Safe Drinking Water Act- Federal Regulations

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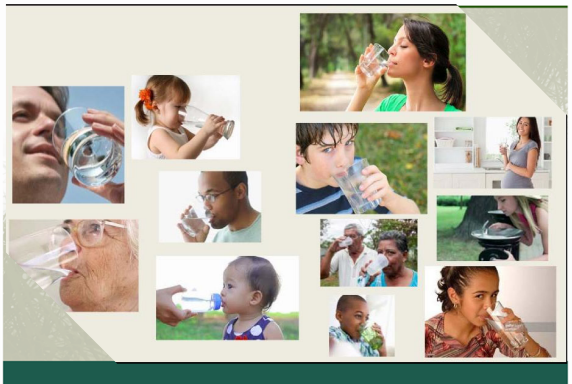
MCET
environmental, health, and safety training

Maryland Center for Environmental Training
at the
COLLEGE of SOUTHERN MARYLAND

Safe Drinking Water Act (SDWA) Federal Regulations



Process Training Sessions

Before class starts, please:
- **Sign in** on Attendance Sheet
- **Fill out** Registration Form, if appropriate

During class, please:
- **Asks questions**
- Feel free to get up and leave the classroom at any time (i.e., rest rooms, phone calls, etc.)
- **Answer questions** on post test

After class, please:
- **Fill out** a Class Evaluation
- **Pick up** Attendance Card, if appropriate

Housekeeping

- 1–day class
- Start class – 8:00 am
- 10-minute Breaks – every hour
- Lunch ~ 11:30 am – 12:30 pm
- End class ~ 3:30 to 4:00 pm

Instructor Expectations

- Begin and end class on time
- Be interactive – participate at your own comfort level
- Share experiences and needs
- Less lecture, more discussions
- Keep it simple
- ***Make this an enjoyable and informative experience!***

The Guiding Expectation

"Things should be made as simple as possible -- but no simpler."

Albert Einstein

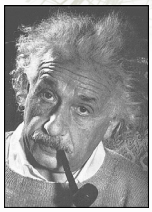


image source: www.physik.uni-frankfurt.de/~jr/physpiceinstein.html

Ground Rules

- Discussion is encouraged; share experiences
- Use terms we all can understand
- Everyone is different, so please show respect for others in the room
- Express opinions - of things, not people
- Maintain confidences

Ice Breaker

- Before we start, let's introduce ourselves.
  - Name,
  - What do you do, and
  - What are your learning needs?

Introduction

Objectives, Focus, and Agenda

SDWA Class Outline

- **Introductions and Class Objectives**
- Definitions and Acronyms
- SDWA History and Overview
- Drinking Water Contaminants & MCLs
- Current Regulations and Rules
- Sampling, Monitoring, and Record Keeping
- Summary and Closing

Expected Learning Objectives

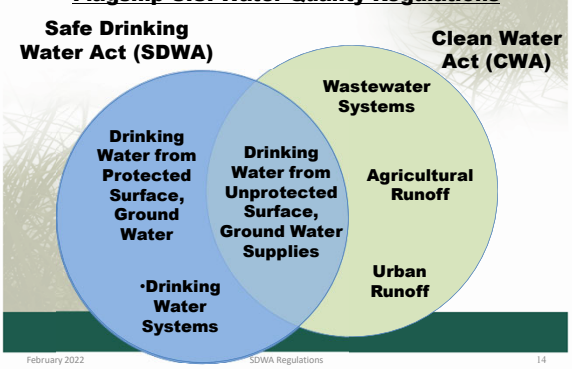
- Objective 1 - to associate SDWA Rules to:
  - Types of Contaminants
  - Primary Drinking Water Standards
  - Secondary Drinking Water Standards
- Objective 2 - to describe monitoring needs for:
  - Inorganic contaminants
  - Bacterial contaminants: Total Coliform and E. Coli
  - Disinfection by-products
- Objective 3 - to explain need for:
  - Water filtration
  - Disinfection with UV and chlorine

Participant Focus

- What information can you use at your work location?
  - SDWA regulations
  - Current **filtration and disinfection technologies**
  - Filtration, UV, and chlorination:
    - **Practical process limits**
    - **Operating and trouble shooting guidelines**
- What information can you contribute to the discussion?
  - Problems with **gravity filters and disinfection**

Regulations

Flagship U.S. Water Quality Regulations



Highlights of SDWA

- Sets enforceable health standards for contaminants in drinking water
  - Currently 94 regulated contaminants
- Requires public notification of public water system violations and annual reports
- Includes provisions to protect underground sources of drinking water

Safe Drinking Water Act of 1974

- Safe Drinking Water Act (SDWA) was established to protect the quality of drinking water in the U.S.
- Focus is on all waters actually or potentially designed for drinking use, above ground and underground sources
- EPA is authorized to establish minimum standards to protect tap water
- Owners or operators of public water systems are required to comply with primary (health-related) standards

Safe Drinking Water Act of 1974

- 1996 amendments to SDWA required that EPA consider a detailed risk and cost assessment, and best available peer-reviewed science, when developing primary (health-related) standards
- State governments, which can be approved to implement rules for EPA, are also encouraged attainment of secondary standards (nuisance-related).

SDWA History

- Federal SDWA introduced in 1974
- Resulted from increased concern and awareness of contaminated drinking water
- Amended: 1986, 1996
- Establishes MCL levels (or TTs in lieu of MCLs), monitoring, and reporting requirements
- Regulates 94 contaminants
  - Microbial
  - Chemical/Radiological

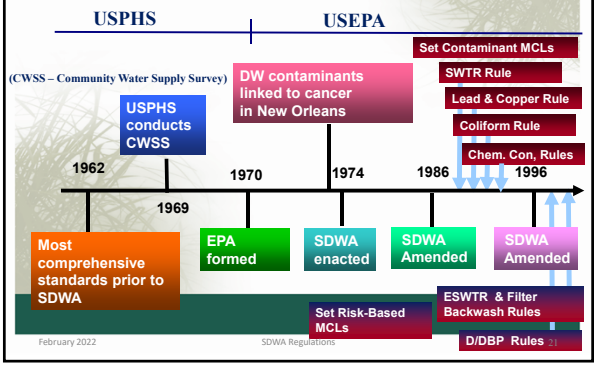
SDWA Contaminants

Microbial Risks
- Turbidity (Water quality indicator)
- Coliform Bacteria (Total, Fecal & E. coli)
- Enteroviruses
- Protozoa (Giardia, Cryptosporidium)

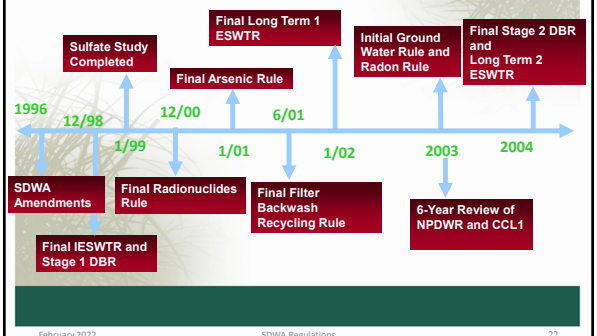
Chemical & Radiological Risks
- Inorganic chemicals (IOCs)
- Volatile organic chemicals (VOCs)
- Synthetic organic compounds (SOCs)
- Disinfectants & Disinfection by products (DBPs)
- Radionuclides (Radium 226/228, Uranium, Radon)

Increased chemical monitoring following the 1986 SDWA amendments

Federal Drinking Water Program



Rule Schedule



SDWA Individual Rules

- Chemical Contaminants (Phase I/II/IIB/V) Rules
  - Protects consumers from chemical contaminants by establishing MCLs
  - Establishes monitoring and reporting requirements

Chemical Contaminants

- Volatile organic chemicals (VOCs)
- Synthetic organic chemicals (SOCs)
- Inorganic chemicals (IOCs)
- Radionuclides
- Disinfection byproducts (DBPs)

The Water-Consuming Public is Aware (and Wary)

- Well-publicized "events"
- Bottled water sales increase dramatically

What's in Your Water?

