State of Ohio Class A Drinking Water Operator Certification Program

Session Two:
Water Treatment; Chlorine; Water Usage; Chlorine Testing; Softening; Filters & Iron Removal

This course includes content developed by the Ohio Environmental Protection Agency, the Pennsylvania Department of Environmental Protection, the Indiana Department of Environmental Management, California State University at Sacramento, and 360water, Inc.

Project funded by the USEPA.

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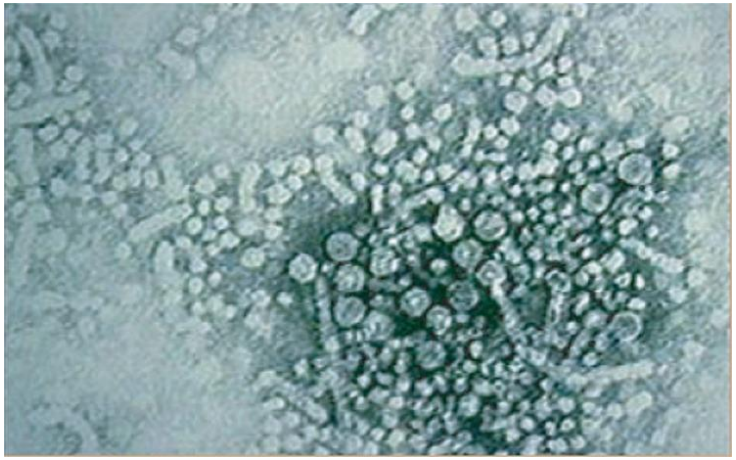
Pathogens in Water

There are two main types of organisms that may be present in water…

Bacteria



Viruses

Both are too small to see with the naked eye and can make people sick

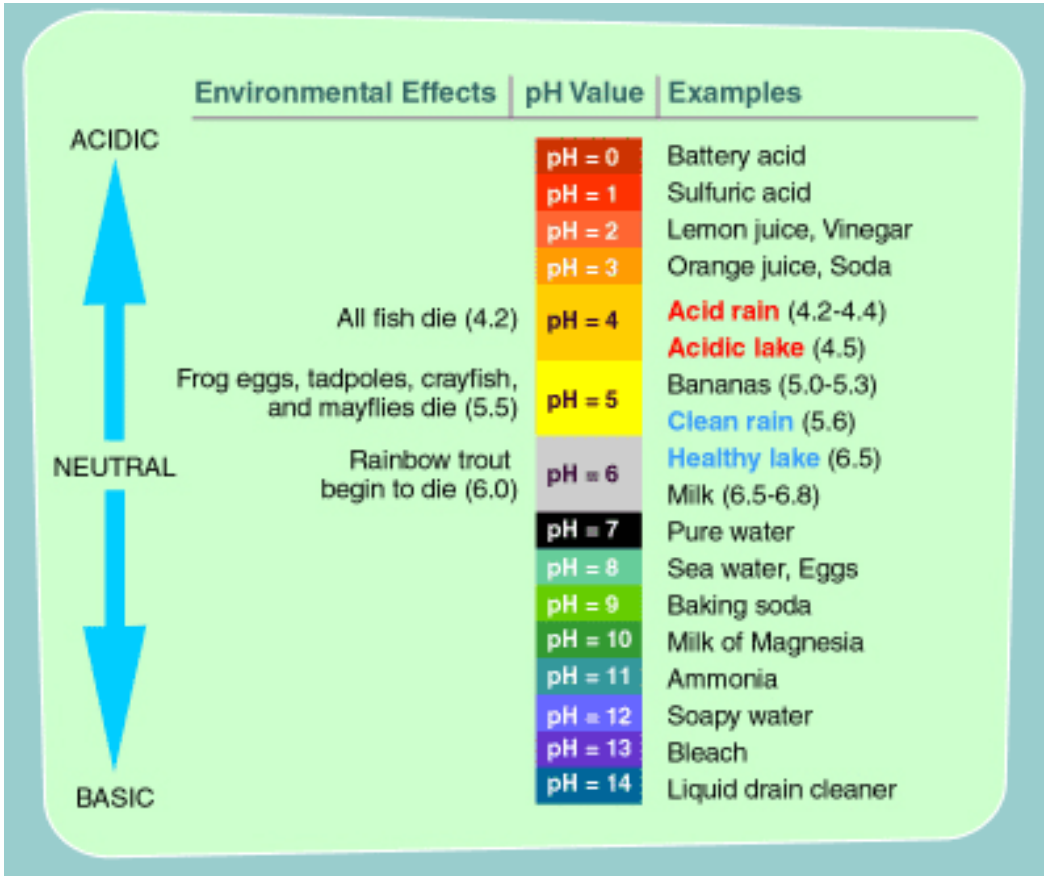
What is Total Coliform Bacteria?

