

The Centers for Disease Control and Prevention's Vessel Sanitation Program is proud to bring to you the following session:

## Potable Water

While this presentation is primarily intended for cruise vessels under the jurisdiction of the Vessel Sanitation Program it may also be used by anyone who is interested in this topic.

This session should not be used as a replacement for existing interactive training but should be used as an adjunct to a comprehensive training program.



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# POTABLE WATER

## Vessel Sanitation Program 2007



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# Learning Objectives

- List pathogens that can cause waterborne illnesses
- List the common deficiencies in drinking water systems that can cause waterborne illnesses
- List the free halogen residuals required for production and distribution
- List the information required during documentation of maintenance, cleaning and disinfection of potable water tanks
- List the requirements for manual monitoring should the far point analyzer recorder fail

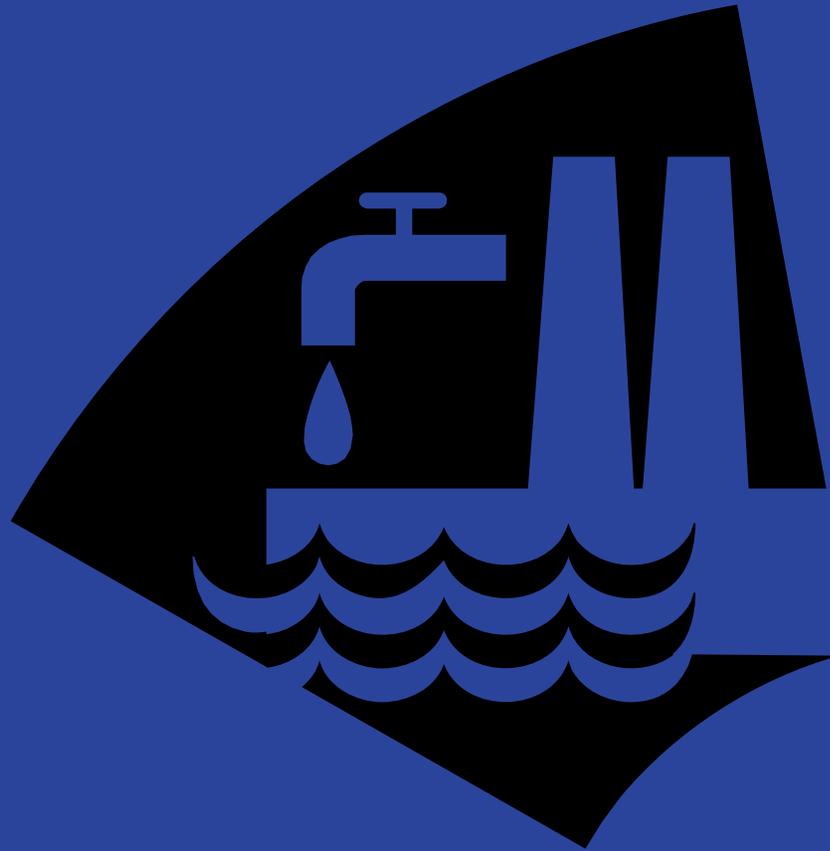


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# Potable Water Illnesses



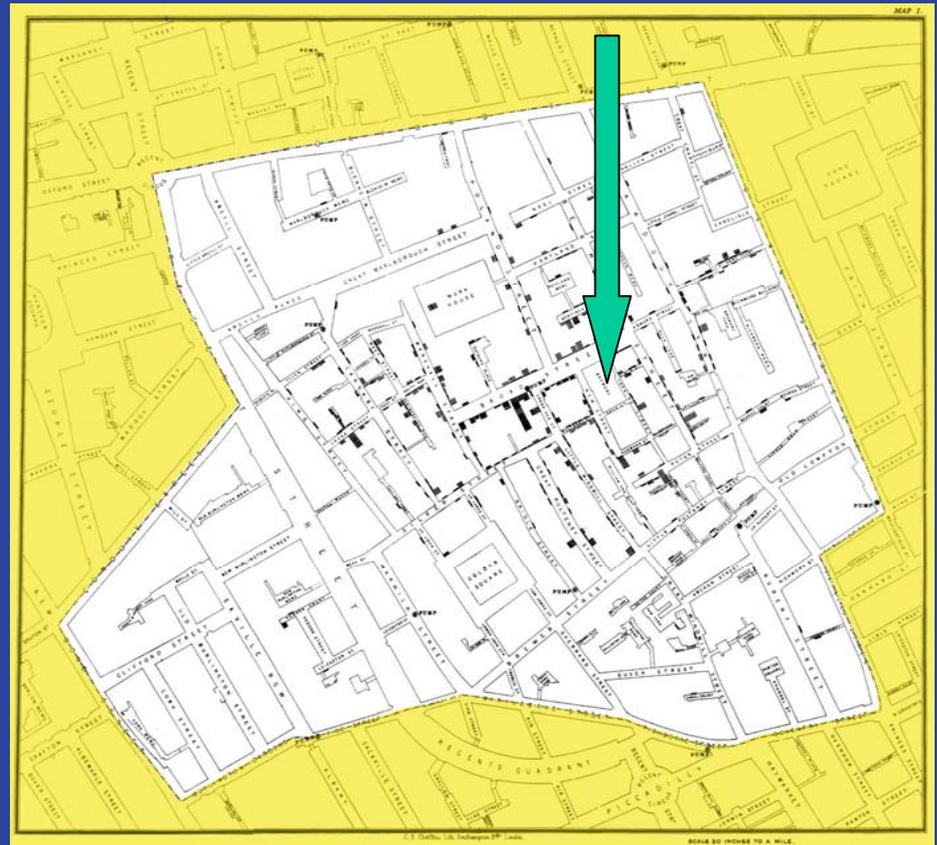
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# England