Introduction

Definitions and Acronyms

Acronyms

- PWS – Public Water System
- MCLG - Maximum Contaminant Level Goal
- MCL - Maximum Contaminant Level
- TT – Treatment Technique
- DS – Distribution System
- IDSE – Initial Distribution System Evaluation
- DBPs – Disinfection Byproducts
  - ✓ THMs – Trihalomethanes
  - ✓ HAA – Haloacetic Acids
- NOM – Natural Organic Matter
- TOC/DOC – Total/Dissolved Organic Carbon
- UV – Ultraviolet Light
  - ✓ UV254 – Ultraviolet Absorbance at 254nm
  - ✓ SUVA – Specific UV Absorbance

History of Drinking Water Regulations

- 1962 – U.S. Public Health Service
- 1974 – Safe Drinking Water Act (SDWA)
- 1975 – Interim Primary Drinking Water Regs.
- 1986 – Amendments to SDWA
- 1996 – New Amendments to SDWA

Public Water Supply Regulations

- The Safe Drinking Water Act of 1974

  Directs the EPA to establish standards and requirements necessary to protect the public from all known harmful contaminants in drinking water

Raw Water Contaminants

- Raw water source
  - Lake
  - Reservoir
  - River
  - aquifer

Concerns:

- Pathogens
- Turbidity
- Color
- Taste and odors
- Fe, Mn
- NOM
- Toxic metals, Pb
- Synthetic organics
  - Pesticides
  - Herbicides
  - Solvents
  - PPCPs/EDCs
- Radioactivity (radon)
- H_2S, CO_2
- F^-, NO_3^-, Arsenic
- Br^-

Source Water Characteristics

Surface Water
(and GWUDISW)

- **Low to high turbidity and NOM**
- **Little to high biological pathogens**

Ground water

- **Low to no turbidity and NOM**
- **Little to no biological pathogens**

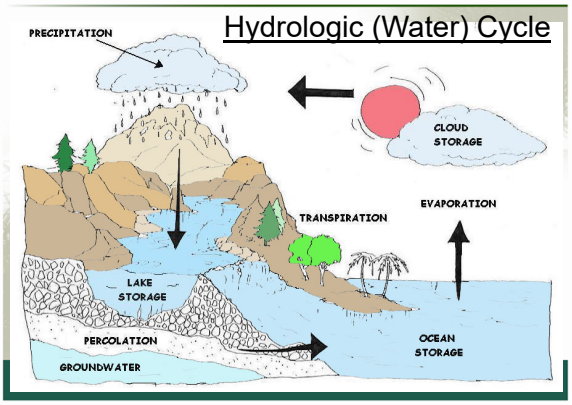
Both can:

1. Be corrosive
2. Contain calcium/magnesium hardness
3. Contain iron/manganese
4. Have taste and odors

Source Water Quality

- Proximity to contamination
- Substances that alter quality:
  1. Organic
  2. Inorganic
  3. Biological
  4. Radiological
- Sources of impurities

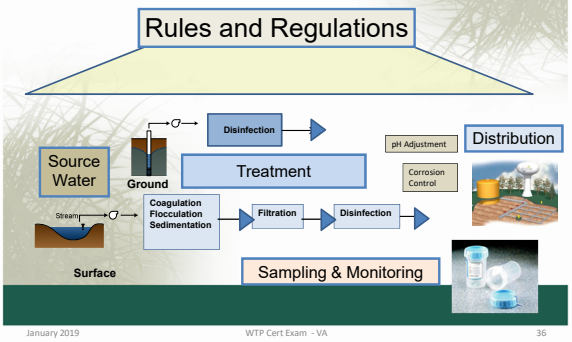
Hydrologic (Water) Cycle



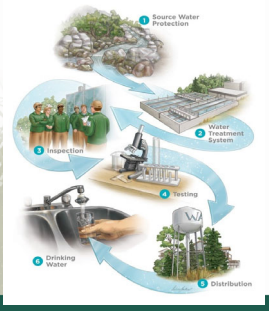
Safe Drinking Water Act (SDWA)

- SDWA is the key federal law that authorizes EPA to regulate contaminants in public water supplies
- Since enactment of the act in 1974, EPA has issued drinking water regulations for 94 contaminants
- Congress twice revised the act's process for evaluating contaminants and developing drinking water regulations (in 1986 and 1996)

Public Drinking Water Systems



Public Drinking Water Systems



National Primary Drinking Water Regulations

Regulation Terminology

- **National Primary Drinking Water Regulation (NPDWR)**
  - Sets legal levels (MCLs) of specific contaminants that can adversely affect public health
  - Recommends Maximum Contaminant Level Goals (MCLG)
  - Treatment Technique (TT) in lieu of MCLs
- **National Secondary Drinking Water Regulation (NSDWR)**
  - Non-enforceable guidelines
  - Covers contaminants that may cause cosmetic or aesthetic effects

Enforcement of SDWA Regulations

- EPA delegates primary enforcement responsibility (also called primacy) for public water systems to states if they meet certain requirements
- Exceptions: Wyoming, District of Columbia

Safe Drinking Water Act (SDWA)

- 1974 Act requires all owners or operators of public water systems to comply with primary (health-related) standards
- State governments can be approved to implement rules for EPA and are encouraged attainment of secondary standards (nuisance-related)

Common Contaminants in Water

USEPA Priority Pollutants

Semivolatile Organics	Volatile Organics	Pesticides & PCBS	Metals & Inorganics
2,4,6-trichlorophenol	1,1,1-trichloroethane	4,4-DDD	Cyanide, Total
2,4-dichlorophenol	1,1,2,2-tetrachloroethane	4,4-DDE	Antimony
2,4-dimethylphenol	1,1,2-trichloroethane	4,4-DDT	Arsenic
2,4-dinitrophenol	1,1-dichloroethane	Aldrin	Beryllium
2-chlorophenol	1,1-dichloroethylene	Alpha-BHC	Cadmium
2-nitrophenol	1,2-dichlorobenzene	Alpha-endosulfan	Chromium
4,6-dinitro-o-cresol	1,2-dichloroethane	Beta-BHC	Copper
4-nitrophenol	1,2-dichloropropane	Beta-endosulfan	Lead
Para-chloro-meta-cresol	1,2-dichloropropylene	Chlordane	Mercury
Pentachlorophenol	1,2-trans-dichloroethylene	Delta-BHC	Nickel
Phenol	1,3-dichlorobenzene	Dieldrin	Selenium
1,2,4-trichlorobenzene	1,4-dichlorobenzene	Endosulfan sulfate	Silver
1,2-diphenylhydrazine	2-chloroethyl vinyl ethers	Endrin	Thallium
2,4-dinitrotoluene	Acrolein	Gamma-BHC	Zinc
2,6-dinitrotoluene	Acrylonitrile	Heptachlor	
2-chloronaphthalene	Benzene	Heptachlor epoxide	
3,3-dichlorobenzidine	Bromoform	Toxaphene	
4-bromophenyl phenyl ether	Carbon tetrachloride	Endrin aldehyde	
4-chlorophenyl phenyl ether	Chlorobenzene	PCB–1242 (Arochlor 1242)	
Acenaphthene	Chlorodibromomethane	PCB–1254 (Arochlor 1254)	
Acenaphthylene	Chloroethane	PCB–1221 (Arochlor 1221)	
Anthracene	Chloroform	PCB–1232 (Arochlor 1232)	
Benzidine	Dichlorobromomethane	PCB–1248 (Arochlor 1248)	
benzo(a) anthracene	Ethylbenzene	PCB–1260 (Arochlor 1260)	
Benzo(a)pyrene	Methyl bromide	PCB–1016 (Arochlor 1016)	
Benzo(b) fluoranthene	Methyl chloride		
Benzo(k) fluoranthene	Methylene chloride		

Review of Current MCLs and TTs

- National Primary Drinking Water Regulations:
  - Microorganisms
  - Disinfection Byproducts
  - Disinfectants
  - Inorganic Chemicals
  - Organic Chemicals
  - Radionuclides

National Primary Drinking Water Regulations

EPA

Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from long-term[3] exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal (mg/L)[2]
Acrylamide	TT[4]	Nervous system or blood problems; increased risk of cancer	Added to water during sewage/ wastewater treatment	zero
Alachlor	0.002	Eye, liver, kidney, or spleen problems; anemia; increased risk of cancer	Runoff from herbicide used on row crops	zero
Alpha/photon emitters	15 picocuries per Liter (pCi/L)	Increased risk of cancer	Erosion of natural deposits of certain minerals that are radioactive and may emit a form of radiation known as alpha radiation	zero
Antimony	0.006	Increase in blood cholesterol; decrease in blood sugar	Discharge from petroleum refineries; fire retardants; ceramics; electronics; solder	0.006
Arsenic	0.010	Skin damage or problems with circulatory systems, and may have increased risk of getting cancer	Erosion of natural deposits; runoff from orchards; runoff from glass & electronics production wastes	0
Asbestos (fibers >10 micrometers)	7 million fibers per Liter (MFL)	Increased risk of developing benign intestinal polyps	Decay of asbestos cement in water mains; erosion of natural deposits	7 MFL
Atrazine	0.003	Cardiovascular system or reproductive problems	Runoff from herbicide used on row crops	0.003

npwdr_complete_table.pdf (epa.gov)

