.
- Then we compare the CT_{required} with the actual CT achieved in the water system (CT_{actual}) where:
$$CT_{\text{actual}} = \text{chlorine concentration (mg/l)} \times \text{contact time (min)}$$
- Must keep $CT_{\text{actual}} \geq CT_{\text{required}}$

USING REGRESSION EQUATIONS TO DETERMINE REQUIRED CT

Using Regression Equations to determine required CT:

1. Built into the MS Excel reporting forms on-line

[http://public.health.oregon.gov/HealthyEnvironm
ents/DrinkingWater/Operations/Treatment/Pages/
index.aspx](http://public.health.oregon.gov/HealthyEnvironm
ents/DrinkingWater/Operations/Treatment/Pages/
index.aspx)

- Surface Water Monitoring and Reporting Forms for CT and Turbidity Data:

If your system has more than one chlorine injection point, or if you have questions about the PDF or MS Excel versions of the monthly turbidity and surface water monitoring forms, contact the DWS technical oversight contact for your system at 971-673-0405.

- Conventional or Direct Filtration: PDF -or- MS Excel
- Slow Sand, Membrane, Diatomaceous Earth Filtration or Unfiltered: PDF -or- MS Excel
- Cartridge or Bag Filtration: PDF -or- MS Excel

USING REGRESSION EQUATIONS, CONT.

Using Regression Equations to determine required CT:

2. Regression equations can be programmed into plant SCADA or spreadsheets

Regression Equation (for Temp < 12.5°C)

$$CT = (0.353 * L)(12.006 + e^{(2.46 - 0.073 * T + 0.125 * C + 0.389 * pH)})$$

Regression Equation (for Temp > 12.5°C)

$$CT = (0.361 * L)(-2.261 + e^{(2.69 - 0.065 * T + 0.111 * C + 0.361 * pH)})$$

Variables:

CT = Product of Free Chlorine Residual and Time required

L = number of log inactivation for Giardia (L = 1 for slow sand)

T = temperature, in Celsius

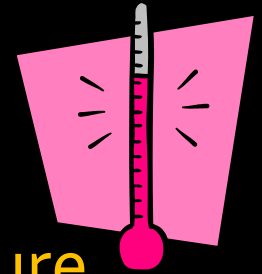
C = chlorine residual in mg/L

pH = pH of water

e = 2.7183, base for natural log

(Smith, Clark, Pierce and Regli, 1995, from EPA's 1999 Guidance Manual for Disinfection Profiling and Benchmarking)

USING EPA CT TABLES - TEMPERATURE



- There are **six EPA CT tables** based on temperature
- Find the correct table based on your water temperature in degrees Celsius.
 - $^{\circ}\text{C} = 5/9 \times (^{\circ}\text{F} - 32)$
- If water temp is between values, then round down
 - Example: for water temp of 12°C , use the 10°C table
 - *Even if the water temp is 14.9°C , round down to 10°C*
- *Water gets more viscous the colder it gets and chemical reactions take longer, so rounding temp down is more conservative.*

USING EPA CT TABLES - TEMP = 12 °C

CT VALUES FOR INACTIVATION OF GIARDIA CYSTS BY FREE CHLORINE AT 10° C

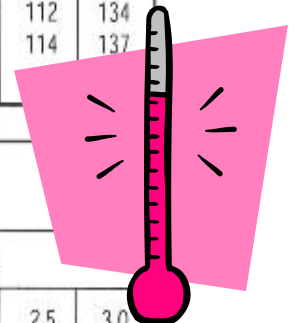
Use 10°C table
for T = 10 – 14.9°C
(round down for
temp)

6.1 – 6.5
PH = 6.5

Chlorine Concentration mg/L < =	PH < 6						PH = 6.5						PH = 6.6 – 6.9					
	Log Inactivations						Log Inactivations						Log Inactivations					
	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0
0.4	12	24	37	49	61	73	15	29	44	59	73	88	17	35	52	69	87	104
0.6	13	25	38	50	63	75	15	30	45	60	75	90	18	36	54	71	89	107
0.8	13	26	39	52	65	78	15	31	46	61	77	92	18	37	55	73	92	110
1	13	26	40	53	66	79	16	31	47	63	78	94	19	37	56	75	93	112
1.2	13	27	40	53	67	80	16	32	48	63	79	95	19	38	57	76	95	114
1.4	14	27	41	55	68	82	16	33	49	65	82	98	19	39	58	77	97	116
1.6	14	28	42	55	69	83	17	33	50	66	83	99	20	40	60	79	99	119
1.8	14	29	43	57	72	86	17	34	51	67	84	101	20	41	61	81	102	122
2	15	29	44	58	73	87	17	35	52	69	87	104	21	41	62	83	103	124
2.2	15	30	45	59	74	89	18	35	53	70	88	105	21	42	64	85	106	127
2.4	15	30	45	60	75	90	18	36	54	71	89	107	22	43	65	86	108	129
2.6	15	31	46	61	77	92	18	37	55	73	92	110	22	44	66	87	109	131
2.8	16	31	47	62	78	93	19	37	56	74	93	111	22	45	67	89	112	134
3	16	32	48	63	79	95	19	38	57	75	94	113	23	46	69	91	114	137

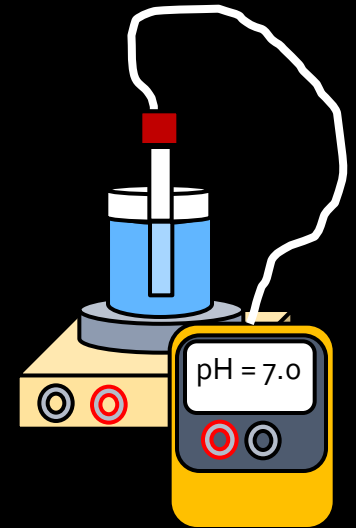
7.1 – 7.5
PH = 8.0

Chlorine Concentration mg/L < =	PH < 7.5						PH = 8.0						PH = 8.5					
	Log Inactivations						Log Inactivations						Log Inactivations					
	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0
0.4	21	42	63	83	104	125	25	50	75	99	124	149	30	59	89	118	148	177
0.6	21	43	64	85	107	128	26	51	M	102	128	153	31	61	92	122	153	183



USING EPA CT TABLES - PH

- There are 7 sections for pH on each table
- Find the section that corresponds to your water's pH level
- If your pH is between the choices, then round up to the higher pH
 - Example: if pH of water is 6.8, use the pH 7.0 section