- Soho
- 1854
- Cholera
- >10,000 Dead



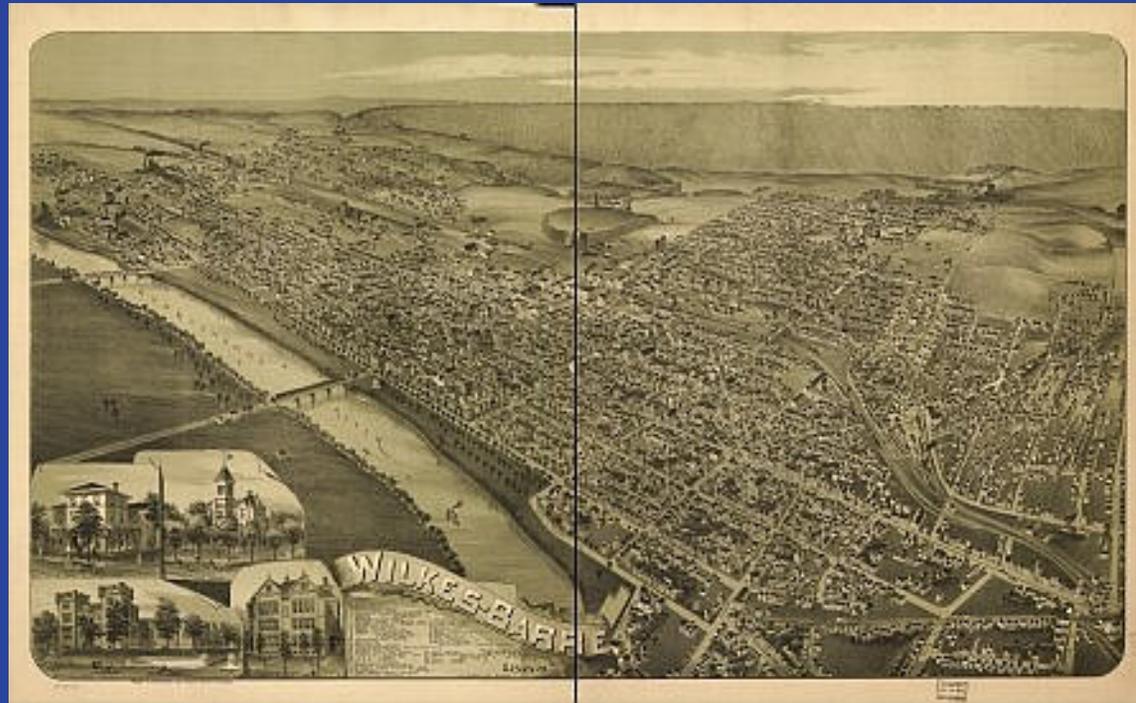
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# Pennsylvania

- Plymouth
- 1885
- Typhoid
- 1000 Sick

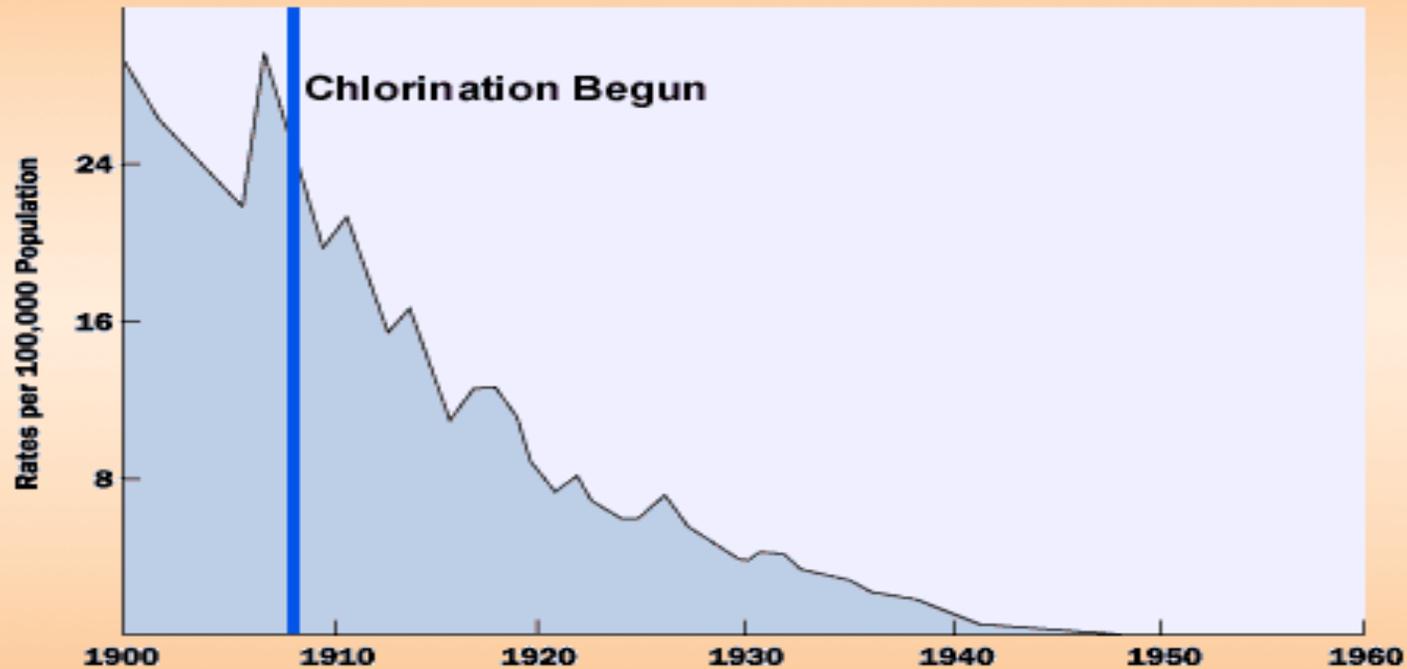


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## Death Rate for Typhoid Fever United States, 1900-1960



Source: U.S. Centers for Disease Control and Prevention, Summary of Notifiable Diseases, 1997.