- Common in the environment
- Generally not harmful
- Indicator used to determine if water may be contaminated with other potentially harmful organisms
- A relatively easy, quick, and inexpensive test

What is Total Coliform Bacteria?...*continued…*

- If a Total Coliform bacterial sample tests positive, the laboratory is required to test further for fecal Coliform and/or *E. coli*, which are bacteria whose presence indicates that the water may be contaminated with human or animal wastes.
- Microbes in these wastes can cause short-term effects, such as diarrhea, cramps, nausea, headaches, and other symptoms
- They may pose a special health risk for infants, young children, the elderly, and people with severely compromised immune systems

pH Scale



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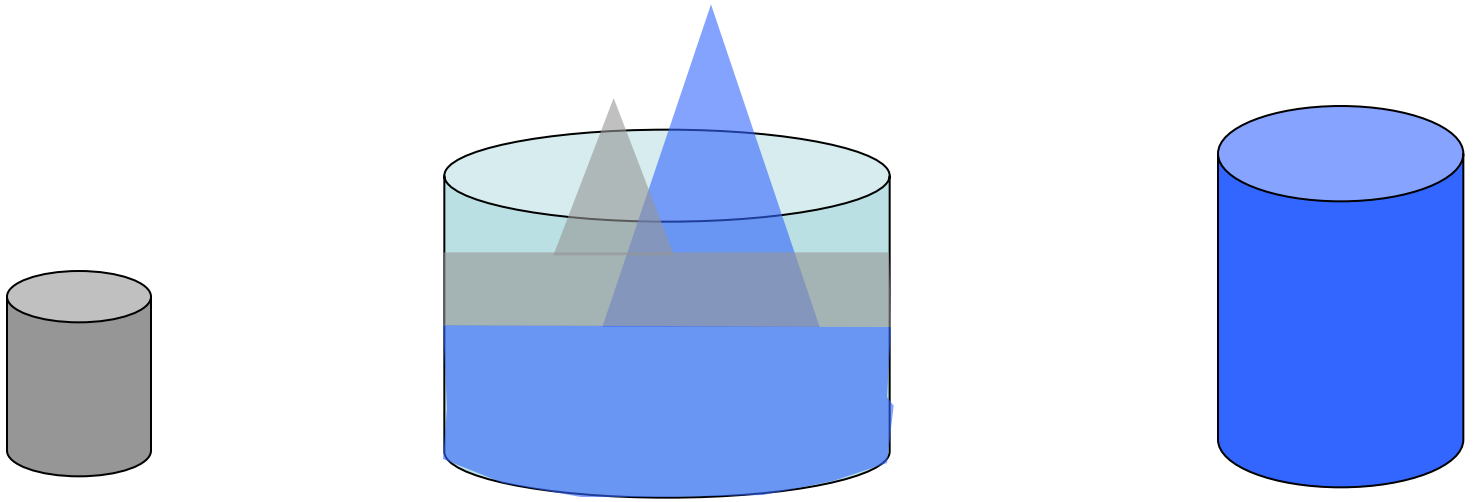
Disinfection

- Chlorine (unscented and NSF-approved) is the most common disinfectant used
- ***5.25% Sodium Hypochlorite*** is recommended
- Wear goggles, gloves, boots, and an apron when handling

How to Mix a Chlorine Solution



1 Gallon of 5.25% Sodium Hypochlorite

5 Gallons Hypochlorite Solution

4 Gallons of Water

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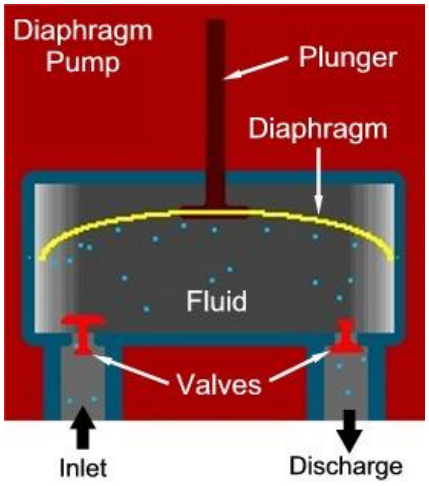
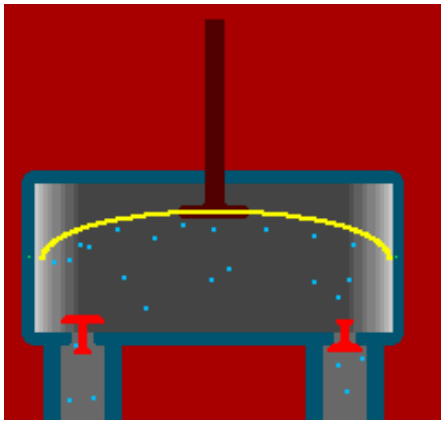
Metering Pumps