USING EPA CT TABLES - PH = 6.8

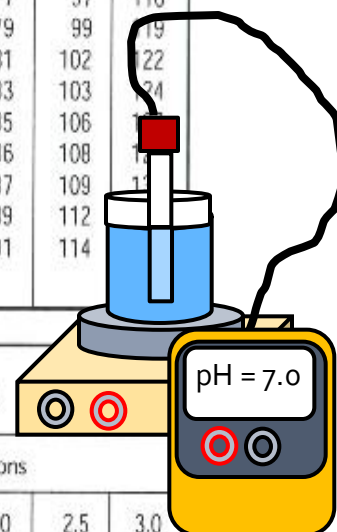
CT VALUES FOR INACTIVATION OF GIARDIA CYSTS BY FREE CHLORINE AT **10° C**

10°C - 14.9°C

Chlorine Concentration mg/L <=	PH < 6						6.1 - 6.5 PH = 6.5						6.6 - 7.0 PH = 7.0					
	Log Inactivations						Log Inactivations						Log Inactivations					
	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0
0.4	12	24	37	49	61	73	15	29	44	59	73	88	17	35	58	77	97	116
0.6	13	25	38	50	63	75	15	30	45	60	75	90	18	36	60	79	99	119
0.8	13	26	39	52	65	78	15	31	46	61	77	92	18	37	61	81	102	122
1	13	26	40	53	66	79	16	31	47	63	78	94	19	37	62	83	103	124
1.2	13	27	40	53	67	80	16	32	48	63	79	95	19	38	64	85	106	127
1.4	14	27	41	55	68	82	16	33	49	65	82	98	19	39	65	86	108	129
1.6	14	28	42	55	69	83	17	33	50	66	83	99	20	40	66	87	109	131
1.8	14	29	43	57	72	86	17	34	51	67	84	101	20	41	67	89	112	134
2	15	29	44	58	73	87	17	35	52	69	87	104	21	41	68	91	114	137
2.2	15	30	45	59	74	89	18	35	53	70	88	105	21	42	69	92	115	140
2.4	15	30	45	60	75	90	18	36	54	71	89	107	22	43	70	93	116	143
2.6	15	31	46	61	77	92	18	37	55	73	92	110	22	44	71	94	117	146
2.8	16	31	47	62	78	93	19	37	56	74	93	111	22	45	72	95	118	149
3	16	32	48	63	79	95	19	38	57	75	94	113	23	46	73	96	119	152

Use pH = 7.0 column
for pH = 6.6 - 7.0
(round up for pH)

Chlorine Concentration mg/L <=	7.1 - 7.5 PH < 7.5						PH = 8.0						PH = 8.5					
	Log Inactivations						Log Inactivations						Log Inactivations					
	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0
0.4	21	42	63	83	104	125	25	50	75	99	124	149	30	59	89	118	148	177
0.6	21	43	64	85	107	128	26	51	76	102	128	153	31	61	92	122	153	183



USING EPA CT TABLES – 1-LOG



- Use the 1-log inactivation column

(slow sand is granted 2.0-log removal credit for *Giardia*, which requires that 1.0-log *Giardia* inactivation is needed through disinfection)

USING EPA CT TABLES – REQUIRED LOG = 1.0

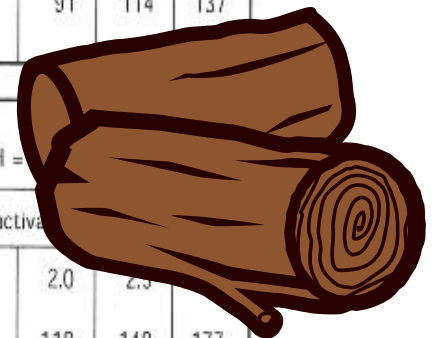
CT VALUES FOR INACTIVATION OF GIARDIA CYSTS BY FREE CHLORINE AT **10° C**

10°C – 14.9°C

Chlorine Concentration mg/L <=	PH < 6						6.1 – 6.5 PH = 6.5						6.6 – 7.0 PH = 7.0					
	Log Inactivations						Log Inactivations						Log Inactivations					
	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0
0.4	12	24	37	49	61	73	15	29	44	59	73	88	17	35	56	75	93	112
0.6	13	25	38	50	63	75	15	30	45	60	75	90	18	36	57	76	95	114
0.8	13	26	39	52	65	78	15	31	46	61	77	92	18	37	58	77	97	116
1	13	26	40	53	66	79	16	31	47	63	78	94	19	37	60	79	99	119
1.2	13	27	40	53	67	80	16	32	48	63	79	95	19	38	61	81	102	122
1.4	14	27	41	55	68	82	16	33	49	65	82	98	19	39	62	83	103	124
1.6	14	28	42	55	69	83	17	33	50	66	83	99	20	40	64	85	106	127
1.8	14	29	43	57	72	86	17	34	51	67	84	101	20	41	65	86	108	129
2	15	29	44	58	73	87	17	35	52	69	87	104	21	41	66	87	109	131
2.2	15	30	45	59	74	89	18	35	53	70	88	105	21	42	67	89	112	134
2.4	15	30	45	60	75	90	18	36	54	71	89	107	22	43	68	90	113	135
2.6	15	31	46	61	77	92	18	37	55	73	92	110	22	44	69	91	114	137
2.8	16	31	47	62	78	93	19	37	56	74	93	111	22	45				
3	16	32	48	63	79	95	19	38	57	75	94	113	23	46				

For slow sand, Use the 1.0-log column

Chlorine Concentration mg/L <=	7.1 – 7.5 PH < 7.5						PH = 8.0						PH = 8.5					
	Log Inactivations						Log Inactivations						Log Inactivations					
	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0
0.4	21	42	63	83	104	125	25	50	75	99	124	149	30	59	89	118	148	177
0.6	21	43	64	85	107	128	26	51	76	102	128	153	31	61	92	122	153	183



USING EPA CT TABLES - CHLORINE



- Match your free chlorine residual on the far left column
- If in between column values, **round up**
 - Rounding chlorine residual up is more conservative because as chlorine residual increases at a given pH, more CT is required
- The point where it intersects with the log inactivation column is the CT_{required}
 - Example: free chlorine residual is 0.6 ppm

USING EPA CT TABLES - $CL_2 = 0.6 \text{ MG/L}$

CT VALUES FOR INACTIVATION OF GIARDIA CYSTS BY FREE CHLORINE AT **10° C**

10°C - 14.9°C

Chlorine Concentration mg/L <=	PH < 6						6.1 - 6.5 PH = 6.5						6.6 - 7.0 PH = 7.0					
	Log Inactivations						Log Inactivations						Log Inactivations					
	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0
0.4	12	24	37	49	61	73	15	29	44	59	73	88	17	35	52	69	87	104
0.6	13	25	38	50	63	75	15	30	45	60	75	90	18	36	54	71	89	107
0.8	13	26	39	52	65	78	15	31	46	61	77	92	18	37	55	73	92	110
1	13	26	40	53	66	79	16	31	47	63	78	94	19	37	56	75	93	112
1.2	13	27	40	53	67	80	16	32	48	63	79	95	19	38	57	76	95	114
1.4	14	27	41	55	68	82	16	33	49	65	82	98	19	39	58	77	97	116
1.6	14	28	42	55	69	83	17	33	50	66	83	99	20	40	60	79	99	119
1.8	14	29	43	57	71	85	17	34	51	67	84	101	20	41	61	81	102	122
2.0	15	30	44	58	72	86	17	35	52	69	87	104	21	41	62	83	103	124
2.2	15	31	45	59	73	87	17	36	53	70	88	105	21	42	64	85	106	127
2.4	16	32	46	60	74	88	17	37	54	71	89	107	22	43	65	86	108	129
2.6	16	33	47	61	75	89	17	38	55	73	92	110	22	44	66	87	109	131
2.8	17	34	48	62	76	90	17	39	56	74	93	111	22	45	67	88	110	132
3.0	17	35	49	63	77	91	18	40	57	75	94	113	23	46	69	89	111	133