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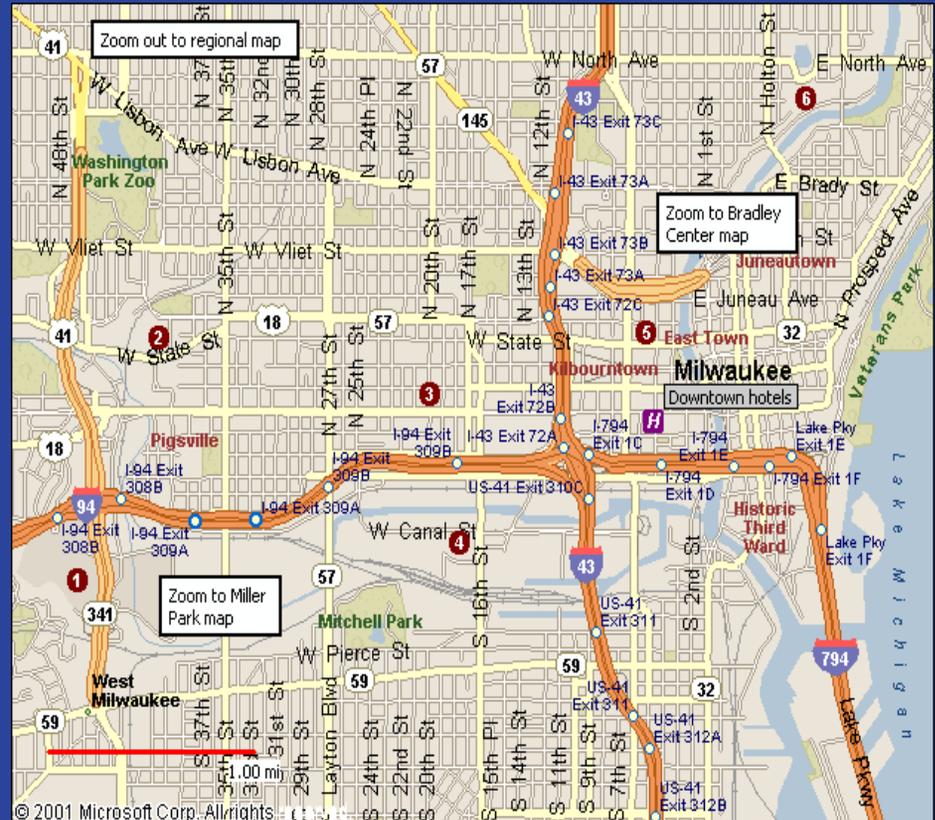
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# Wisconsin

- Milwaukee
- 800,000 Population
- Cryptosporidium
- 370,000 III
- 4,400 Hospitalized
- 40 Deaths (?)



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# Alabama

- 1992
- Seafood
- *Vibrio cholera*



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# Waterborne Illnesses

- Routes of Exposure
  - Ingestion
  - Respiration
  - Contact
- Pathogen Type
  - Bacteria
  - Viruses
  - Protozoa



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# Pathogens and Water

- Shigella species
- Giardia
- Cryptosporidium
- Vibrio cholerae
- Escherichia coli
- Legionella



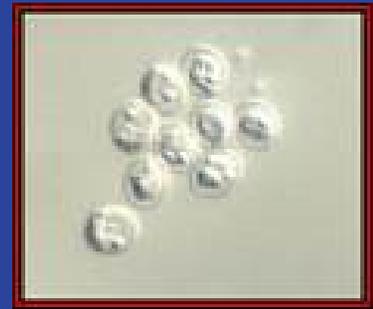
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# Cryptosporidium parvum

- Coccidian protozoa
- Reservoir-humans, cattle, and other domestic animals
- Water treatment optimization
  - Sedimentation, coagulation, filtration (0.1-1.0  $\mu\text{m}$ )
  - Boiling water 1 minute to eliminate oocysts



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# Vibrio cholerae

- Bacterial illness
- Humans are the reservoir
- Disinfection with chlorine very effective



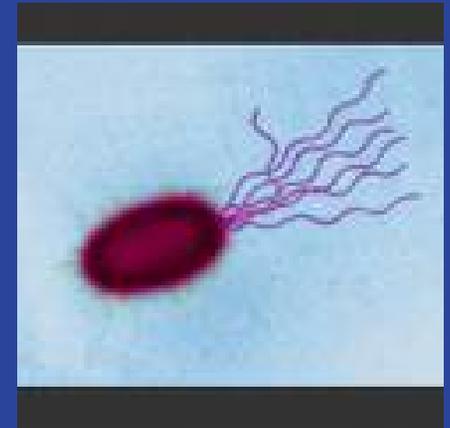
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# Escherichia coli

- Several important pathogenic strains based on serology and virulence
  - Enterohemorrhagic (EHEC)
  - Enteroinvasive (EIEC)
  - Enterotoxigenic (ETEC)
  - Enteroaggregative (EAaggEC)
  - Enteropathogenic (EPEC)
  - Diffuse adherent (DAEC)



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# Escherichia coli (EHEC)

- E. coli O157:H7
- Cattle primary reservoir
- Chlorination of water is an effective treatment for water



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# Escherichia coli (not EHEC)

- ID =  $10^8$ - $10^{10}$
- Humans primary reservoir
- Chlorination is an effective treatment of water