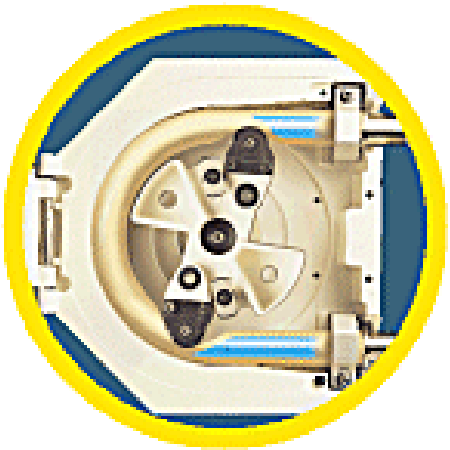
- Metering Pumps are used as feed pumps to apply various disinfectants to the water. The most common Metering Pump is a ***Diaphragm Pump***.
- These pumps contain a Diaphragm with at least one suction valve and one discharge valve
- The Diaphragm takes in fluid when it moves away from the valves and pushes it out when it moves toward the valves





Metering Pumps

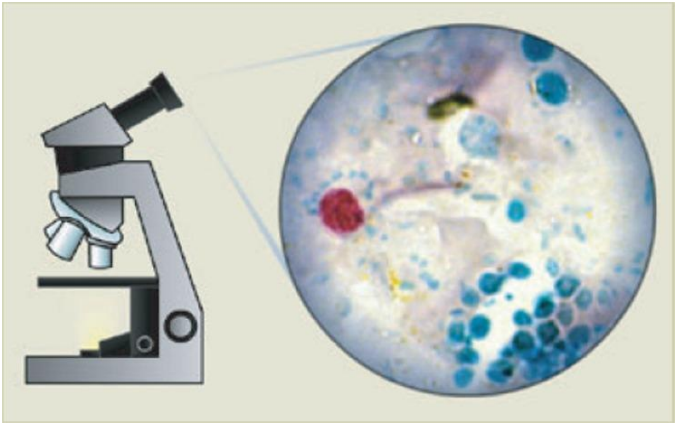
- Some metering pumps are ***Peristaltic Pumps***
- These pumps contain a roller that moves the water by pushing it from the outside, thus not contaminating the water
- Easier to maintain than a Diaphragm Pump



Water-Borne Diseases

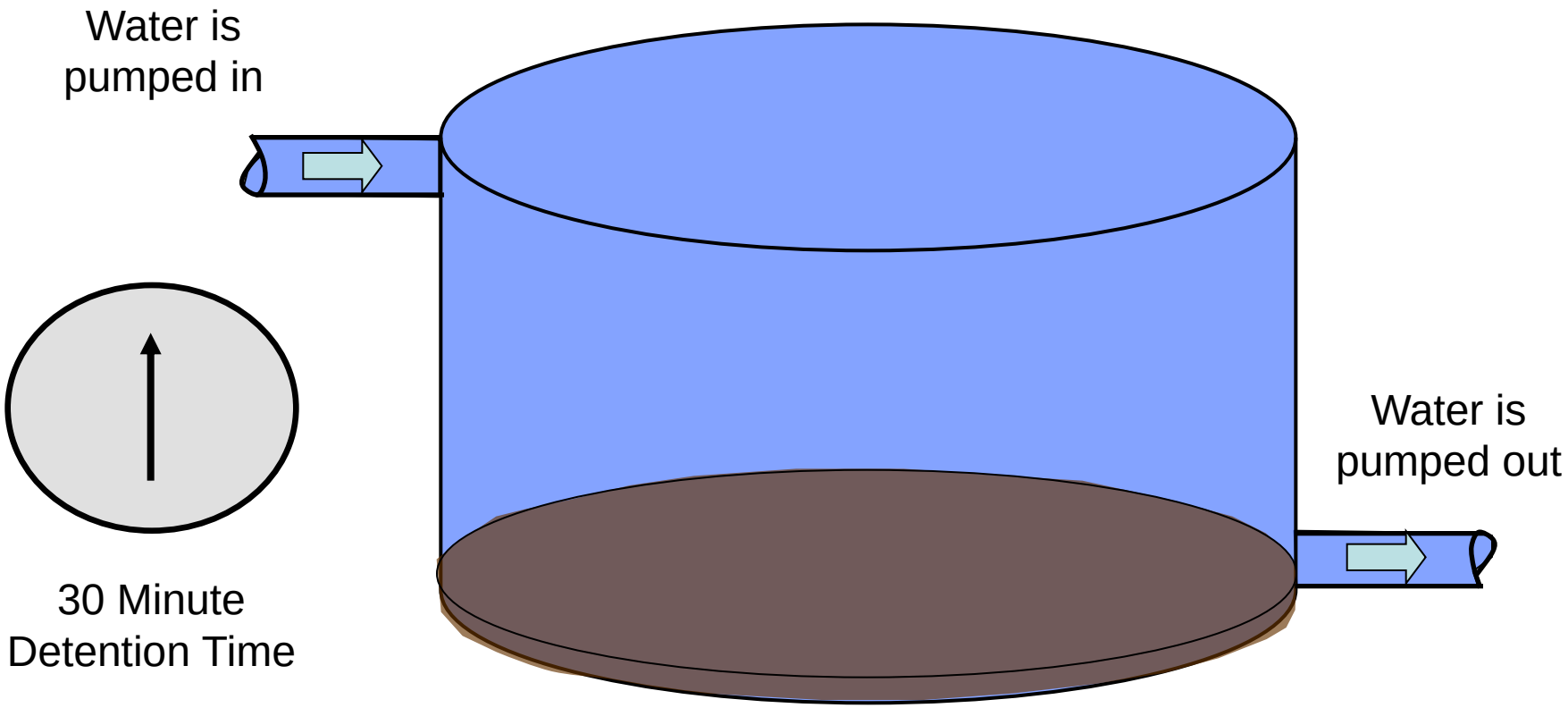
Not all of the microorganisms in water are bad, but some varieties can cause serious diseases such as:

- Amoebic Dysentery
- Typhoid Fever
- Cholera
- Giardiosis
- Cryptosporidiosis



All of these organisms are too small to see with the naked eye. To see if they are present, a ***Total Coliform*** test is performed. If the test is positive, then the water must be disinfected with ***Chlorine*** to kill the disease-causing organisms. ***A 30 minute contact time is required to inactivate or kill pathogens with chlorine.***

Detention Time



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Chlorination

- When chlorine is added to water, it does not destroy contaminants until enough is added
- When adding chlorine to the water supply, you should use the ***Breakpoint Method***. This ensures that enough chlorine is added to kill all harmful contaminants.
- Let's take a look at how the Breakpoint Method works…

Definitions

- *Residual Chlorine:* The concentration of chlorine present in water after the chlorine demand has been satisfied
- *Free Residual:* The amount of uncombined chlorine remaining in the water after reactions with inorganic and organic material
- *Combined Residual:* The amount of chlorine residual present after combining with inorganic and organic material
- *Total Chlorine Residual:* The sum of the Free and Combined Chlorine Residuals

Definitions, *continued…*

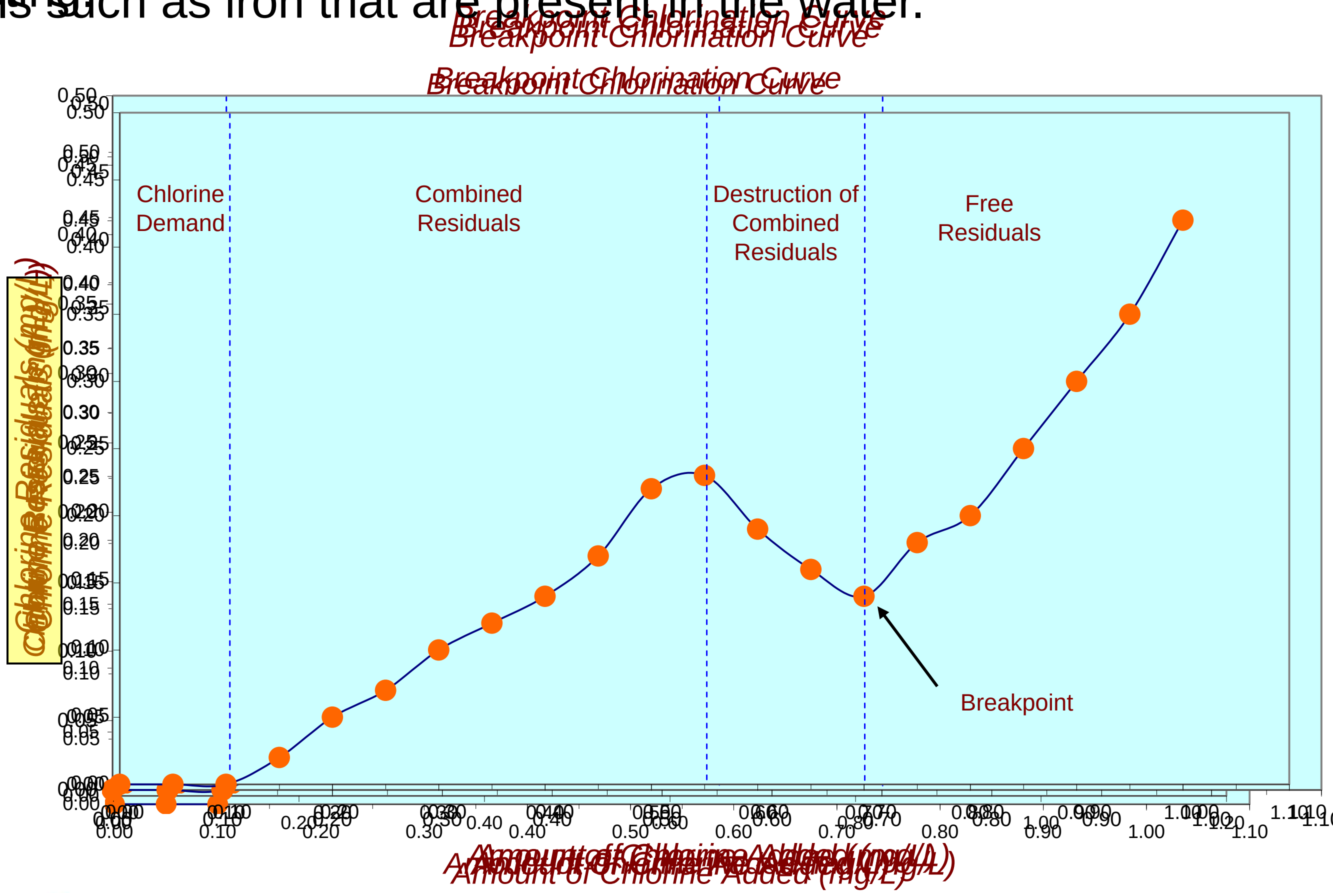
- *Chlorine Demand:* The amount of chlorine needed to attain a Chlorine Residual
- *Chlorine Dose:* The amount of chlorine needed to satisfy the Chlorine Demand plus the amount of Chlorine Residual needed for disinfection