Round up if measured CL_2 is between values in the chlorine concentration column

Chlorine Concentration mg/L <=	7.1 - 7.5 PH < 7.5						PH = 8.0						PH = 8.5					
	Log Inactivations						Log Inactivations						Log Inactivations					
	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0
0.4	21	42	63	83	104	125	25	50	75	99	124	149	30	59	89	118	148	177
0.6	21	43	64	85	107	128	26	51	76	100	125	150	31	61	92	122	153	183

17

Cl

Chlorine
35.45

USING EPA CT TABLES - $CL_2 = 0.6 \text{ MG/L}$

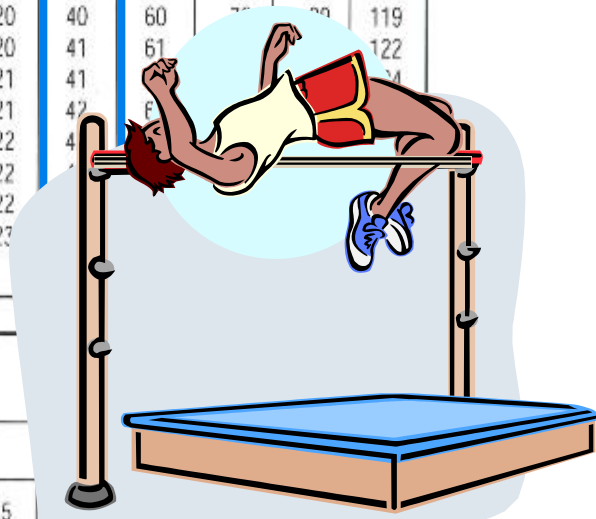
CT VALUES FOR INACTIVATION OF GIARDIA CYSTS BY FREE CHLORINE AT **10° C**

10°C - 14.9°C

Chlorine Concentration mg/L <=	PH < 6						PH = 6.5						PH = 7.0					
	Log Inactivations						Log Inactivations						Log Inactivations					
	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0
0.4	12	24	37	49	61	73	15	29	44	59	73	88	17	35	52	69	85	101
0.6	13	25	38	50	63	75	15	30	45	60	75	90	18	36	54	71	88	107
0.8	13	26	39	52	65	78	15	31	46	61	77	92	18	37	55	73	92	110
1	13	26	40	53	66	79	16	31	47	63	78	94	19	37	56	75	93	112
1.2	13	27	40	53	67	80	16	32	48	63	79	95	19	38	57	76	95	114
1.4	14	27	41	55	68	82	16	33	49	65	82	98	19	39	58	77	97	116
1.6	14	28	42	56	70	84	16	34	50	66	83	99	20	40	60	79	99	119
1.8	14	29	43	57	71	86	16	35	51	67	84	101	20	41	61	81	101	122
2	15	30	44	58	73	88	16	36	52	69	87	104	21	41	62	82	102	124
2.2	15	31	45	59	74	89	16	37	53	70	88	105	21	42	63	83	103	125
2.4	15	32	46	60	75	90	16	38	54	71	89	107	22	43	64	84	104	126
2.6	15	33	47	61	76	91	16	39	55	73	92	110	22	44	65	85	105	127
2.8	16	34	48	62	77	92	16	40	56	74	93	111	22	45	66	86	106	128
3	16	35	49	63	78	93	16	41	57	75	94	113	23	46	67	87	107	129

CT_{required} = 36

If you get confused on which way to round, think about how you want to set the bar (CT_{required}) as high as possible to be the most conservative and most protective of public health.



Chlorine Concentration mg/L <=	PH = 8.0						PH = 8.5						PH = 9.0					
	Log Inactivations						Log Inactivations						Log Inactivations					
	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0
0.4	21	42	63	83	104	125	25	50	75	99	124	149	30	60	90	120	148	177
0.6	21	43	64	85	107	128	26	51	76	102	128	153	31	61	92	122	153	183

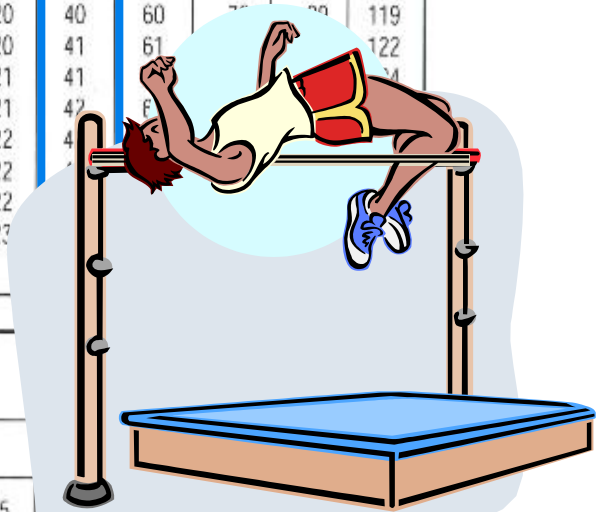
USING EPA CT TABLES - $CL_2 = 0.6 \text{ MG/L}$

CT VALUES FOR INACTIVATION OF GIARDIA CYSTS BY FREE CHLORINE AT 10°C

$10^\circ \text{C} - 14.9^\circ \text{C}$

Chlorine Concentration mg/L <=	PH < 6						6.1 - 6.5 PH = 6.5						6.6 - 7.0 PH = 7.0					
	Log Inactivations						Log Inactivations						Log Inactivations					
	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0
0.4	12	24	36	48	60	72	15	29	44	59	73	88	17	35	52	69	85	101
0.6	13	25	38	50	63	75	15	30	45	60	75	90	18	36	54	71	88	105
0.8	13	26	39	52	65	78	15	31	46	61	77	92	18	37	55	73	92	110
1	13	26	40	53	66	79	16	31	47	63	78	94	19	37	56	75	93	112
1.2	13	27	40	53	67	80	16	32	48	63	79	95	19	38	57	76	95	114
1.4	14	27	41	55	68	82	16	33	49	65	82	98	19	39	58	77	97	116
1.6	14	28	42	56	70	84	16	34	50	66	83	99	20	40	60	79	99	119
1.8	14	29	43	57	71	85	16	35	51	67	84	101	20	41	61	81	101	122
2	15	30	44	58	72	86	16	36	52	69	87	104	21	41	62	82	102	124
2.2	15	31	45	59	73	87	16	37	53	70	88	105	21	42	63	83	103	125
2.4	15	32	46	60	74	88	16	38	54	71	89	107	22	43	64	84	104	126
2.6	15	33	47	61	75	89	16	39	55	73	92	110	22	44	65	85	105	127
2.8	16	34	48	62	76	90	16	40	56	74	93	111	22	45	66	86	106	128
3	16	35	49	63	77	91	16	41	57	75	94	113	23	46	67	87	107	129

For example, if you rounded down for pH instead of up, you would get a CT_{required} of only 30 as opposed to 36.