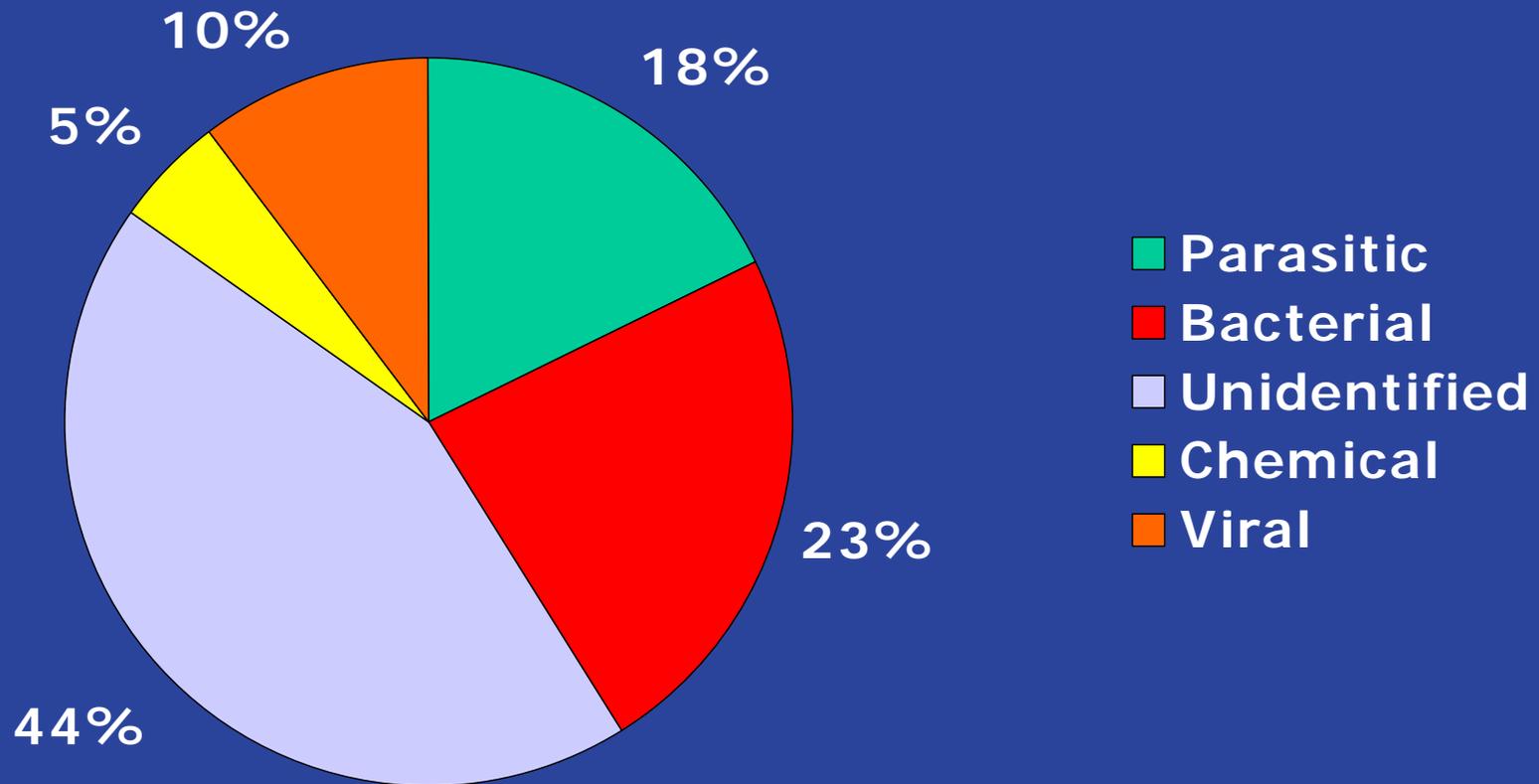


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## Waterborne Illness Associated with Drinking Water by Etiologic Agent- United States 1999-2000

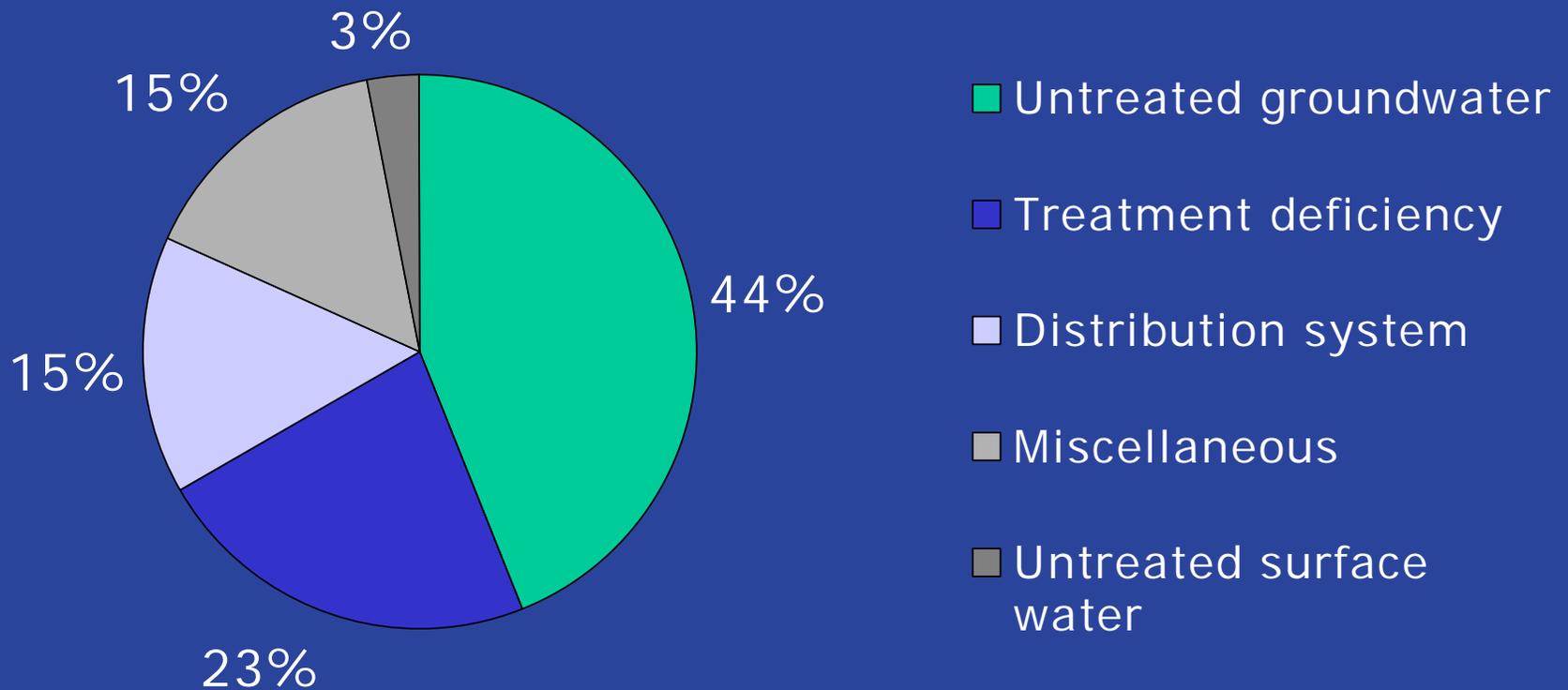


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# Waterborne Illness Associated with Drinking Water by Deficiency United States 1999-2000