Safe Drinking Water Act (SDWA)

- Law focuses on all waters designed for drinking use, whether from above ground (surface) or underground (well) sources
- With EPA's approval, states can select contaminants to monitor in drinking waters
- Both Maryland and Virginia have been approved to monitor ≅ 50 - 60 contaminants

Consumer Confidence Report

- Customers served *by* a public water system can contact their local water supplier and ask for information on contaminants in their drinking water

Consumer Confidence Report

- The CCR:
  - Lists the levels of contaminants that have been detected in the water
  - Whether the water system meets state and EPA drinking water standards


ANNUAL CONSUMER CONFIDENCE REPORT

Results of Water Quality Testing for 2020

Consumer Disclosure

Public water systems must produce an annual consumer confidence report identifying the water source along with levels of regulated contaminants.

- A regulated chemical or pathogen
- Maximum contaminant level goal at which there is no known or expected health risk
- Maximum contaminant level, the standard for the highest level allowed in drinking water
- The average result used for judging compliance, along with the range of test results

Contaminant	MCLG (Goal)	MCL	2014 Results System Wide
Inorganics			
Arsenic (ppb)	0 ppb	10 ppb	ND
Barium (ppm)	2 ppm	2 ppm	0.10 (0.029 – 0.28)
Chromium (ppb)	100 ppb	100 ppb	BDL (ND – 2.2)
Flouride (ppm)	4 ppm	4 ppm	0.78 (0.071 – 1.1)
Nitrate (ppm)	10 ppm	10 ppm	0.89 (ND – 5.9)

Note: ppb = parts per billion; ppm = parts per million; ND = non-detect; BDL = below detection level

Local Consumer Confidence Reports

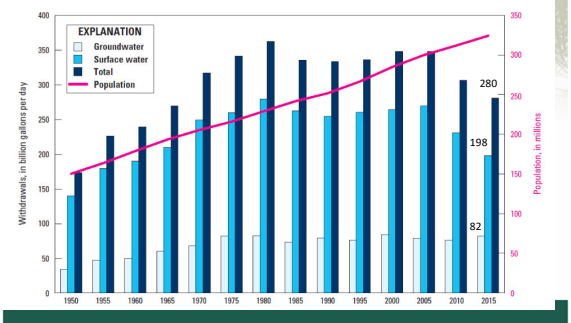
- 0150005-Washington-Suburban-Sanitary-Commission.pdf (maryland.gov)
- ccr_2021.pdf (fairfaxwater.org)
- 2020 Baltimore City Water Quality Report Web.pdf.pdf
- 2020 DC Annual Drinking Water Compliance Report (pdf)

Freshwater Sources

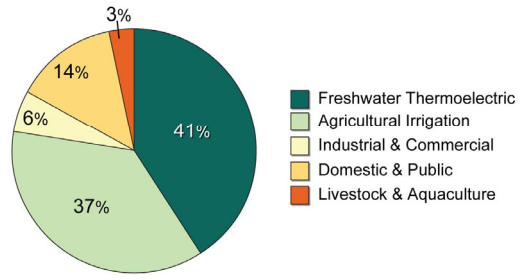
Three water sources:

1. Surface Water
2. Ground Water
3. Ground Water Under the Direct Influence of Surface Water (GWUDISW)

Population & Freshwater Withdrawals



Freshwater Withdrawals by Sector



Public Water Supply Use, BGD

USA (Community and Noncommunity)					
Source	1995	2000	2005	2010	2015
Surface water, BGD	25,100	27,300	29,600	26,200	24,000
Ground water, BGD	15,100	16,000	14,600	15,900	15,200
Total, BGD	40,200	43,300	44,200	42,100	39,200
Community Water Systems					
Consumption, BGD	22,700	24,200	25,600	23,700	23,300
Population Served, 000	225,000	242,000	258,000	269,000	283,000
gpd/capita	101	100	99	89	83

Source: USGS - "Estimates of Public Water Supply Use in USA"

Public Water Supply Sources, MGD

Maryland (Community and Noncommunity)					
Source	1995	2000	2005	2010	2015
Surface water, MGD	750	740	693	703	656
Ground water, MGD	83	84	96	89	94
Total, MGD	833	824	759	792	750
Community Water Systems					
Consumption, MGD	433	428	405	412	390
Population Served, 000	4,167	4,364	4,383	4.412	4,582
gpd/capita	104	98	92	93	85

Source: USGS - "Estimates of Public Water Supply Use in USA"

Public Water Supply Sources, MGD

Virginia (Community and Noncommunity)					
Source	1995	2000	2005	2010	2015
Surface water, MGD	704	650	721	594	605
Ground water, MGD	82	71	84	71	75
Total, MGD	786	721	805	665	680
Community Water Systems					
Consumption, MGD	424	412	442	476	503
Population Served, 000	4,960	4,900	5,890	6,350	6,825
gpd/capita	85	84	75	75	74

Source: USGS - "Estimates of Public Water Supply Use in USA"

Public Water System Withdrawals

- **Public Water System** withdrawals in 2015 were 39.2 Bgal/d, 7 percent less than in 2010
- Declines in water withdrawal observed
- Population served by public water systems increased 5 percent from 269 million in 2010 to 283 million in 2015

Per Capita Water Consumption

- Average gpd/capita water usage is declining also
- Gallons gpd/capita decreased 6 gallons from 89 in 2010 to 83 in 2015
- GPD/capita represents the daily water usage for the population supplied by public water systems

Public Water Systems (2015)

- Approximately 151,600 public water systems in the United States in 2015
- 50,500 (33.3%) were community systems
- 101,100 (66.7%) were noncommunity systems;
  - 83,100 transient systems
  - 18,000 nontransient systems

Public Water Systems (2015)

Public drinking water systems by type (2015)

System type	Number of systems
Community water systems	50,496
Non-transient non-community water systems	18,034
Transient non-community water systems	83,124
United States total	151,654†

† **Note**: Includes U.S. territories and American Indian tribal areas
Source: *U.S. Environmental Protection Agency*, "National Drinking Water Activity Dashboard"

Public Water Systems (2011)

		Water System Population Size Category					
		Very Small 500 or less	Small 501-3,300	Medium 3,301-10,000	Large 10,001-100,000	Very Large >100,000	Totals
CWS	# Systems	28,346	13,737	4,936	3,802	419	51,356
	Pop. Served	4,763,672	19,661,787	28,737,564	108,770,014	137,283,104	299,216,141
	% of Systems	55%	27%	10%	7%	1%	100%
	% Of Pop.	2%	7%	10%	36%	46%	100%
NTNCWS	# Systems	15,461	2,566	132	18	1	18,178
	Pop. Served	2,164,594	2,674,694	705,320	441,827	203,000	6,189,435
	% of Systems	85%	14%	1%	0%	0%	100%
	% Of Pop.	35%	43%	11%	7%	3%	100%
TNCWS	# Systems	80,347	2,726	92	13	1	83,179
	Pop. Served	7,171,054	2,630,931	514,925	334,715	2,000,000	12,651,625
	% of Systems	97%	3%	0%	0%	0%	100%
	% Of Pop.	57%	21%	4%	3%	16%	100%
	Total # of Systems	124,270	19,029	5,160	3,833	421	152,713

Source: EPA, *Fiscal Year 2011 Drinking Water and Ground Water Statistics*, EPA 816-R-13-003, March 2013, p. 8, http://water.epa.gov/scitech/datait/databases/drink/sdwisfed/upload/epa816r13003.pdf.