Chlorine Concentration mg/L <=	PH < 7.5						PH = 8.0									
	Log Inactivations						Log Inactivations									
	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0
0.4	21	42	63	83	104	125	25	50	75	99	124	149	30	60	90	120
0.6	21	43	64	85	107	128	26	51	76	102	128	153	31	61	92	122

USING EPA CT TABLES - $\text{CL}_2 = 0.6 \text{ MG/L}$

CT VALUES FOR INACTIVATION OF GIARDIA CYSTS BY FREE CHLORINE AT 10°C

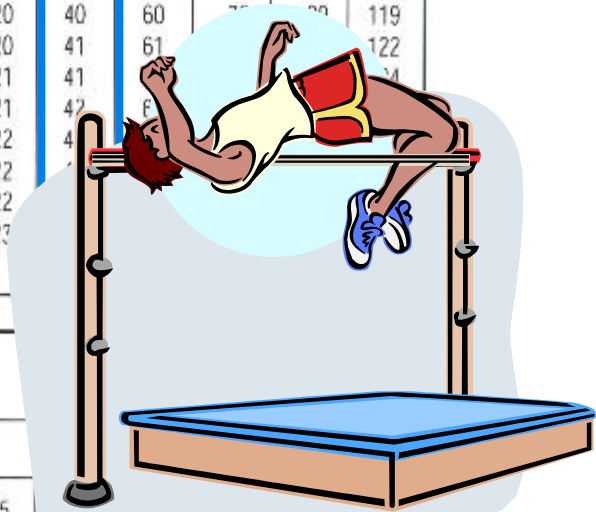
$10^\circ \text{C} - 14.9^\circ \text{C}$

Chlorine Concentration mg/L <=	PH < 6						PH = 6.5						PH = 7.0					
	Log Inactivations						Log Inactivations						Log Inactivations					
	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0
0.4	12	24	37	49	61	73	15	29	44	59	73	88	17	35	52	69	85	101
0.6	13	25	38	50	63	75	15	30	45	60	75	90	18	36	54	71	88	107
0.8	13	26	39	52	65	78	15	31	46	61	77	92	18	37	55	73	92	110
1	13	26	40	53	66	79	16	31	47	63	78	94	19	37	56	75	93	112
1.2	13	27	40	53	67	80	16	32	48	63	79	95	19	38	57	76	95	114
1.4	14	27	41	55	68	82	16	33	49	65	82	98	19	39	58	77	97	116
1.6	14	28	42	56	70	84	16	34	50	66	83	99	20	40	60	79	99	119
1.8	14	29	43	57	71	86	16	35	51	67	84	101	20	41	61	81	101	122
2	15	30	44	58	73	88	16	36	52	69	87	104	21	41	62	82	102	124
2.2	15	31	45	59	74	89	16	37	53	70	88	105	21	42	63	83	103	125
2.4	15	32	46	60	75	90	16	38	54	71	89	107	22	43	64	84	104	127
2.6	16	33	47	61	76	91	16	39	55	73	92	110	22	44	65	85	105	128
2.8	16	34	48	62	77	92	16	40	56	74	93	111	22	45	66	86	106	129
3	16	35	49	63	78	93	16	41	57	75	94	113	23	46	67	87	107	130

$\text{CT}_{\text{required}} = 35$

$\text{CT}_{\text{required}} = 36$

If you rounded down for chlorine residual, you would get a $\text{CT}_{\text{required}}$ of only 35 as opposed to 36.



Chlorine Concentration mg/L <=	PH < 7.5						PH = 8.0									
	Log Inactivations						Log Inactivations									
	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0
0.4	21	42	63	83	104	125	25	50	75	99	124	149	30	60	90	120
0.6	21	43	64	85	107	128	26	51	76	101	126	151	31	61	92	122

REPORTING FORMS – REQUIRED CT

OHA - Drinking Water Program – Surface Water Quality Data Form

System Name:

ID #:

WTP-:

Month/Year:

Date / Time	Minimum Cl ₂ Residual at 1 st User (C) ³	Contact Time (T)	Actual CT	Temp	pH	Required CT	CT Met? ³	Peak Hourly Demand Flow
	[ppm or mg/L]	[minutes]	C X T	[° C]		Use tables	Yes / No	[GPM]
1 / 9 AM	0.6	100	60	12	6.8	36	Yes	1,000
2 /								
3 /								
4 /								
5 /								
6 /								
7 /								
8 /								
9 /								
10 /								
11 /								
12 /								

Notify the State within 24-hrs if CT was not met.

Public Health After Hours Duty Officer:

Cell (971) 246-1789

Pager (503) 938-6790

Oregon Emergency Response System:

1-800-452-0311

1. Enter Required CT (CT tables or Regression Equations)
2. Was CT Met? Yes if Actual CT \geq Required CT
3. Actual CT must be \geq Required CT

REPORTING FORMS – MONTHLY SUMMARY – CT & CL₂

Everyone needs to fill out the CT section of the Monthly Summary

Monthly Summary (Answer Yes or No)	
CT's met everyday? (see back) Yes No	All Cl ₂ residual at entry point ≥ 0.2 mg/l? Yes No
PRINTED NAME:	
SIGNATURE:	DATE:
PHONE #: ()	CERT #:

MONTHLY REPORT

Slow Sand/Membrane/ DE Filtration/Unfiltered		Monthly Summary (Answer Yes or No)	
95% of daily turbidity readings \leq 1 NTU? ²	Yes / No	CT's met everyday?	All Cl ₂ residual at entry point \geq 0.2 mg/l?
All daily turbidity readings \leq 5 NTU?	Yes / No		
Notes:		PRINTED NAME:	
		SIGNATURE:	
		DATE:	
		PHONE #: ()	CERT #:

DAY	12 AM [NTU]	4 AM [NTU]	8 AM [NTU]	Noon [NTU]	4 PM [NTU]	8 PM [NTU]	Highest Reading of the Day [NTU]
1			0.34				0.50

Date & Time	Minimum Cl ₂ Residual at 1 st User (C) [mg/L]	Contact Time (T) [min]	Actual CT C x T	Temp [° C]	pH	Required CT (Use CT tables)	CT Met? (Yes / No)	Peak Hourly Demand Flow (GPM)
1 / 9 AM	0.6	100	60	12	6.8	36	Yes	1,000

FILLING OUT THE MONTHLY REPORT – COMMON MISTAKES

- Not calculating CT's daily
 - Don't wait until the end of the month to do the calculations because if you discover you didn't meet CT's, it's too late!
- If adjusting contact time according to flow rate, use the demand flow, not the plant flow.
- Failure to answer questions at bottom of form correctly (or at all)
- Always answering "Yes" to the questions at the bottom of the form without actually looking at the numbers

FILLING OUT THE MONTHLY REPORT – COMMON MISTAKES

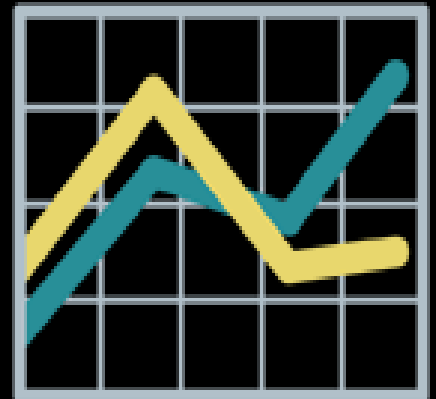
- Rounding errors when using EPA tables to determine CT_{required}
 - Must round down for temperature
 - Must round up for pH
 - Must round up for free chlorine residual
- Bad CT formulas in excel spreadsheets:
 - Make sure you understand your formula
 - Wilkes Equation not allowed, must use Regression Equation

FILLING OUT THE MONTHLY REPORT – AVOIDING MISTAKES

- Check how T is calculated at your plant
- Do all treatment plant operators understand it?
- Review spreadsheet equation for CTs (if applicable)
- Write an SOP for CT determination
- Arrange for a tracer study if necessary
- Calculate CT and fill out monthly report daily
- Know what to do and who to call when things go wrong (contact State regulator & refer to Emergency Response Plan)

STRIVE TO IMPROVE DATA QUALITY

- Make data reliability a plant goal
- Only collect data used for process control or compliance reporting
- Establish protocols for collection and recording of data
- Establish a data verification process that can be routinely used to confirm data integrity
- Turn data into information (e.g., draw the graph).