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# POTABLE WATER

- Importance
- Water sources
- Water storage
- Water distribution
- Bacteriological testing (monitoring)



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# POTABLE WATER SOURCES

- Bunkered Water
  - Loaded from shore side
- Production Water
  - Evaporators
  - RO units



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# Bunkered Water

- Many different sources
  - Ground water
  - Surface water
  - Mixed ground & surface
  - Desalination



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# Bunkered Water

- Minimum Requirement
  - Must meet World Health Organization drinking water quality standards
  - Must have a recent water quality report on board



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# Bunkered Water

- Advantages
  - Large quantities
- Disadvantages
  - Variable quality
  - Expensive



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# Potable Water Filling



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# Bunker Hoses

- Storage
- Handling
- Connection Procedures
- Labeling



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# Hose Storage

- Hoses
  - No other use
  - Drained
  - Rolled up or hose reel
  - Capped or coupled together



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# Hose Storage



- Cabinet / Locker
  - Durable
  - Labeled
  - Easy to clean
  - Self draining
  - Elevated off of the deck
    - 45 cm (18 inches)



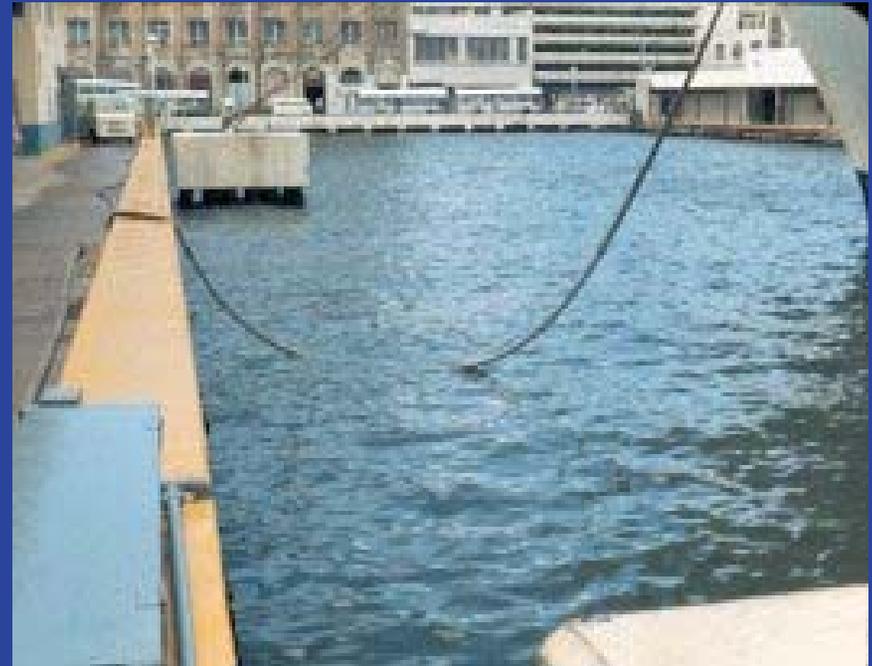
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# Handling

- Sanitary manner
  - Not in
    - Harbor
    - Standing water
  - Don't drag ends



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# Connection Procedures

(Recommended)

- Sanitize connections
  - 100 mg/L chlorine
- Flush shore side connection to waste
- Connect hose(s) to shore
- Flush to waste
- Connect to vessel



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# Potable Water Hose Labeling

- “potable water only” at connection ends



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# Production Water

- Advantages
  - Consistent quality
  - Unlimited supply
  - Low cost
- Disadvantages
  - Operate at sea only
  - Quantity limited