Now, if we add even more chlorine until we reach a concentration of 0.55 ...

Chlorine Residual ... ***Free Residuals*** ... ***Combined*** ***Residuals*** ... ***Breakpoint***

... well because of compounds that attach to it.

... minerals such as iron that are present in the water.



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Chlorination

More points on the chlorination process…

- The ***Total Chlorine Residual*** is the Combined Residual plus the Free Residual

  Total Chlorine Residual = Combined Residual + Free Residual

- The ***Chlorine Dose*** is the Chlorine Demand plus the Chlorine Residual

  Chlorine Dose = Chlorine Demand + Chlorine Residual

Chlorination Regulations

The Ohio EPA mandates that water systems maintain, at representative points throughout the distribution system, one of the following:

- A Free Residual reading of 0.2 mg/L, ***OR***
- A Combined Residual of 1.0 mg/L

For example, if your Chlorine Residual Reading (the Total Reading) is 1.5 mg/L and your Free Residual Reading is 0.5 mg/L, then your Combined Residual Reading is:

Total Residual Reading – Free Residual Reading = Combined Residual

1.5 mg/L – 0.5 mg/L = 1.0 mg/L

Therefore, you have met the regulation

Chlorine Feed Rate

Now that we know how to determine the Chlorine Dosage for a chlorination treatment, we can determine the speed at which the chlorine must be injected into the water supply by a feed pump to achieve the correct dosage. This pump's output is calculated in ***Gallons Per Day***, or GPD.

To determine the pump output rate, we use the formula below:

GPM ***mg/L***

$$\text{Feed Pump Output} = \frac{\text{Well Pump Output Rate} \times \text{Chlorine Dosage} \times 1{,}440}{\text{Chlorine Solution Concentration}}$$

mg/L

The Chlorine Solution Strength is the concentration of the chlorine solution that you are using

Example

Here is an example of how to calculate the rate a pump must inject chlorine into the water to achieve the correct Chlorine Dosage.

Assume the Well Pump is pumping water at a rate of ***7 Gallons Per Minute (GPM),*** the required Chlorine Dosage was determined by the Breakpoint method to be ***1 mg/L***, and the concentration of the chlorine solution you are using is ***10,000 mg/L***.

7 GPM ***1 mg/L***

$$\text{Feed Pump Output} = \frac{\text{Well Pump Output Rate} \times \text{Chlorine Dosage} \times 1{,}440}{\text{Chlorine Solution Concentration}}$$

$$\frac{7 \text{ GPM} \times 1 \text{ mg/L} \times 1{,}440}{10{,}000 \text{ mg/L}}$$

= 1.008 Gallons per Day

Water Produced Per Capita Per Day

The Daily Usage value that was determined previously can be used it to calculate another value, the ***Water Produced Per Capita Per Day (gpcd)***

To calculate this value, divide the ***Daily Usage*** by the ***Population***

$$\text{Gallons Produced Per Capita Per Day} = \frac{\textit{Daily Usage}}{\textit{Population}}$$

Water Produced Per Capita Per Day

We can divide these two numbers on our calculator to determine the Water Produced Per Capita Per Day, which is ***204 Gallons of Water Per Person***.