O&M MANUALS



Keep written procedures on:

- Instrument calibration methods and frequency
- Data handling/reporting
- Chemical dosage determinations
- Filter operation and cleaning
- CT determinations
- Responding to abnormal conditions (emergency response plan)

DISINFECTION

- Types of disinfectants
 1. Radiation (UV)
 2. Chemical (chlorine, chloramines, chlorine dioxide, ozone)
- Forms of chlorine
- NSF/ANSI Standard 60



TYPES OF DISINFECTANTS - UV

- Works by subjecting water to ultraviolet (UV) light rays as water passes through a tube
- Drawbacks:
 - Interfering agents such as turbidity can screen pathogens from the UV light
 - Effective against *Giardia* and *Cryptosporidium* but not viruses at normal doses
 - No residual is present throughout the distribution system
 - For this reason, chlorination for residual maintenance is required when UV is used



TYPES OF DISINFECTANTS - CHEMICAL

1. Chlorine
2. Chloramines
3. Chlorine dioxide
4. Ozone

TYPES OF DISINFECTANTS - CHLORINE

- The most widely used form of disinfection
- Also used as an oxidizing agent for iron, manganese and hydrogen sulfide and for controlling taste and odors
- Effectiveness as a disinfecting agent depends on factors such as pH, temperature, free chlorine residual, contact time and other interfering agents

FORMS OF CHLORINE

- Sodium Hypochlorite
- Onsite generated sodium hypochlorite
- Calcium Hypochlorite
- Chlorine Gas

FORMS OF CHLORINE – SODIUM HYPOCHLORITE

- The liquid form of chlorine
- Clear and has a slight yellow color
- Ordinary household bleach (~5% chlorine by solution) is the most common form
- Industrial strength: 12% and 15% solutions
- Can lose up to 4% of its available chlorine content per month; should not be stored for more than 60 to 90 days
- Very corrosive; should be stored and mixed away from equipment that can be damaged by corrosion

FORMS OF CHLORINE – SODIUM HYPOCHLORITE

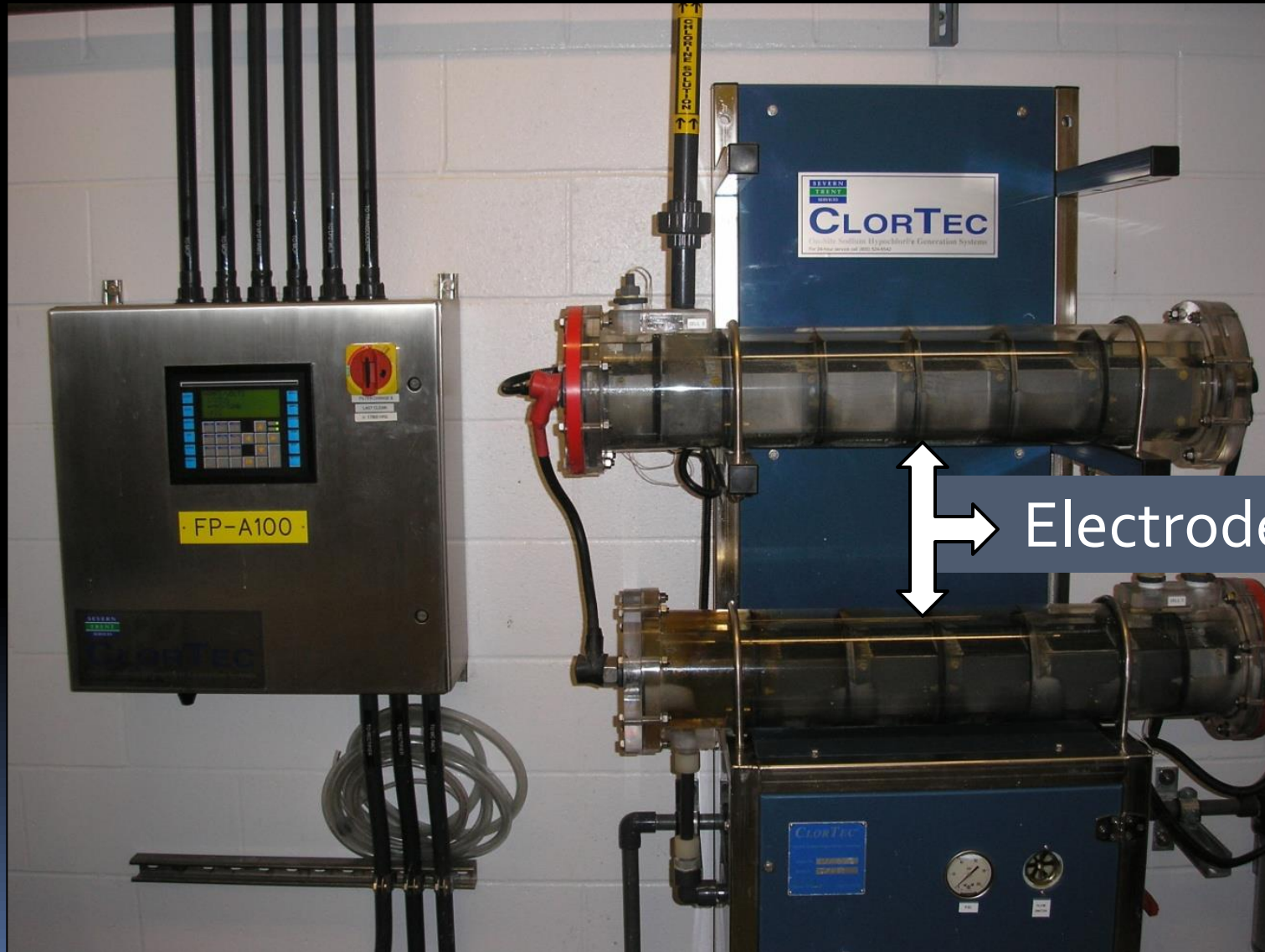


Diaphragm pump
with chlorine
solution tank

ON-SITE GENERATED SODIUM HYPOCHLORITE

- 0.8% sodium hypochlorite is produced on demand by combining salt, water & electricity
- Electrolysis of brine solution produces sodium hydroxide and chlorine gas, which then mix to form sodium hypochlorite
- Hydrogen gas byproduct; vented to atmosphere
- Alleviates safety concerns associated w/ hauling and storing bulk chlorine
- Higher initial cost, high power cost
- Mixed oxidants (proprietary)

ON-SITE GENERATED SODIUM HYPOCHLORITE



FORMS OF CHLORINE - CALCIUM HYPOCHLORITE

- The solid form of chlorine
- Usually tablet or powder form (see photo below)
- Contains ~65% chlorine by weight
- White or yellowish-white granular material and is fairly soluble in water
- Important to keep in a dry, cool place
- More stable than liquid
- Common in small systems w/ low flows or no power



FORMS OF CHLORINE - CALCIUM HYPOCHLORITE



Erosion chlorinator

Inside Hopper =>



FORMS OF CHLORINE – CHLORINE GAS

- 99.5% pure chlorine
- yellow-green color 2.5x heavier than air
- Liquefied at room temperature at ~107 psi – hence the pressurized cylinders actually contain liquefied chlorine gas.
- Liquefied Cl_2 is released from tanks as chlorine gas, which is then injected into the water stream.
- usually used only by large water systems
- Smaller systems may find initial cost of operation prohibitive

FORMS OF CHLORINE – CHLORINE GAS

Below: 1 ton cylinders. Note scale used to monitor product use.