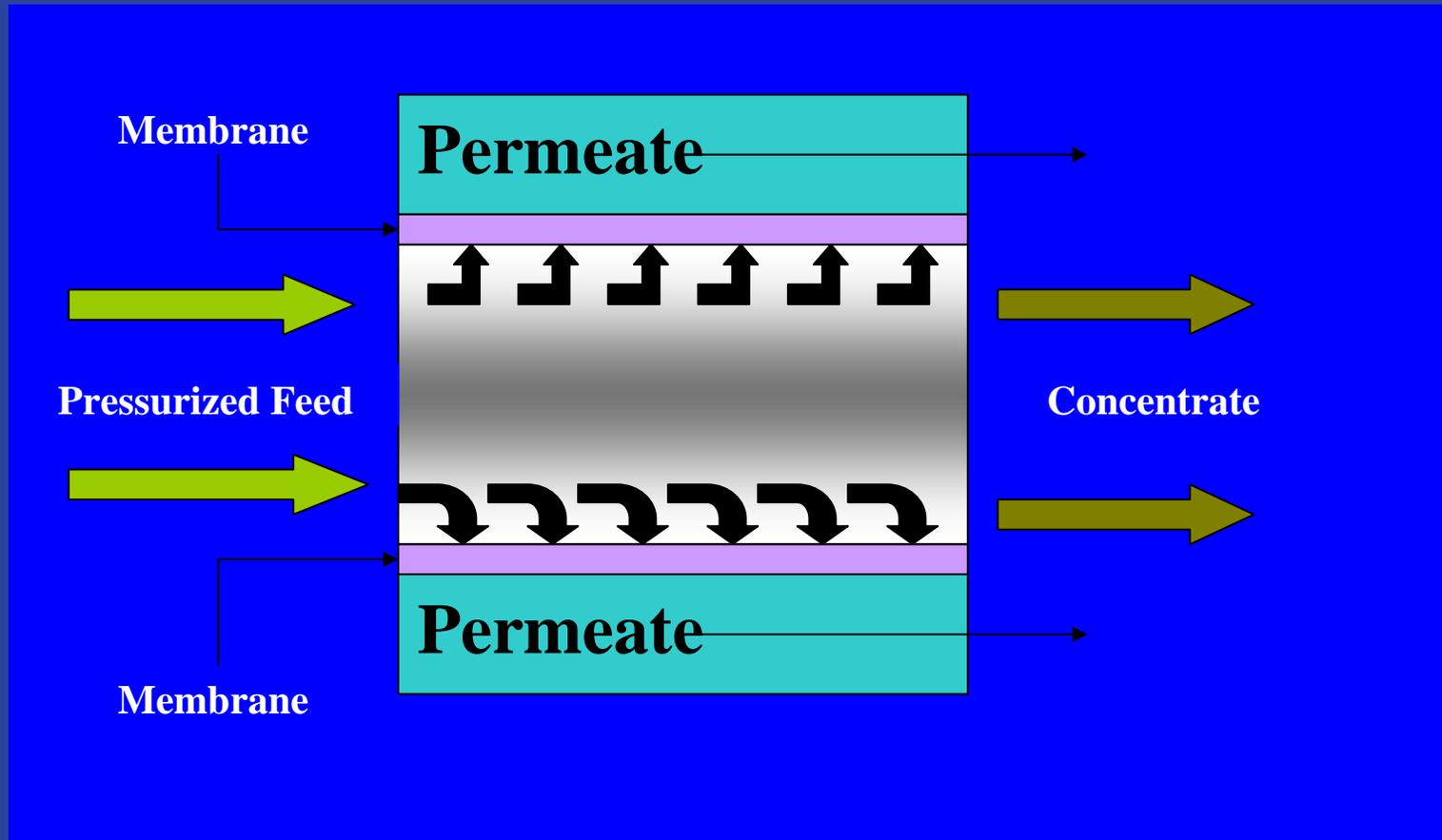


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# Reverse Osmosis (RO)



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# Producing Water in Port

- Allowed only if system cannot produce potable water



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# Treatment of Bunkered/Production Water

- Production
  - Halogenated to 2 mg/L (ppm)
  - Halogen level tested and recorded every 4 hours
- Bunkered
  - Halogenated to 2 mg/L (ppm)
  - Halogen level tested and recorded every 1 hour

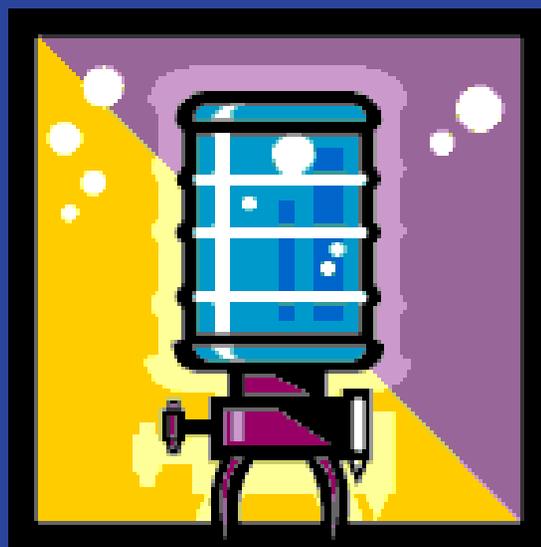


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# Potable Water Storage



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# Storage Facilities

- Tanks labeled
- Coatings approved
  - Documentation available on vessel
- Sample point
- Sanitary water depth determination
- Vent and overflow protected



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# Potable Water Tank Maintenance

- Every 2 years or every dry dock whichever is less
- **Detailed** records
  - Maintenance
  - Cleaning
  - Disinfection
    - Residual, contact time, flushing or dechlorination



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# Distribution System Water Disinfection



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# Water Disinfection Methods

- Methods
  - Boiling
  - Ultraviolet Light (U/V)
  - Ozone
  - Halogenation



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# Water Disinfection Ultraviolet Light

- Advantages
  - No taste/odor
  - No by-products
- Disadvantages
  - No residual



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# Water Disinfection

## Ozone

- Advantages
  - No taste/odor
  - No by-products
- Disadvantages
  - No residual



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# Water Disinfection

## Halogenation

### Chlorine and Bromine

- Advantages
  - Residual available
  - Easy to test for
  - Inexpensive test
- Disadvantages
  - Taste/odor
  - By-products