Public Drinking Water Use

- Water consumption has steadily declined since 2000
- Water conservation devices/efforts is the very likely explanation
- Decline is possibly due to increasing water (and sewer) service rates

Safe Drinking Water Act (SDWA)

- EPA assesses future supplies and demands
- EPA addresses chlorine concerns
- 1996 amendment put emphasis on:
  - Emerging contaminants, such as *Cryptosporidium,* perchlorate, and perfluorinated compounds (PFCs)
  - Public involvement
  - Public right-to-know (i.e., annual reports)

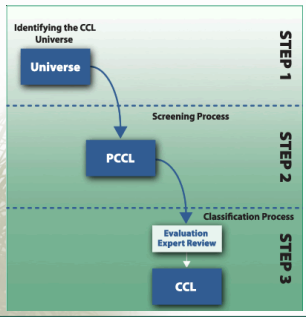
Safe Drinking Water Act (SDWA)

- SDWA requires EPA to review, and revise if necessary, existing national primary drinking water regulations every six years
- SDWA also requires that any revisions to drinking water regulations maintain or provide greater health protection

Safe Drinking Water Act (SDWA)

- Since 1996, EPA has screened over 7,500 contaminants for potential regulation, revised existing regulations, and established new regulations and standards for several contaminants

Contaminant Selection Process

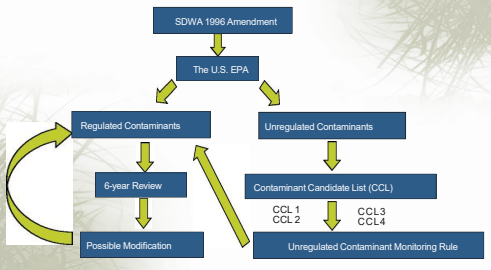


7,500 Contaminants

561 Contaminants

CCL4 includes 97 chemicals and chemical groups and 12 microbial contaminants

Regulatory Development Process



Safe Drinking Water Act (SDWA)

- EPA uses three criteria to decide or make a preliminary decision whether to regulate a particular contaminant:
  1) Health effect data
  2) Frequency and levels of the occurrence
  3) Meaningful opportunity to reduce any health risk if regulated

SDWA Contaminant Regulation Timeline

Date	Regulatory Action	Number	Cumulative
Dec. 1975 - July 1976	Interim NPDWRs	New (22)	22
November 1979	Total Trihalomethanes Rule	New (1)	23
April 1986	Fluoride Rule	Revised (1)	23
July 1987	Phase I NPDWRs	New (8)	31
June 1989	Total Coliform Rule	Revised (1)	31
June 1989	SWTR	New (4) and Revised (1)	35
Jan. & July 1991	Phase II NPDWRs	New (27), Rev. (11), Deleted (1)	61
June 1991	Lead and Copper Rule	New (1) and Revised (1)	62
July 1992	Phase V NPDWRs	New (22) and Revised (1)	84
June 1995	Nickel NPDWR	Remanded (1)	83
December 1998	Stage I D/DBP Rule	New (6) and Revised (1)	89
December 1998	Enhanced SWTR	New (1) and Revised (2)	90

SDWA Contaminant Regulation Timeline

Date	Regulatory Action	Number	Cumulative
January 2000	Lead and Copper Rule	Revised (2)	90
December 2000	Radionuclides Rule	New (1) and Revised (4)	91
January 2001	Arsenic Rule	Revised (1)	91
June 2001	Filter Backwash Recycling Rule	Revised (1)	91
January 2002	Long Term 1 Enhanced SWTR	Revised (2)	91
January 2006	Long Term II Enhanced SWTR	Revised (1)	91
November 2006	Groundwater Rule	New (3)	94
October 2007	Lead and Copper Rule	Revised (2)	94
October 2009	Aircraft Drinking Water Rule	New	94
February 2013	Revised Total Coliform Rule	Revised (1)	94
December 2021	Lead and Copper Rule	Revised (1)	94

What will the Future Bring?

Regulatory Challenges
- Federal Rules
- State Ordinances
- Local Ordinances

Contaminants to watch:
- Strontium
- Perchlorate
- Chrome VI
- Perfluorinated Compounds

Strontium

- Strontium is easily taken from water and food and deposited in bones
- Natural strontium citrate is both safe and extremely beneficial for your bones
- Excessive absorption of strontium negatively affects skeletal development and leads to thickened bones prone to fracture

Strontium

- Natural forms of strontium have been safely used in medicine for over 100 years
- Natural strontium is confused with strontium ranelate — a synthetic version with many potential adverse side effects
- The safety of natural strontium is also confused with radioactive strontium

Strontium

- Infants, children, and adolescents are especially sensitive to strontium
- Since strontium is excreted primarily in the urine, strontium also adds burden to patients with kidney disease

Strontium

- In October 2014, EPA made a preliminary determination to regulate strontium in drinking water based on data generated from UCMR 3
- In 2016, EPA delayed making a final decision on whether to regulate strontium

Perchlorate
(EPA Notice - January 2012)

- EPA Will Regulate Perchlorate
  - EPA has 24 months to propose an MCL
  - ~ 24 additional months for promulgation
  - CA MCL = 6 µg/L; MA MCL = 2 µg/L; NV Action Level = 18 µg/L
  - EPA's Federal Register notification from 2010: MCL as low as 1 µg/L
- Sources of Perchlorate
  - Munitions (Ground sources at Aberdeen, Indian Head)
  - Rocket fuel
  - Industrial sites
  - Fireworks, flares
  - **Hypochlorite (drinking water treatment)!!!**

Perchlorate

Common name	Stock name	Oxidation state	Formula
Hypochlorite	Chlorate(I)	+1	ClO^-
Chlorite	Chlorate(III)	+3	ClO_2^-
Chlorate	Chlorate(V)	+5	ClO_3^-
Perchlorate	**Chlorate(VII)**	+7	ClO_4^-

Perchlorate adversely affects human health by interfering with iodine uptake into the thyroid gland.

Perchlorate

- May 2019 - EPA published proposed perchlorate drinking water regulations
  - EPA requested comments on a Maximum Contaminant Level (MCL) and a health-based Maximum Contaminant Level Goal (MCLG) at 56 micrograms per liter
  - Three alternative regulatory options:
    - 18 micrograms per liter.
    - 90 micrograms per liter.
    - Withdrawal of perchlorate regulations

Perchlorate – Final Action

- On July 21, 2020 – Final Action
- EPA determined that perchlorate **does not** meet the criteria for regulation as a drinking water contaminant under the SDWA
- EPA withdrew the 2011 regulatory determination and made a final determination not to issue a national regulation for perchlorate

Chromium

- Chromium is an odorless and tasteless metallic element
- Chromium is found naturally in rocks, plants, soil and volcanic dust, and animals.
- The most common forms of chromium that occur in natural waters in the environment are:
  - Trivalent chromium (chromium III)
  - Hexavalent chromium (chromium VI)

Chromium

- Chromium (III) is an essential human dietary element
- It is found in many vegetables, fruits, meats, grains, and yeast
- Chromium (VI) occurs naturally in the environment from the erosion of natural chromium deposits
- It can also be produced by industrial processes (i.e., metal plating)

Chromium

- The national primary drinking water regulation that established the MCL for Total Chromium of 0.1 mg/L was promulgated in 1991
- In September 2010, EPA released a draft assessment of the Toxicological Effects of Hexavalent Chromium for public comment and external peer review

Chromium

- To assess the levels of chromium VI in drinking water, EPA is requiring a selected number of systems to perform chromium VI monitoring under UCMR 3
- The UCMR 3 requires many but not all public water systems to monitor chromium VI for a one-year period

Chromium VI ("Hexavalent" Chromium)

- CA regulates total chromium at 50 ppb
- CA's draft Cr^{+6} Public Health Goal = 0.02 ppb
  - Note that current detection limits are 1 ppb!!
- Environmental Working Group December 2011 report sparked renewed interest from EPA
- EPA is considering moving Cr^{+6} to UCMR4
  - But one additional contaminant must be removed from UCMR4

Perfluorinated Chemicals

- In the 1980s and 1990s, a few laboratory toxicity studies reported liver toxicity and induction of tumors when animals were exposed to perfluorinated chemicals (PFCs)

Perfluorinated Chemicals

- Perfluorooctanoic Acid (PFOA) and Perfluorooctane Sulfonate (PFOS) are two of the most widely used and studied chemicals in the PFAS group
- PFOA and PFAS have been replaced in the United States with other PFAS in recent years

Perfluorinated Chemicals

- One common characteristic of concern of PFAS is that many break down very slowly and can build up in people, animals, and the environment over time

Perfluorinated Chemicals

- Humans can be exposed to PFAS by:
  a. Working in occupations such as firefighting or chemicals manufacturing and processing
  b. Drinking water contaminated with PFAS
  c. Eating certain foods that may contain PFAS, including fish
  d. Swallowing contaminated soil or dust
  e. Breathing air containing PFAS
  f. Using products made with PFAS or that are packaged in materials containing PFAS