Our analysis was ***50,998.8 Gallons*** per Day for ***250 People***. The formula is shown below.

$$\text{Gallons Produced Per Capita Per Day} = \frac{\textit{Daily Usage}}{\textit{Population}}$$

$$\frac{\textit{50,998.8 Gallons of Water Per Day}}{\textit{Population}}$$

$$\frac{\textit{50,998.8 Gallons of Water Per Day}}{\textit{250 People}}$$

$$= 204\ \textit{gpcd}$$

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Water Usage Statistics

Sample listing of several categories (for full list, check the Ohio EPA website):

Camps/Parks/Recreation/Travel

- Golf Course (per person): 5 gallons/day
- Recreational Vehicle with Water & Sewer Hookup (per space): 125 gallons/day

Employment Facilities

- Factories, no Showers (per person): 25 gallons/day
- Factories with Showers (per person): 35 gallons/day

Water Usage Statistics, *continued…*

Residential Communities

- Apartment (One Bedroom): 250 gallons/day
- Mobile Homes (per unit): 300 gallons/day

Schools

- Elementary/Day Care (per person): 15 gallons/day
- High & Jr. High (per person): 20 gallons/day

Why Chlorination is Necessary...

- To kill or inactivate pathogens

- The Ohio EPA requires all community and major non-community water systems to maintain a Chlorine Residual

This is a sample Chlorine meter, or DPD kit

Free Chlorine Testing at the Pump House or Entry Point of the Distribution System

1. Run the sample tap for 2-5 minutes or longer, to ascertain that chlorine from the main water supply is flowing from the sample tap
2. Reduce the flow from the tap
3. Fill a clean 10 mL test cell to the line with water from the sample tap
4. Remove the colorimeter's protective cap
5. Wipe the sample cell so that it is dry and clean
6. Place the cell into the well on the colorimeter, making sure that the index mark faces to the front of the colorimeter
7. Cover the cell with the instrument's cap
8. Press "ZERO"
9. Wait for the colorimeter to register "0.00" on the LCD display

Free Chlorine Testing at the Pump House or Entry Point of the Distribution System, *continued…*

10. Remove the cell from the colorimeter
11. Fill another sample cell with fresh sample to the 10 mL line
12. Immediately add one Free Chlorine DPD powder packet to sample.
13. Cap the cell and shake it for 10 seconds
14. Immediately place the cell in the colorimeter's well
15. Cover the cell with the instrument's cap
16. Press "READ"
17. Wait for the colorimeter to show the Free Chlorine results in mg/L
18. Record the results as Free Chlorine in mg/L

Total Chlorine Testing at the Pump House or Entry Point of the Distribution System

1. Run the sample tap for 2-5 minutes or longer, to ascertain that chlorine from the main water supply is flowing from the sample tap
2. Reduce the flow from the tap
3. Fill a clean 10 mL test cell to the line with water from the sample tap
4. Remove the colorimeter's protective cap.
5. Wipe the sample cell so that it is dry and clean
6. Place the cell into the well on the colorimeter, making sure that the index mark faces to the front of the colorimeter
7. Cover the cell with the instrument's cap
8. Press "ZERO"
9. Wait for the colorimeter to register "0.00" on the LCD display
10. Remove the cell from the colorimeter

Total Chlorine Testing at the Pump House or Entry Point of the Distribution System, *continued…*

11. Fill another sample cell with fresh sample to the 10 mL line
12. Immediately add one Total Chlorine DPD powder packet to sample
13. Cap the cell and shake it for 10 seconds
14. On an accurate timer, time for 3-5 minutes
15. After 3-5 minutes place the cell in the colorimeter's well
16. Cover the cell with the instrument's cap
17. Press "READ"
18. Wait for the colorimeter to show the total chlorine results in mg/L
19. Record the results as Total Chlorine in mg/L
20. Calculate combined chlorine by subtracting Free Chlorine from Total Chlorine.
21. Record the calculated value as Combined Chlorine mg/L

Iron Removal

Requirements: OAC 3745-82-02

- New community water systems shall provide treatment for removal of iron to meet the secondary maximum contaminant level of 0.3 mg/L when the level of iron in water entering the water plant exceeds the secondary maximum contaminant level.