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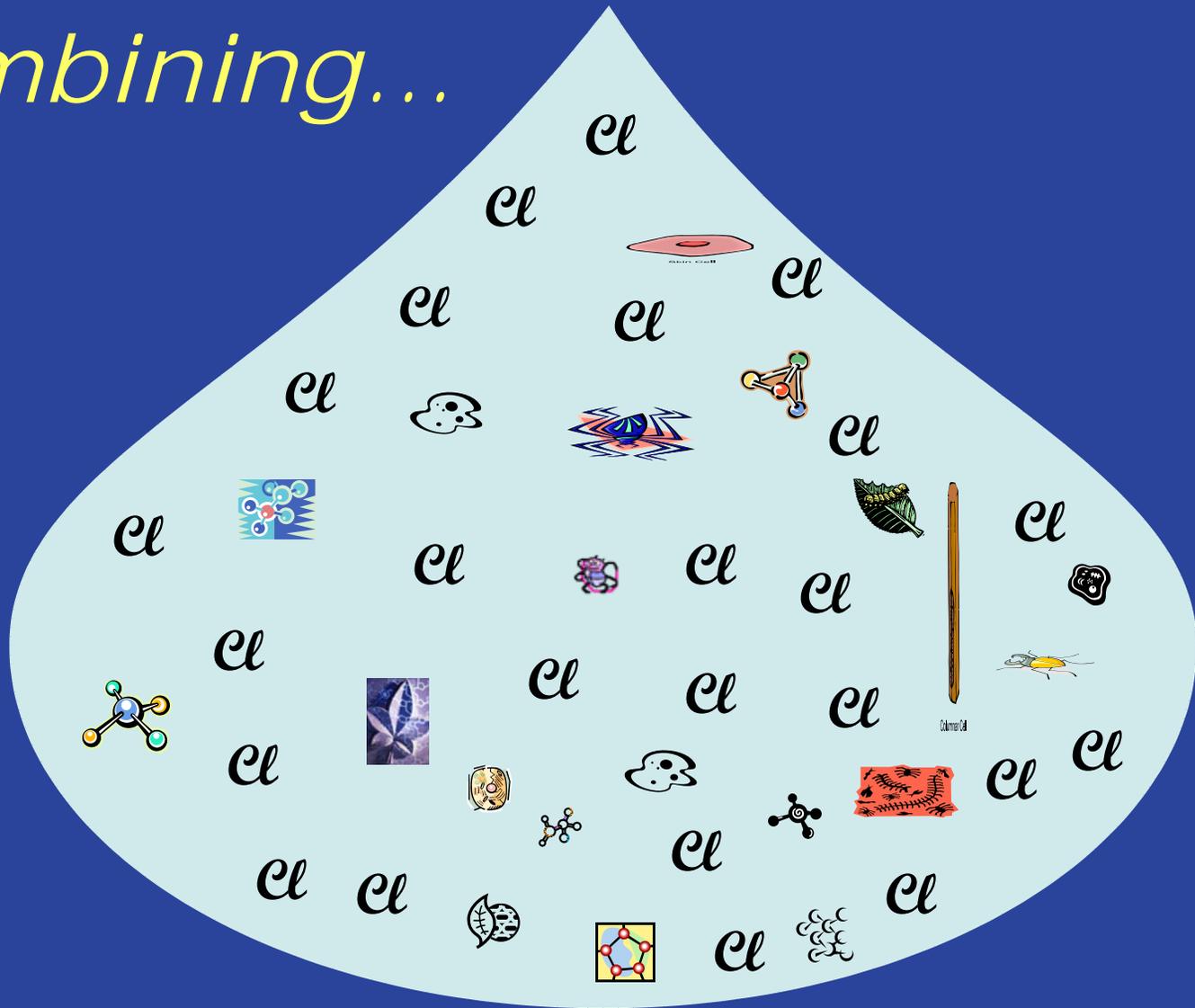
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*Combining...*

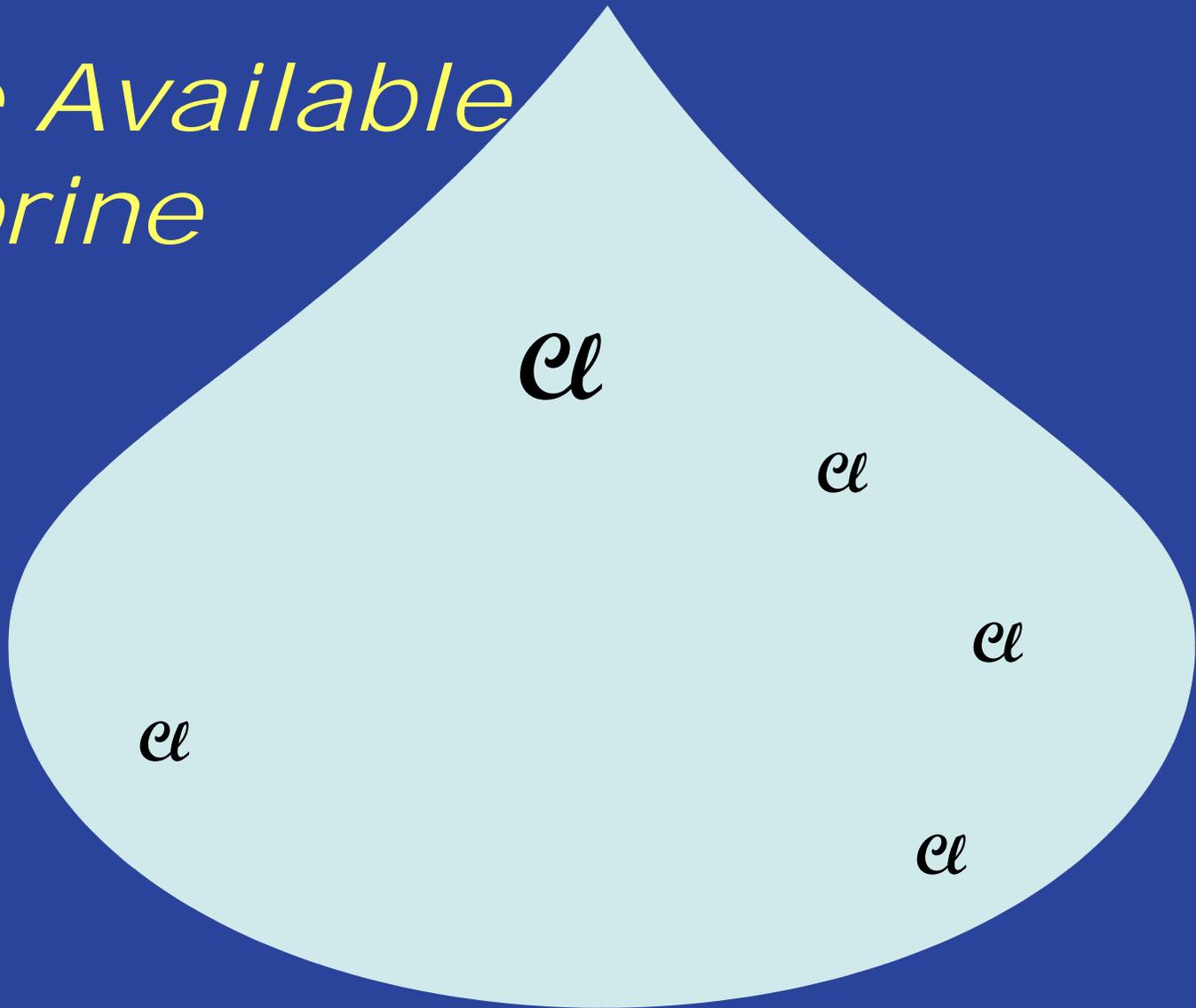


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# *Free Available Chlorine*



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# Chlorination Mechanics

How does chlorine kill microorganisms?