Perfluorinated Chemicals

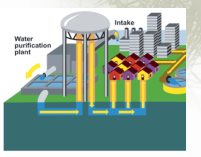
- Exposure to certain levels of PFAS may lead to:
  a. Reproductive effects such as decreased fertility or increased high blood pressure in pregnant women
  b. Developmental effects or delays in children, including low birth weight, accelerated puberty, bone variations, or behavioral changes
  c. Increased risk of some cancers, including prostate, kidney, and testicular cancers
  d. Reduced ability of the body's immune system to fight infections, including reduced vaccine response
  e. Interference with the body's natural hormones
  f. Increased cholesterol levels and/or risk of obesity

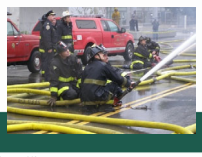
SDWA Definitions

- PWS: Public Water System
  - 15 or more connections
  - 25 or more people per day
  - At least 60 days per year
  - Three subcategories
    - Community Water System
    - Transient Non-Community Water System
    - Non-Transient Non-Community Water System

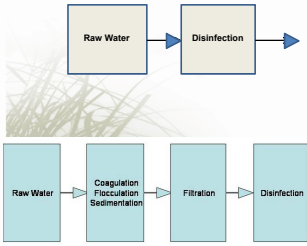
Public Water Systems

- Public water systems deliver adequate quantities of water at pressures enough to:
  - Provide clean drinking water to:
    - Residential units
    - Businesses
    - Industrial complexes
  - Support fire-fighting equipment



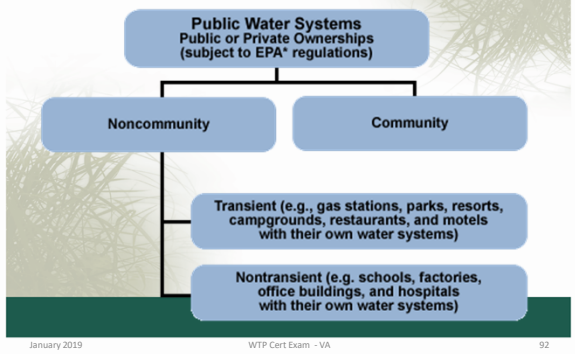


COMMON TREATMENT TECHNIQUES

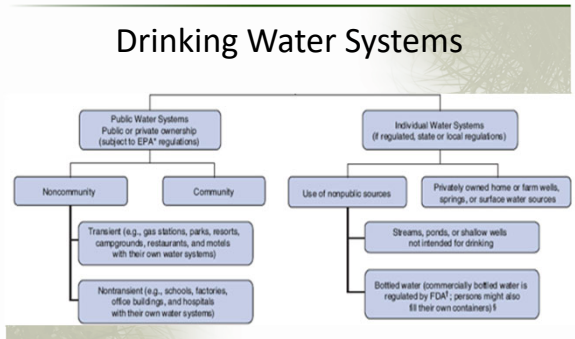


- GROUNDWATER
  - pH adjustment
  - Disinfection
  - Fluoridation
  - Corrosion Control
- SURFACE WATER (& GWUDISW)
  - **Screening**
  - **Coagulation**
  - **Flocculation**
  - **Sedimentation**
  - **Filtration**
  - Disinfection
  - Fluoridation
  - Corrosion control

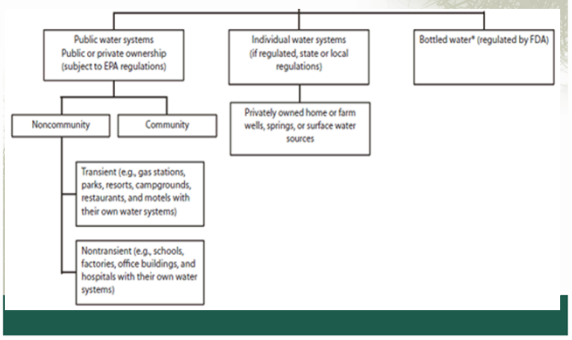
Drinking Water Systems



Drinking Water Systems



Drinking Water Systems



SDWA Definitions

- Community Water System (CWS)
  - A PWS that supplies water to the same residential population year-round.
  - Examples:
    - Cities
    - Towns
    - Rural Water Systems
    - Trailer Parks (not seasonal)

Community Water Systems

- Over 283 million Americans get their drinking water from community water systems (2015)
- 8% of U.S. community water systems provide water to 82% of the U.S. population through large municipal water systems

SDWA Definitions

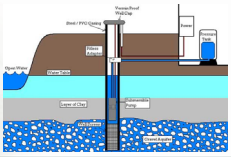
- Transient Non-Community Water Systems
  - Provides water in a place where people do not stay for long periods of time
  - Examples include:
    - Restaurants
    - Rest stops
    - Campgrounds

SDWA Definitions

- Nontransient Non-Community Water Systems (NTNSWS)
  - Regularly supplies water to at least 25 people at least 6 months per year but not to their residences
  - Examples include:
    - Schools
    - Factories

Private Well Systems

- About 10 percent of people in the United States rely on water from private wells
- Private wells are not regulated under the SDWA

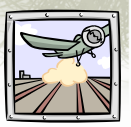


Regulation Terminology

- Contaminant - Any physical, chemical, biological, or radiological substance or matter in water
- MCLG – Maximum Contaminant Level Goal; a health goal which allows an adequate margin of safety
- MCL – Maximum Contaminant Level; highest level of contaminant allowed in water; set close to MCLG

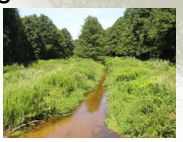
Types of Contaminants

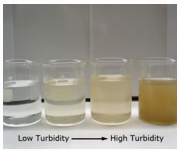
- Chemicals (organic and inorganic)
  - Naturally occurring
  - Man-made
- Microbiological
- Disinfectants and disinfection by-products
- Radiological



Contaminants

- **Physical** contaminants primarily impact the physical appearance of water
- Examples of physical contaminants are turbidity and natural organic material (NOM) suspended in lakes, rivers, and streams from soil erosion





Contaminants

- **Chemical** contaminants are elements or compounds
- May be naturally occurring or man-made
- Examples of chemical contaminants include nitrates, bleach, salts, pesticides, metals, toxins produced by bacteria, and human or animal drugs

Contaminants

Chemical Contaminants

- Any cleaning chemical accidently used in a food would cause immediate and severe illness
- Chemical contaminants can cause cancer and nervous disorders

Contaminants

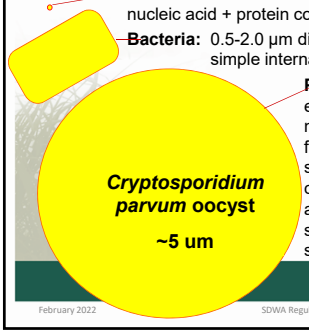
- **Biological** contaminants – microorganisms
- Examples of biological or microbial contaminants include bacteria, viruses, and parasites (Protozoans and Metazoans)

Classes of Microorganisms: The Microbial World

Viruses: smallest (0.02-0.3 µm diameter); simplest: nucleic acid + protein coat (+ lipoprotein envelope)

Bacteria: 0.5-2.0 µm diameter; prokaryotes; cellular; simple internal org.; binary fission.

Protozoa: most >2 µm - 2 mm; eucaryotic; single cell; non-photosynthetic; flexible cell membrane.; wide range sizes and shapes; hardy cysts and oocysts; flagellates amoebae, ciliates, sporozoans (*Cryptosporidium* sp.) and microsporidia.