150-lb cylinders
Note security chain
spare tank & labeling.



FORMS OF CHLORINE – CHLORAMINES

- Chlorine + ammonia = chloramination
- Two advantages to regular chlorination:
 1. produce a longer lasting chlorine residual (helpful to systems with extensive distribution systems)
 2. may produce fewer by-products depending on the application
- Disadvantage:
 1. Need a lot of contact time to achieve CTs compared to free chlorine (300 times more) which is why not used for primary disinfection
 2. Requires specific ratio of chlorine to ammonia or else potential water quality problems

CHLORINE DIOXIDE - ADVANTAGES

Advantages:

1. More effective than chlorine and chloramines for inactivation of viruses, *Cryptosporidium*, and *Giardia*
2. Oxidizes iron, manganese, and sulfides
3. May enhance the clarification process
4. Controls T&O resulting from algae and decaying vegetation, as well as phenolic compounds
5. Under proper generation conditions halogen-substituted DBPs are not formed
6. Easy to generate
7. Provides residual

CHLORINE DIOXIDE - DISADVANTAGES

Disadvantages

1. Forms the DBP chlorite
2. Costs associated with training, sampling, and laboratory testing for chlorite and chlorate are high
3. Equipment is typically rented, and the cost of the sodium chlorite is high
4. Explosive, so it must be generated on-site
5. Decomposes in sunlight
6. Can lead to production noxious odors in some systems.

OZONE

- Colorless gas (O_3)
- Strongest of the common disinfecting agents
- Also used for control of taste and odor
- Extremely Unstable; Must be generated on-site
- Manufactured by passing air or oxygen through two electrodes with high, alternating potential difference



OZONE - ADVANTAGES

Advantages:

1. Short reaction time enables microbes (including viruses) to be killed within a few seconds
2. Removes color, taste, and odor causing compounds
3. Oxidizes iron and manganese
4. Destroys some algal toxins
5. Does not produce halogenated DBPs

OZONE - DISADVANTAGES

Disadvantages:

1. Overfeed or leak can be dangerous
2. Cost is high compared with chlorination
3. Installation can be complicated
4. May produce undesirable brominated byproducts in source waters containing bromide
5. No residual effect is present in the distribution system, thus post-chlorination is required
6. Much less soluble in water than chlorine; thus special mixing devices are necessary

NSF/ANSI STANDARD 60 - CHEMICALS

- Addresses the health effects implications of treatment chemicals and related impurities.
- The two principal questions addressed are:
 1. Is the chemical safe at the maximum dose, and
 2. Are impurities below the maximum acceptable levels?



NSF/ANSI STANDARD 60 - CHEMICALS

<http://info.nsf.org/Certified/PwsChemicals/>

NSF/ANSI 60

Drinking Water Treatment Chemicals - Health Effects

Morton Salt, Inc.

123 North Wacker Drive
Chicago, IL 60606-1743
United States
312-807-2000

Facility : 0111 Glendale, AZ

Sodium Chloride[1] [CL]

Trade Designation

Bulk White Crystal Solar Salt
Bulk w/Crystal Crse. Sol. Salt
Fine Solar Salt
Morton® Commercial Grade Water Softening Pellets
Morton® System Saver® II Formula Pellets
White Crystal Solar Salt
White Crystal Water Softening Solar Salt

Product Function

Other
Other
Other
Other
Other
Other
Other



NSF/ANSI STANDARD 61 – COMPONENTS & MEDIA

<http://info.nsf.org/Certified/PwsComponents/index.asp?standard=o61>

Cemex

5180 Golden Foothill Parkway
Suite 200
El Dorado Hills, CA 95762
United States
925-426-8787

Facility : Marina, CA

Size

.2 mm - 3 mm

Process Media

Trade Designation

Size

Water
Contact
Temp

Water
Contact
Material

Sand

Lapis Lustre Sand

.2 mm - 3 mm

CLD 23

SLDOX

[1] Certified products include F-101 through F-112.

NOTE: Certified for water treatment plant applications.

This product has not been evaluated for point of use applications.



RESOURCES FOR OPERATORS

- For surface water systems:

www.healthoregon.gov/dwp

Click on “Water System Operations” on left-side menu list, then “Surface Water Treatment”

- Monthly Surface Water Quality Report form template
 - Tracer Study form
- Surface Water Treatment Rule guidance manual, Appendix C: Determination of Disinfectant Contact Time

RESOURCES FOR OPERATORS

- EPA Rules

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

- AWWA <http://www.pnws-awwa.org/Index.asp>

- OAWU <http://www.oawu.net/>

- Circuit Rider

<http://public.health.oregon.gov/HealthyEnvironments/DrinkingWater/Operations/Pages/circuitrider.aspx>

RESOURCES FOR OPERATORS

Oregon Drinking Water Services

Working to keep drinking water safe for Oregonians

Access to safe drinking water is essential to human health. Each person on Earth requires a safe source of drinking water for drinking, cooking and simply keeping themselves clean. Oregon Drinking Water Services works to ensure that all Oregonians have access to safe drinking water.

Oregon Drinking Water Services (DWS) administers and enforces drinking water quality standards. DWS focuses resources in the areas of highest public health benefit and promotes voluntary standards. DWS also emphasizes prevention of contamination through source water protection and provides water system operator training.

[Contact Us](#)[Sign up for DWS Alerts](#)[Data Online](#)

"Drinking
Water Data
Online"

(data specific to
each water
system)



Services

- Cross Connection & Backflow Prevention
- Emergency Preparedness & Security
- Groundwater & Source Water Protection
- Monitoring & Reporting
- Operator Certification
- Plan Review
- State Revolving Fund (SRF)
- Water System Operations

Resources

- County & Department of Agriculture Resources
- Data Online
- Domestic Well Safety Program
- Drinking Water Advisory Committee (DWAC)
- For Consumers
- Rules & Implementation Guidance
- Training Opportunities
- Site Map
- Contact Us

* News and Hot Topics

Link

[PAY 2018 WATER SYSTEM SURVEY FEE ONLINE](#)[Cyanotoxin Resources for Water System Operators](#)[2019 Drinking Water Source Protection Grants](#)[PPL Public Notice for Comments April 29 - May 8, 2019](#)[Start-up tips for seasonal systems](#)[Information on Healthy School Facilities](#)[Contact Us](#)

Current News
and Events

Water
System
Operations

www.healthoregon.gov/dwp

RESOURCES FOR OPERATORS

Resources for Oregon Water System Operators

[Drinking Water Services](#)

[Water System Operations](#)

[Surface Water Treatment](#)

[Capacity Development](#)

[Public Notice Resources & Templates](#)

[Fact Sheets & Best Management Practices](#)

[Water System Surveys & Outstanding Performance](#)

[Circuit Rider Program](#)

[Pipeline Newsletter](#)

[Contact Us](#)

[Surface Water Treatment](#)

Water systems that treat surface water sources have to deal with complex regulatory requirements, constantly changing raw water quality, and costly management of various assets. The [Surface Water Treatment](#) site provides information and tools needed to optimize water treatment processes and maximize public health protection without costly capital improvements.