Chlorine effectiveness  
Lowest Highest

- **Bacteria:** Penetrates cell wall and kills the organism
- **Viruses:** Inactivation (incapable of reproduction)
- **Giardia:** Inactivation
- **Cryptosporidium:** Used alone, chlorine has no observed germicidal effect



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# Chlorination Mechanics

Chlorine treatment standards : "C x T"

- T = time water is in contact with the chlorine.
- C = concentration of free chlorine (mg/l), measured after "T".



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# Chlorination Mechanics

- Fraction of microbes killed increases linearly with:
  - disinfectant concentration
  - disinfectant contact time.
- Concentration can be traded for time:

Example:

$$5 \text{ PPM} \times 100 \text{ minutes} = 20 \text{ PPM} \times 25 \text{ minutes}$$

- *Disinfectant + microbe → dead microbe*



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# Halogen Level Requirements

- 0.2 – 5.0 mg/L (ppm)
  - Measured at a far point



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# Treatment System

- Halogen injection
- Monitoring



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# Halogen Injection System

- **Automatic** with backup system
  - Analyzer controlled
- **Manual**
  - Emergencies only



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# Monitoring System

- Halogen Analyzer
- Chart Recorder



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# Free Halogen Analyzer

- Far point location
- Accurate to +/- 0.2 mg/L (ppm)
- Calibrated or checked daily and recorded
  - In a log or on charts
- Low halogen level alarm
  - Audible in a continuously occupied location



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# Chart Recorder

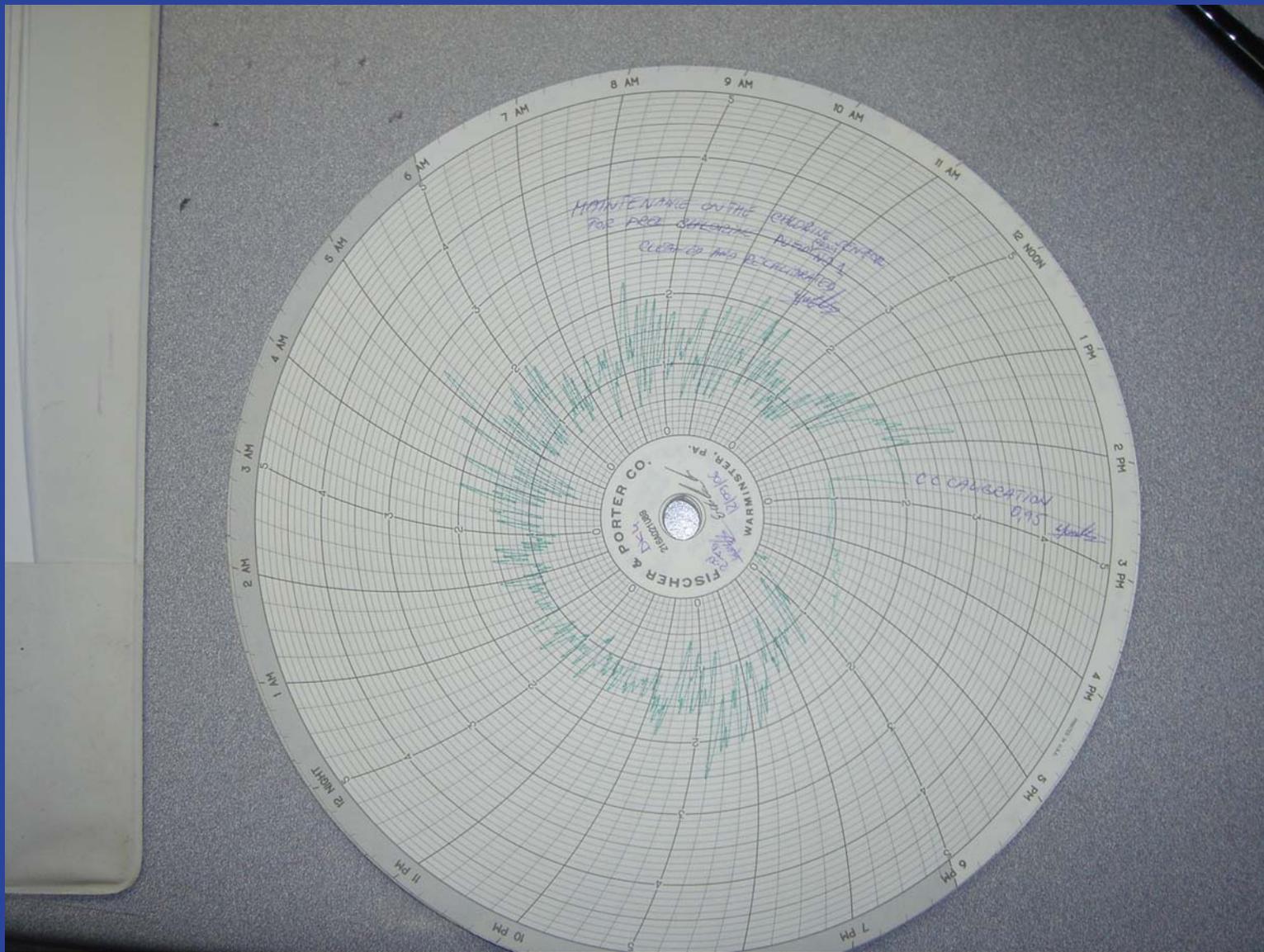
- Range: 0.0 – 5.0 mg/L (ppm)
- Dated, reviewed and initialed
  - Changed every 24 hours



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# Manual Monitoring

- Readings every 4 hours
- 10 consecutive days maximum
- Recorded
  - On charts or in a log



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# Microbiological Testing



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# Requirements

- Analyze for E. coli (fecal coliforms)
- 4 samples a month from distribution system
- Different points
- Follow-up on positive test results



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# Analysis

- Meets Standard Methods for the Examination of Water and Wastewater
  - Colilert
  - Colisure
  - Membrane filter technique
  - Fermentation tube



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# Record Keeping

- Keep records on board for at least 12 months



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# Resources and References

- [www.cdc.gov](http://www.cdc.gov)
  - [www.cdc.gov/nceh/vsp](http://www.cdc.gov/nceh/vsp)
- [www.epa.gov](http://www.epa.gov)



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