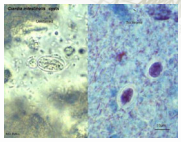
Waterborne Diseases

Viruses	Norovirus (gastroenteritis) Rotavirus (gastroenteritis) Hepatitis A virus (infectious hepatitis) Adenovirus (respiratory, gastroenteritis)
Bacteria	*Escherichia coli* (gastroenteritis) *Salmonella typhi* (typhoid fever) *Vibrio cholerae* (cholera) *Shigella* (dysentery)
Protozoa	*Giardia lamblia* (gastroenteritis) *Cryptosporidium parvum* (cryptosporidiosis)

Waterborne Pathogens

- Disease symptoms usually are explosive emissions from either end of the digestive tract

Escherichia coli



Giardia sp.*

Protozoa

Giardia

Cryptosporidium

Contaminants

- **Radiological** contaminants are chemical elements with an unbalanced number of protons and neutrons
  - Result: Unstable atoms that can emit ionizing radiation
- Examples of radiological contaminants include radium, radon, cesium, plutonium, and uranium

Regulation Terminology

- **Treatment Technique**
  - § 141.2(b)(7): "…in lieu of establishing a maximum contaminant level (MCL), if…it is not economically or technologically feasible to ascertain the level of the contaminant."
  - Examples: Filtration and disinfection techniques for inactivating viruses and Giardia to avoidance levels

Treatment Technique (TT)

- Alternative to an MCL when it is not economically and technologically feasible to ascertain the level of the contaminant
- A TT is also an enforceable standard involving a measurable procedure or level of technological performance (e.g., "Action Level")

Steps for Developing Drinking Water Standards

- Setting the MCLG
  - Health effects information
  - Exposure information
  - Relevant information and procedures developed by EPA for risk assessment and characterization

Safe Drinking Water Act (SDWA)

- 1996 amendments to SDWA require that EPA consider a detailed risk and cost assessment, and best available peer-reviewed science, when developing standards
- Risk-based process – prioritizes contaminants for regulation based on the contaminant's health effects and occurrence

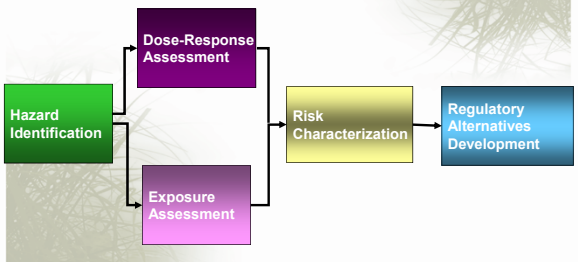
First Objective

- Provide an understanding of the **risk** reduction goals of SDWA and the chemical monitoring under the drinking water regulations

What is Risk?

- EPA definition (from Integrated Risk Information System)
  - **Probability** of injury, disease or death from exposure to a chemical agent or a mixture of chemicals

Components of Risk Assessment in Rulemaking



What is an Adverse Health Effect?

- **EPA definition (from Integrated Risk Information System):**

"… any biological, physiological, anatomical, pathological, and/or behavioral change that may affect the performance of the whole organism or reduce the ability of the organism to respond to additional challenges."

Identifying Adverse Health Effects

- Different adverse effects can occur with different magnitude, frequency and durations of exposure
- Typically, two broad categories of adverse health effects are considered:
  - Cancer
  - Non-cancer

Maximum Contaminant Level Goals (MCLG)

- Considerations in setting an MCLG:
  - End-point – cancer or noncancer
  - Acute or chronic exposure concerns
  - Sensitive populations
- Data obtained from epidemiological and toxicological studies

Contaminant Candidate Lists (CCLs)

- Process for creation of CCLs:
  - Consider broad universe of contaminants and collect into unified database (CCL database)
  - Develop screening criteria to cull universe to several thousand (PCCL)
  - Develop classification algorithm to narrow list to ~100 contaminants
  - Regulatory determination: 5 to 10 contaminants every five to six years

Regulatory Development Process

	First	Second	Third	Fourth
CCL	1998	2005	2009	2016
	60	51	119	109
UCMR	1999	2007	2012	2016
	26	25	30	30
RegDet	2003	2008	2016	2021
	9 NR	11 NR	4 NR 1 Delayed	6 NR 2 Reg
			(Strontium)	(PFOA & PFOS)

Unregulated Contaminants

- Under the Unregulated Contaminant Monitoring Rule(UCMR), EPA collects data for contaminants suspected to be present in drinking water, but that do not have health-based standards set under the SDWA

Current and Previous UCMRs

- UCMR 5 (2022-2026)
- UCMR 4 (2017-2021)
- UCMR 3 (2012-2016)
- UCMR 2 (2007-2011)
- UCMR 1 (2001-2005)
- UCM-State Rounds 1&2 (1988-1997)

Contaminant Candidate List

- Every five years EPA reviews the list of contaminants, largely based on the Contaminant Candidate List

Current and Previous CCLs

- Draft CCL 5
- CCL 4 (2016)
- CCL 3 (2009)
- CCL 2 (2005)
- CCL 1 (1998)

Regulatory Determination

- The SDWA requires EPA to periodically decide whether to regulate at least five contaminants on the CCL
- This action is called regulatory determination
- A regulatory determination is a formal decision on whether EPA should develop a national primary drinking water regulation for a specific contaminant

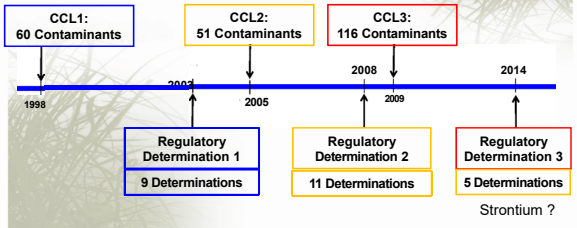
Regulatory Determination

- EPA is required to make regulatory determinations for at least five contaminants from the most recent CCL
- Determinations must be decided within five years after the completion of the previous round of regulatory determinations

Regulatory Determination

- Regulatory Determination 4
- Regulatory Determination 3
- Regulatory Determination 2
- Regulatory Determination 1

Timeline of CCL and Regulatory Determinations



Background on CCL and Regulatory Determinations

- CCL 1 and Regulatory Determinations
  - March 1998 - Published CCL1 and listed 60 contaminants
  - July 2003 - Published final determination "not to regulate" 9 of the 60 contaminants
- CCL 2 and Regulatory Determinations
  - February 2005 - Published CCL2 and carried forward 51 remaining CCL1 contaminants
  - July 2008 - Published final determination "not to regulate" 11 of the 51 contaminants

Background on CCL and Regulatory Determinations

- CCL 3 and Regulatory Determinations
  - September 2009 - Published CCL 3 and listed 116 contaminants
  - October 2014 – Published final determination to regulate strontium and "not to regulate" 4 of the 116 contaminants
- CCL 4 – Final
  - November 2016 – EPA Published CCL 4 and listed 109 contaminants
  - 97 chemicals or chemical groups and 12 microbial contaminants

Drinking Water Rule Groups

Contaminant Type	Regulation
Chemical contaminants	•Arsenic rule •Chemical contaminant rules •Lead and copper rule •Radionuclides rule •Variance and exemptions rule
Microbial contaminants	•Aircraft drinking water rule •Ground water rule •Stage 1 and stage 2 disinfectant/disinfection byproducts rule •Surface water treatment rules •Total coliform rule and revised total coliform rule
Right-to-know rules	•Consumer confidence report rule •Public notification rule

Contaminants of Concern

- Turbidity (in surface waters)
- Chlorine & Disinfection Byproducts
- Total/Fecal/e. Coli Coliforms
- Lead and Copper
- Inorganic Chemicals (Arsenic and others)
- Volatile Organic Chemicals (THMs, HAAs)
- Radioactive materials (Radium)

Contaminants

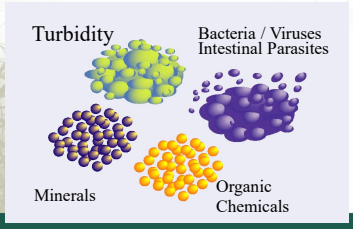
Turbidity in Surface Waters

SDWA Individual Rules

- SWTR
  - Surface Water Treatment Rule
  - Protects against exposure to harmful viruses, bacteria, Giardia and other pathogens by requiring certain types of treatment for surface water sources

SURFACE WATER TREATMENT

"The water treatment plant is the primary barrier against unsafe water…any malfunction in the treatment process could result in water quality problems."



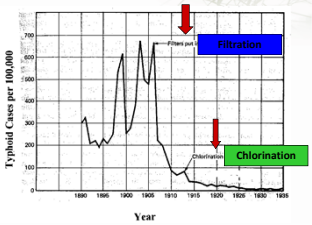
Early USA Water Treatment Milestones

1871:	First slow sand filter in USA
1896:	First rapid sand filter in USA
1908:	First use of chlorine as a primary disinfectant
1920s:	Filtration and chlorination used widely in large cities

Filtration and Chlorination

- In 1908, a water treatment plant in Jersey City, New Jersey, used chlorine as primary disinfectant
- USA typhoid cases began to drop dramatically
- In early 1900s most U.S. water treatment systems were using filtration and chlorine disinfection to remove microbial contaminants.