[Capacity Development](#)

Water system capacity is the technical, managerial and financial capability of a water system to achieve and maintain compliance with drinking water standards and consistently provide safe drinking water. The [Capacity Development](#) site provides information and resources for drinking water systems to help build their capacity.

[Public Notice Resources & Templates](#)

Water systems are required to issue public notices to alert consumers under specific circumstances (for example, when exceeding a Maximum Contaminant Level, failing to complete required tests, failing to report the results, or failing to meet treatment technique requirements). This page includes information on public notification requirements and templates for issuing public notices, as well as translations and FAQs for effective communication with partners and the public.

[Fact Sheets & Best Management Practices](#)

Key Resources

- [Drinking Water Data Online](#)
- [For Consumers](#)
- [Site Map](#)

RESOURCES FOR OPERATORS

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www.healthoregon.gov/dwp

DATA FOR EACH SYSTEM ON-LINE

**Oregon Public Health**
Drinking Water Data Online



[Introduction](#) : [Data Search Options](#) : [Data Search Options](#)



Drinking Water Data Online

Welcome to **Data Online**, the data access site for [Oregon Drinking Water Services](#).

Here you can access a fair amount of data on public drinking water systems in Oregon. You can find data on chemical testing, contacts, violations, enforcements, public notices, and basic system information.

The [Search Options](#) page explains many of the data pages that are available. Use the [Water System Search](#) system by water system ID number, name, or location.

Info by County

Data shown here are "live" data. That means they're as current as the reports we have in our system. This is the same data that Drinking Water Services (DWS) staff see and use. If something is missing, that usually means it has not been reported to us or we have not entered it yet. If you (water system personnel, county staff, lab staff, etc.) find a report is missing, please forward a comment to us at:
DWS, PO BOX 14350, Portland, OR 97293.

For questions or updates regarding water system sampling, inventory, or compliance, please contact Drinking Water Services at 971-673-0405 or Info.DrinkingWater@odhsoha.oregon.gov.

See the [Contact Us](#) page on the main Drinking Water site for more contact options.

Information for all water systems:

[Water System Inventory](#) :: [Water System Surveys](#) :: [Outstanding Performers](#) :: [Treatment Plant Inspections](#) :: [Treatment](#) :: [Plan Reviews](#)
[Alerts](#) :: [Violations](#) :: [Compliance & Enforcement](#) :: [Deficiencies](#) :: [System Scores](#) :: [Exceedances](#) :: [Public Notices](#)
[Water Advisories](#) :: [Contact Reports](#) :: [Cyanotoxins](#) :: [PFAS](#) :: [Post-wildfire VOCs](#) :: [Fluoride](#)


[Introduction](#) :: [Data Search Options](#) :: [Water System Search](#) :: [DWS Home](#) :: [DWS Rules](#)


Need help? [Email Drinking Water Services](#) for assistance.

Staff/Partner Login

DATA FOR EACH SYSTEM ON-LINE

Water System Search (search using water system name or ID#)

**Oregon Public Health
Drinking Water Data Online**




[Introduction](#) :: [Data Search Options](#) :: [Water System Search](#) :: [DWS Home](#) :: [DWS Rules](#)

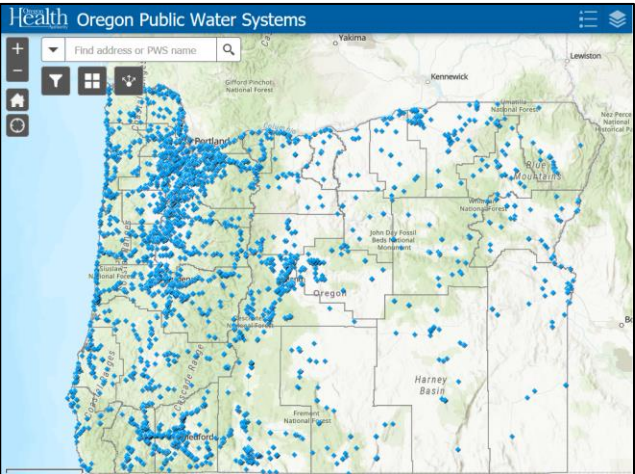
Water System Search

Search by water system name or number.

You can enter all or part of the water system's name. Only exact matches will be returned.

or Search by location:





or water system name or number in the map's search bar. You can also drag the map

1. Select Water System Search

2. Enter water system name (e.g., "Salem")

3. Click Search

Note: You also could have used WS ID #
and entered the ID# for Salem (00731)
or used the map to find a water system

DATA FOR EACH SYSTEM ON-LINE

Select the Water System by
Clicking on the PWS ID# 00731

Search results: 5 systems found. *Select a water system by clicking on its row (opens in a new tab).*

PWS ID	Water System Name	Regulating Agency	County Served	System Type	Activity Status
05564	BPA-SALEM SUBSTATION	POLK COUNTY	Polk	OVS	Inactive
95003	FORUM SALEM CAMPUS	DEPT OF AGRICULTURE	Marion	NTNC	Active
00779	SALEM MOBILE ESTATES/SHADY ACRES	MARION COUNTY	Marion	C	Active
00731	SALEM PUBLIC WORKS	REGION 1	Marion	C	Active
00768	SUBURBAN EAST SALEM WD	REGION 1	Marion	C	Active

OR41 00731 SALEM PUBLIC WORKS Classification: COMMUNITY

Contact: DWAYNE BARNES Phone: 503-588-6483 [View on Map](#)
PO BOX 14300 County: MARION
SALEM, OR 97309 Activity Status: ACTIVE -- [History](#)
Population: 199,820 Number of Connections: 55,970
Operating Period: January 1 to December 31 Regulating Agency: [REGION 1](#)
[Certified Operator\(s\)](#) Owner Type: LOCAL GOVERNMENT
Required: Y Licensed By: N/A
Distribution class: 4 Approved Drinking Water Protection Plan: No
Treatment class: 3 Source Water Assessment: Yes
Filtration Endorsement Required: No Last Survey Date: [Jul 25, 2023](#) - [Outstanding Performer!](#)

General
Information

Sources

Facility ID	Facility Name - Well Logs	Activity Status	Availability	Source Type
EP-A	EP FOR GEREN ISLAND (ALDERSGATE)	A		SW
SRC-AA	NORTH SANTIAM RIVER	A	Permanent	SW
SRC-AB	GEREN ISLAND EAST WELL - L75842	A	Permanent	GU
SRC-AC	GEREN ISLAND WEST WELL - L75839	A	Permanent	GU
SRC-AD	I.G. / ROUGHING FILTER #1	A	Seasonal	GU
EP-B	EP FOR ASR WELLS	A		GW
SRC-BA	ASR WELL #1 - L82685	A	Seasonal	GW
SRC-BB	ASR WELL #2 - L82688	A	Seasonal	GW
SRC-BC	ASR WELL #4 - L10522	A	Seasonal	GW
SRC-BD	ASR WELL #5 - L16342	A	Seasonal	GW
EP-C	EP FOR HEMLOCK WELL	I		GW
SRC-CA	HEMLOCK WELL - L62600	I	Emergency	GW