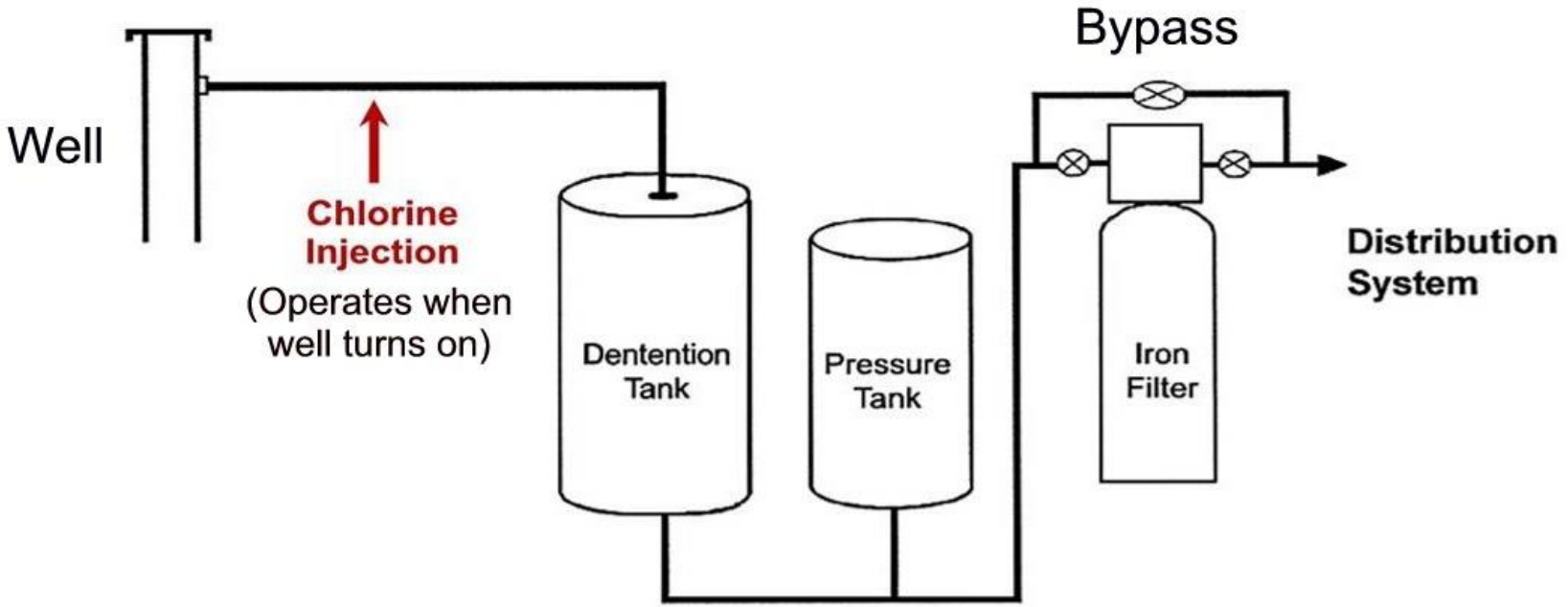
- Existing community water systems, which develop a new source, or change a source shall provide treatment for iron if the level at the entry point to the distribution system increases and exceeds the secondary maximum contaminant level.

Iron Removal, *continued…*

Treatment Methods

- Oxidation/Pressure Sand Filtration: oxidation (addition of Chlorine) followed by filtration is an acceptable means for iron removal
- Backwashing of the filtration unit is required after a pre-determined volume of water has been treated
- The volume of water treated depends upon the iron level of the raw water

Iron Removal Schematic



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Commercial Filters

If not flushed, a commercial filter could cause bacteria problems

Softener

Requirements:

- Ohio EPA does not require that water is softened. The acceptable level of hardness depends upon the experience and the requirements of the consumers.

- When softening is employed, a blended water having a finished hardness of 120 to 150 mg/L (7 to 9 grains) is recommended

Softener, *continued…*

Softening:

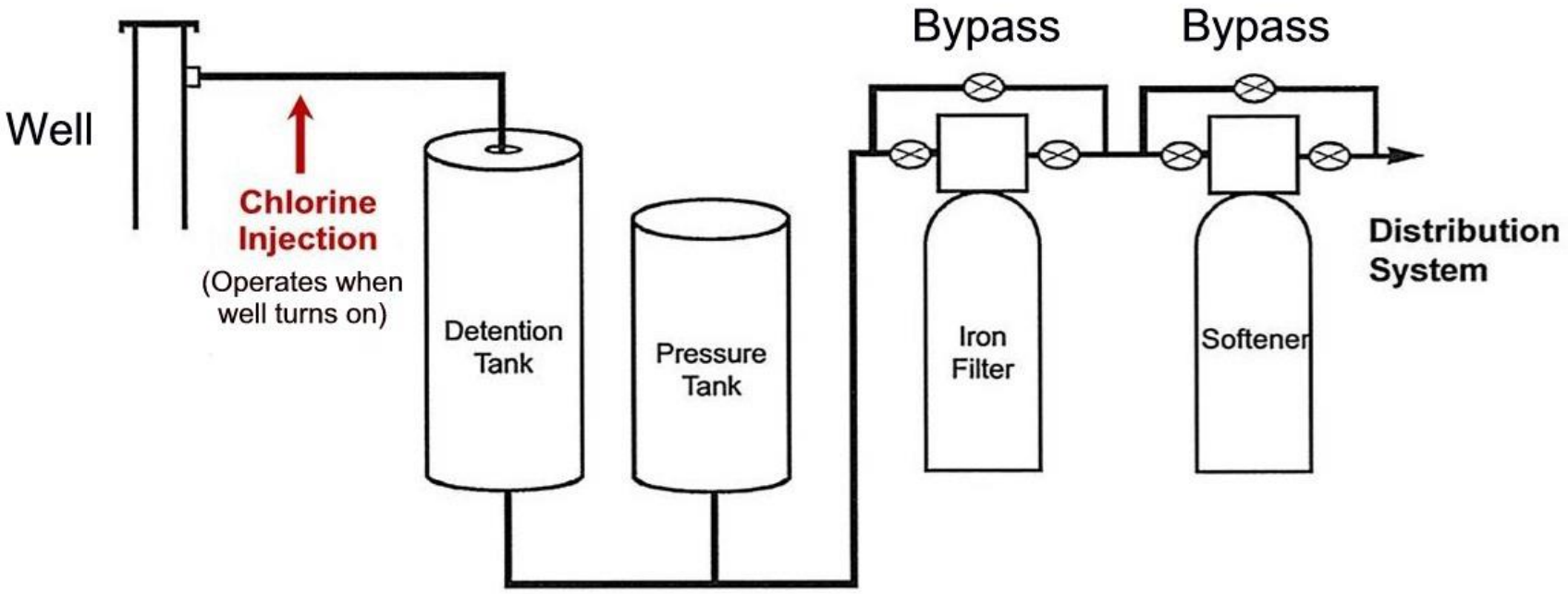
The Calcium and Magnesium ions that cause hardness in the water are exchanged for sodium ions in the salt-brine regenerated resin. Once the resin has been depleted of its exchange capacity, the ion exchange unit must be regenerated.