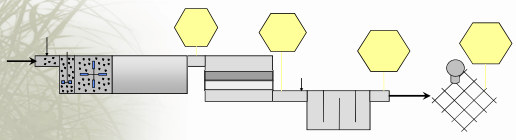
Figure 1 Typhoid Cases 1890-1935 Philadelphia



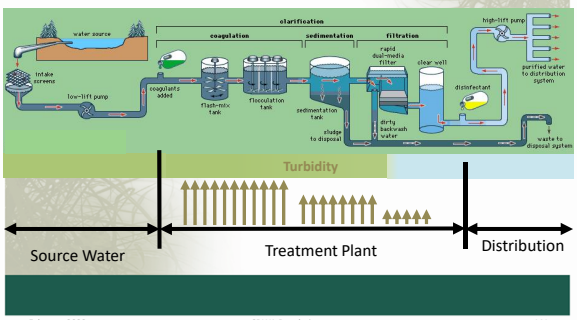
From McGhee, 6th Ed., 1991

Water Treatment Goals

- Turbidity removal often requires treatment beyond regulatory levels
- Water treatment strategies focus on multiple barrier approaches to assure safe drinking water
  - Turbidity removal
    - Coagulation/flocculation + sedimentation + **filtration**
  - Disinfection

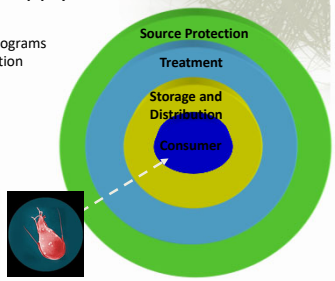


Surface Water Treatment Plant and Distribution System

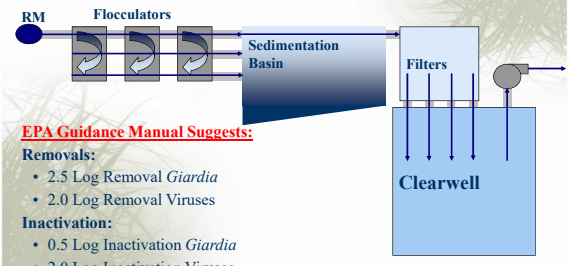


Multiple Barriers In Water Supply Protection

- Sources
  - Watershed management programs
  - Intake and wellhead protection
- Treatment
  - Coagulation, flocculation, sedimentation
  - Filtration
  - Disinfection
- Storage
  - Disinfectant contact time
  - Screens
- Distribution
  - Pressure
  - Disinfection



Filtration: Conventional

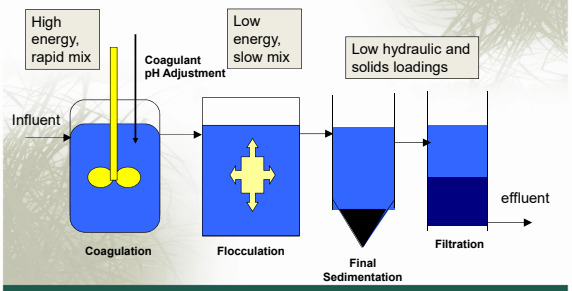


EPA Guidance Manual Suggests:

Removals:
- 2.5 Log Removal *Giardia*
- 2.0 Log Removal Viruses

Inactivation:
- 0.5 Log Inactivation *Giardia*
- 2.0 Log Inactivation Viruses

Enhanced Solids Removal System



Percentage vs. Log Reductions

Percentage Reductions	Log Reductions
90	1-log
99	2-log
99.9	3-log
99.99	4-log

Filtration: Direct

EPA Guidance Manual Suggests:

Removals:
- 2.0 Log Removal *Giardia*
- 1.0 Log Removal Viruses

Inactivation:
- 1.0 Log Inactivation *Giardia*
- 3.0 Log Inactivation Viruses

Filtration: Conventional or Direct

- At Least 95 Percent of the Combined Filter Effluent (CFE)[1] Turbidity Samples Must Be < 0.5 NTU Each Month Except That:
  - The State Can Determine That Some Level Higher Than 0.5 NTU but <1 NTU Will Inactivate And/or Remove 99.9 Percent of *Giardia lamblia* Cysts
- The CFE Turbidity Must at No Time Exceed 5 NTU

[1]The Rule Says "Representative Samples of a System's Filtered Water." EPA considers this to be CFE; some states apply the limit to individual filters.

Surface Water Treatment Options

Surface Water Treatment Rule (SWTR - 1989)

- Objectives: To ensure adequate treatment of raw water
  To filter and disinfect surface water sources
- Finished water **turbidity standard of ≤ 0.5 NTU; cannot exceed 5 NTU**
- Concentration and time (C x T) requirements for disinfection; detectable residual chlorine cannot be less than 0.2 mg/L for more than 4 hours
- Maintain Total Coliforms < 100MPN/100 ml and fecal coliforms < 20 MPN/ml in 90% of water samples
- Annual watershed inspection and report; system Sanitary Surveys periodically

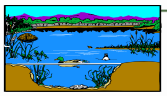
Surface Water Treatment Options

Enhanced Surface Water Treatment Rules (ESWTR – 1998 - 2006)

- Objectives: To treat raw water for **Cryptosporidium**
- To cover or treat remaining finished water reservoirs
- Finished water turbidity standard of ≤ 0.3 NTU
- Benchmark/**profile for Cryptosporidium** removal

Long Term 1 Enhanced Surface Water Treatment Rule (LT1ESWTR)

January 14, 2002



SDWA Individual Rules

- LT1ESWTR
  - Long Term 1 Enhanced Surface Water Treatment Rule
  - Applies to systems serving <10,000 people.
  - Sets Cryptospiridium removal and turbidity requirements
  - Requires disinfection benchmarking and covers on new finished water reservoirs

Long Term 1 Enhanced Surface Water Treatment Rule

- Goals
  - Improve control of microbial pathogens, including Cryptosporidium, in drinking water
  - Address risk trade-offs with disinfection byproducts

Summary of the LT1 Rule

- MCLG of zero for *Cryptosporidium*
- Requirements for SW/GWUDI systems serving 10,000 or fewer people
  - 2 log removal of *Cryptosporidium* for systems required to filter under the SWTR
  - Strengthened turbidity performance standards for combined filter effluent
  - Individual filter turbidity monitoring and reporting provisions for systems
  - Disinfection profile and benchmark provisions to assure continued levels of microbial protection where facilities take steps to comply with new DBP standards

Summary of the LT1 Rule

- Compliance Dates
  - January 2002(last revised)
    - IESWTR: Surface water systems and Subpart H systems serving 10,000 or more persons
  - January 2005
    - LT1SWTR:Small surface water and ground water under the influence systems serving fewer than 10,000 persons must comply with strengthened turbidity performance standards and individual filter monitoring and reporting requirements
    - States begin first round of sanitary surveys

Public Health Concerns Addressed

- *Cryptosporidium* is common in source waters and is highly resistant to chlorination disinfection practices
- *Cryptosporidium* causes gastro-intestinal illness lasting a few days in healthy, adult individuals
- Symptoms can be much more severe in sensitive populations (including death for those with weakened immune systems)
- Milwaukee outbreak
  - 400,000 illnesses
  - 4,000 hospitalizations
  - 50 deaths

Waterborne Disease Outbreaks Cause Irreparable Damage to Public and PWSs

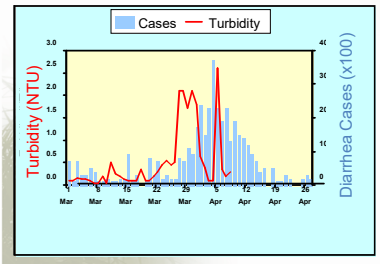
Year	State/Territory	Cause of Disease	No. of People Affected
1985	Massachusetts	*Giardia lamblia* (protozoan)	703 illnesses
1987	Georgia	*Cryptosporidium parvum* (protozoan)	13,000 illnesses
1987	Puerto Rico	*Shigella sonnei* (bacterium)	1,800 illnesses
1989	Missouri	*E. coli* 0157 (bacterium)	243 illnesses / 4 deaths
1991	Puerto Rico	*Unknown*	9,847 illnesses
1993	Missouri	*Salmonella typhimurium* (bacterium)	650 illnesses / 7 deaths
1993	Wisconsin	*Cryptosporidium parvum* (protozoan)	400,000 illnesses 50+ deaths
1998	Texas	*Cryptosporidium parvum* (protozoan)	1,400 illnesses
1999	New York	*E. coli* 0157 (bacterium)	150 illnesses / 1 death
2000	Ontario	*E. coli* 0157 (bacterium)	1,000 illnesses / 7 deaths