[Find Purchasers/Sellers](#)

Sources

Treatment

Facility ID	Facility Name	Filter Type	Giardia Removal Credit	Treatment Process	Treatment Objective
WTP-A	TP FOR GEREN ISLAND	SLOW SAND	2.0-log	FILTRATION, SLOW SAND HYPOCHLORINATION, POST PH/ALKA ADJ-SODA ASH OZONATION, PRE ACT. CARBON, PWD - CYANOTOXINS	PARTICULATE REMOVAL DISINFECTION CORROSION CONTROL DISINFECTION OTHER

Treatment

System
Classification



OR41 00731

SALEM PUBLIC WORKS

Classification: COMMUNITY

Contact: DWAYNE BARNES
PO BOX 14300
SALEM, OR 97309

Population: 199,820

Operating Period: January 1 to December 31

Certified Operator(s)

Required: Y

Distribution class: 4

Treatment class: 3

Filtration Endorsement Required: No

Phone: 503-588-6483

County: MARION

Activity Status: ACTIVE -- [History](#)

Number of Connections: 55,970

Regulating Agency: [REGION 1](#)

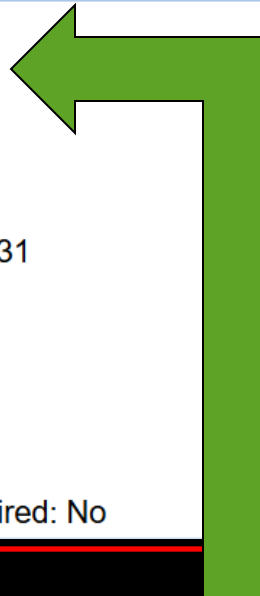
Owner Type: LOCAL GOVERNMENT

Licensed By: N/A

Approved Drinking Water Protection Plan: No

Source Water Assessment: Yes

Last Survey Date: [Jul 25, 2023](#) - [Outstanding Performer!](#)



All written correspondence goes to this person (e.g.,
violation notices, general mailings, etc.)

View a list of Certified Operators



Oregon Public Health Drinking Water Data Online		
Introduction :: Data Search Options :: WS Name Look Up :: WS ID Look Up :: DWS Home :: Quick Data Links		
OR41 00731	SALEM PUBLIC WORKS	Classification: COMMUNITY
Contact:	SOPHIA HOBET 1410 20TH ST SE BLDG 2 SALEM, OR 97302	Phone: 503-588-6483 County: MARION Activity Status: ACTIVE - History Number of Connections: 51,112 Regulating Agency: REGION 1 Owner Type: LOCAL GOVERNMENT Licensed By: N/A Approved Drinking Water Protection Plan: No Source Water Assessment: Yes Last Survey Date: Aug 23, 2011
Population: 189,000		
Operating Period: January 1 to December 31		
Certified Operator(s)	Required: Y Distribution class: 4 Treatment class: 3 Filtration Endorsement Required: No	

More information for this water system:

SDWIS ID 3906

[System Info](#) :: [Report for Lenders](#) :: [Alerts](#) :: [Violations](#) :: [Compliance & Enforcement](#) :: [Contacts & Advisories](#) :: [Site Visits](#) :: [Public Notice](#)

[Coliform Summary](#) :: [Coliform Results](#) :: [Coliform Schedules](#) :: [LT2](#) :: [GW/GWUDI Source Details](#) :: [Plan Review](#) :: [Annual Fee](#)

[Chemical Summary](#) :: [Chemical Results](#) :: [Chemical Schedules](#) :: [Chemical Schedule Summary](#) :: [Arsenic RAA](#) :: [Cyanotoxins](#) :: [PFAS](#)

[Lead & Copper](#) :: [Corrosion Control \(LCR\)](#) :: [DBP Sample Sites](#) :: [FANLs](#) :: [MRDL](#) :: [GWR 4-Log](#) :: [Turbidity](#) :: [SWTR](#) :: [LRAA](#)

2010	Jun 27, 2011	Jun 27, 2011
2009	Jun 29, 2010	Jun 29, 2010
2008	Jun 28, 2009	Jun 28, 2009
2007	Jun 04, 2008	Jun 04, 2008
Cross Connection Annual Summary Reports (Last 3 Records)		
Ordinance Received	Ordinance Status	ASR Received
Yes	Final	2011 2010 2009

For further information on this public water system, click on the area of interest below:

[System Info](#) :: [Report for Lenders](#) :: [Alerts](#) :: [Violations](#) :: [Enforcements](#) :: [Contacts](#) :: [Site Visits](#) :: [Public Notice](#) :: [Plan Review](#)
[Coliform Summary](#) :: [Coliform Results](#) :: [Coliform Results before 2005](#) :: [Sampling Schedule for Coliform](#)
[Chemical Source Summary](#) :: [Local Chemical Results](#) :: [Flow Point Details](#) :: [Single Analysis Results](#)
[Chemical Schedule Summary](#) :: [Chemical Schedule Details](#) ::
[Lead & Copper](#) :: [Corrosion Control/LCR](#) :: [Nitrates](#) :: [Arsenic](#) :: [Radionuclides](#)
[DBPs](#) :: [TOD & Aesthetics](#) :: [DBP/TOD/Biomass/Chlorine Monitors](#) :: [FANLs](#) :: [MRDL](#) :: [Turbidity](#) :: [SWTR](#) :: [RAA](#)

Information by county:

[Inventory](#) :: [Surface Water Systems](#) :: [Water System Surveys](#) :: [Outstanding Performance](#) :: [Plan Reviews](#) :: [System Scores](#) ::
[Alerts](#) :: [Violations](#) :: [Open Enforcements](#) :: [Significant Deficiencies](#) :: [Cross Connection ASRs](#) :: [Treatment Plant Inspections](#)

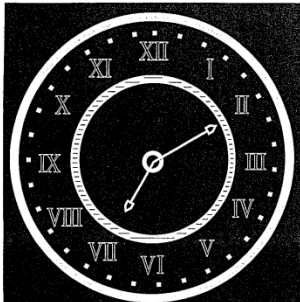
[Inventory List](#) for all Oregon Drinking Water Systems in Excel or printable screen format:
[Web Help](#) :: [Tools for Laboratories](#)

[Introduction](#) :: [Data Search Options](#) :: [WS Name Look Up](#) :: [WS ID Look Up](#) :: [DWP Home](#)

1. Alerts, Violations, & Compliance
2. Contacts, Advisories, & Public Notices
3. Site Visits
4. Plan Review
5. Coliform and Chemical Sampling Schedules
6. Sampling Results

MORE QUESTIONS?

- Call your technical services contact at the State.
State Drinking Water Services
 - General Info: (971) 673-0405



TIMELESS
TECHNOLOGY
FOR
MODERN
APPLICATIONS

Slow Sand Filtration Workshop

October 27-30, 1991
New England Center
University of New Hampshire
Durham, New Hampshire

Sponsored by
American Water Works Association
and the University of New Hampshire



Astoria, OR 5 MGD plant (photo taken by Frank Wolf)