Regeneration:

There are four cycles in the regeneration process:

- Backwash cycle
- Regeneration cycle
- Slow rinse cycle
- Fast rinse cycle

Iron Removal and Ion Exchange Softening



SAMPLE MATH PROBLEM 1

Convert 23,000 gallons per day to million gallons per day:

$$\frac{23{,}000}{1{,}000{,}000} =$$

0.023 MGD

SAMPLE MATH PROBLEM 2

Convert 1,000,000 gpd to gpm:

$$\frac{1{,}000{,}000}{1{,}440} =$$

694 gpm

Recall that 1,440 = 24 x 60

SAMPLE MATH PROBLEM 3

Convert 0.0155 mg/L to µg/L:

0.0155 mg/L x 1,000 =

15.5 µg/L

SAMPLE MATH PROBLEM 4

Convert 1,350 µg/L to mg/L:

$$\frac{1{,}350}{1{,}000} =$$

1.35 mg/L

SESSION TWO SAMPLE QUESTIONS BEGIN NOW

SESSION TWO SAMPLE QUESTION

1. How often should operation data, such as flow rate, amount of water treated, dosage of chemical, and reservoir levels, be recorded?

   a. Twice a day
   b. Daily
   c. Weekly
   d. Monthly

b. Daily

SESSION TWO SAMPLE QUESTION

2. Which federal law regulates public water supplies?

a. Safe Drinking Water Act
b. Clean Water Act
c. Taft-Hartley Act
d. Standard Methods

a. Safe Drinking Water Act

SESSION TWO SAMPLE QUESTION

3. What is a commonly used indicator of possible health problems found in plants, soil, water, and the intestines of humans and warm-blooded animals?

   a. Viruses
   b. Coliform bacteria
   c. Intestinal parasites
   d. Pathogenic organisms

b. Coliform bacteria

SESSION TWO SAMPLE QUESTION

4. What are disease-producing bacteria called?

a. Parasites
b. New strain
c. Sour-type
d. Pathogens

d. Pathogens

SESSION TWO SAMPLE QUESTION

5. Which of the following should an operator investigate first when well pump and control problems occur?

a. Depth of supply
b. Piping
c. Electricity
d. Water leaks

c. Electricity

SESSION TWO SAMPLE QUESTION

6. What is the purpose of a check valve?

a. Regulate the rate of flow through the discharge pipe
b. Act as automatic shutoff valve when the pump stops
c. Permit air to escape from the pipe
d. Prevent clogging of the suction line

b. Act as automatic shutoff valve when the pump stops

SESSION TWO SAMPLE QUESTION

7. What are the two most important safety concerns when entering a confined space?

a. Corrosive chemicals and falls
b. Bad odors and claustrophobia
c. Extreme air temperatures and slippery surfaces
d. Oxygen deficiency and hazardous gases

d. Oxygen deficiency and hazardous gases

SESSION TWO SAMPLE QUESTION

8. Which type of fire extinguisher should be used for fires with live electricity present?

a. Class A
b. Class B
c. Class C
d. Class D

c. Class C

SESSION TWO SAMPLE QUESTION

9. Chlorine Demand is satisfied at the point when . . .

a. The reaction of chlorine with organic and inorganic materials stops
b. Free chlorine residuals reach 2.5 mg/L
c. An odor of chlorine is present
d. Chlorine reaches the last tap

a. The reaction of chlorine with organic and inorganic materials stops

SESSION TWO SAMPLE QUESTION

10. What is the common test the Ohio EPA requires public water systems to conduct as an indicator to determine if the drinking water is contaminated with other potentially harmful organisms?

    a. Total Coliform bacteria
    b. Free Chlorine
    c. Total Chlorine
    d. Fecal bacteria

a. Total Coliform bacteria

Questions?

END OF SESSION TWO