Source: HDR's Handbook of Public Water Systems

Milwaukee Disease Outbreak - 1993

403,000 illnesses (out of 1.6 million population)

Ineffective coagulation, flocculation, and filtration



Benefits of the LT1ESWTR

- Improve public health by increasing level of protection from exposure to *Cryptosporidium* and other pathogens through improvements in filtration
- Decrease the likelihood of endemic illness from *Cryptosporidium* by 110,000 to 463,000 cases annually and related health costs
- Reduce likelihood of occurrence of out-breaks by providing a larger margin of safety

LT1 Treatment Techniques

- Treatment techniques in lieu of MCLs for *Giardia lamblia*, viruses, heterotrophic plate count bacteria, *Legionella*, and *Cryptosporidium*
- These requirements are in addition to the requirements in the existing Surface Water Treatment Rules

LT1 Treatment Techniques

- Treatment technique requirements consist of installing and properly operating water treatment processes that reliably achieve a number of conditions
- Filtered systems
  - At least 99% (2 log) removal of *Cryptosporidium* between point where source water is not subject to recontamination by surface water runoff and point downstream before or at first customer
  - Unfiltered systems:
  - Must include *Cryptosporidium* control under watershed control program
  - Compliance with disinfection profiling and benchmarking provisions

Surface Water Treatment Techniques

- System is in compliance with treatment technique requirements if it meets SWTR and LT1ESWTR requirements
  - Disinfection (including profiling/benchmarking); and
  - Filtration avoidance or applicable turbidity performance standards

Turbidity Standards

- Systems using conventional filtration or direct filtration
  - Turbidity level of representative samples of filtered water must be less than or equal to 0.3 NTU in at least 95% of the measurements taken each month
  - Turbidity level of representative samples of filtered water must at no time exceed 1 NTU
  - Framework for these requirements is identical to SWTR—only specific standards have changed

Monitoring Requirements for Individual Filters

- Rule establishes new requirements to continuously monitor individual filter performance
- Individual filter monitoring requirements are not part of the treatment technique
- Exceedance of the performance requirement triggers other actions—it is not a violation
- Designed to raise awareness of individual filter performance (informational)

Individual Filter Provisions

- Monitoring Requirements
- For systems using conventional or direct filtration
  - Systems must conduct continuous turbidity monitoring for each individual filter
    - If a system has 1 or 2 filters, continuous monitoring of the combined filter effluent may be substituted.
  - Systems must record results of individual filter monitoring every 15 minutes
  - Must calibrate turbidimeters using procedure specified by manufacturer
  - If there is a failure in the continuous turbidity monitoring equipment, system must conduct grab sampling every 4 hours in lieu of continuous monitoring but for no more than 5 working days following failure of the equipment

Individual Filter Provisions

- Trigger (A)
  - Individual filter turbidity level greater than 1.0 NTU in 2 consecutive measurements taken 15 minutes apart
- Action (A)
  - Record filter number, turbidity measurement, date(s) exceedance occurred
  - Produce filter profile within 7 days of exceedance (if no obvious reason for exceedance)
  - Report that profile has been produced or report obvious reason for exceedance within 10 days after then end of each month system serves water to the public

Individual Filter Provisions

- Trigger (B)
  - Individual filter turbidity level greater than 1.0 NTU in 2 consecutive measurements taken 15 minutes apart in each of 3 consecutive months
- Action (B)
  - Record filter number, turbidity measurement, date(s) exceedance occurred
  - Self-assessment of filter within 14 days of exceedance
    - Assessment of filter performance
    - Development of filter profile
    - Identification/prioritization of factors limiting performance
    - Assessment of applicability of corrections
    - Filter self-assessment report

Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR)

January 24, 2005

LT2ESWTR Requirements

- Purpose: to limit exposure by requiring microbial disinfection based on source water quality
- Required disinfection levels –
  - *Cryptosporidium* 3.0 log - 5.5 log (99.9% - 99.9997%)
  - viruses (IESWTR) 4.0 log (99.99%)
  - *Giardia* (IESWTR) 3.0 log (99.9%)

Rule Background

- Builds on existing Surface Water Treatment Rules
- Flexible, risk-based Rule based on new *Cryptosporidium* (*Crypto*) data
- Accounts for
  - Current level of treatment
  - Source water quality
  - System size
- Offers range of compliance options
- Improves public health protection

Rule Summary

- Source water monitoring requirements
- Profiling and benchmarking requirements
- Treatment technique requirements
- Microbial toolbox components
- Uncovered finished water storage facilities
- Sanitary surveys

Sanitary Survey - Definition

"..an onsite review of the water source, facilities, equipment, operation and maintenance of a public water system for the purpose of evaluating the adequacy of such source, facilities, equipment, operation, and maintenance for producing and distributing safe drinking water."

Why Conduct Sanitary Surveys?

- Helps to ensure:
  - Public health protection
  - Compliance with regulations
- Proactive and preventive in nature

8 Elements of A Sanitary Survey as Defined by EPA

1. Source
2. Treatment
3. Distribution System
4. Finished Water Storage
5. Pumps, Pumping Facilities, and Controls
6. Monitoring, Reporting, and Data Verification
7. System Management and Operation
8. Operator Compliance with State Requirements

Crypto Monitoring

- Applies to system ≥ 10,000
- Sample at least monthly for 2 years for crypto, turbidity and *E. coli*
- **Initial Distribution System Evaluation (IDSE)** and Compliance Monitoring
- Monthly reporting of results to State or EPA HQ

E. coli Monitoring

- Applies to systems < 10,000
- Sample at least once every two weeks for 1 year
- Crypto monitoring initiated if annual mean *E. coli* concentration is greater than…
  - 10 *E. coli* /100 mL for lake/reservoir sources
  - 50 *E. coli* /100 mL for flowing stream sources
- Crypto monitoring at least twice per month for 1 year or monthly for 2 years
- Monthly reporting to state

Population Based Monitoring

- Required for **Initial Distribution System Evaluation (IDSE)** and Compliance Monitoring
- Monitoring based on population and source water type
- Targets problem areas based on better understanding of DBP, Crypto, E. coli occurrence and formation
- Greater equity of public health protection

The IDSE

- Purpose: to select new monitoring sites that more accurately reflect sites representing high TTHM and HAA5 levels
- Approach: standard monitoring program or system-specific study

IDSE General Requirements

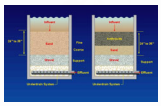
- Purposes of IDSEs
  - Determine locations of high TTHMs and HAAs throughout the distribution system
  - Results are used in conjunction with the Stage 1 DBPR monitoring in order to identify locations for Stage 2 DBPR monitoring

IDSE – Very Small System Waivers

- For systems serving under 500, the State will review the current data to determine whether existing monitoring locations are sufficient. The status of an IDSE waiver will be documented in the system's monitoring schedule, if applicable.

SDWA Individual Rules

- **Filter Backwash Recycling Rule (FBRR)**
  - Reduces risks from recycling contaminants removed during filtration
  - Affects systems that recycle spent filter backwash water, thickener supernatant, or liquids from dewatering



Background

- Filter backwash recycle reintroduces contaminants back into the treatment process
- 1996 SDWA Amendments require EPA to promulgate a regulation that "governs" recycle of filter backwash water within a treatment plant

Purpose of FBRR

- Recycle streams are source of high concentration of microbial pathogens and chemical contaminants
  - Contribute to the contaminant load
  - Coagulant chemistry imbalance
  - Hydraulic surge--overwhelms plant's unit processes
- Waste flows may adversely affect plant performance and, subsequently, pathogen removal

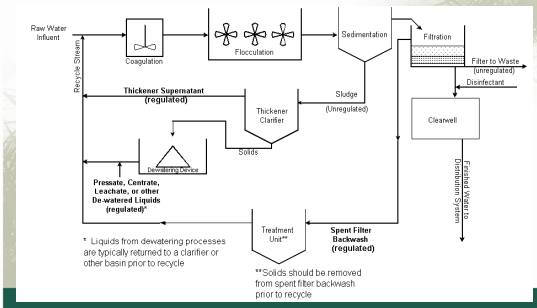
Purpose of FBRR

- FBRR reduces potential for *Cryptosporidium* oocysts to pass through filters into finished water by ensuring proper management of residual streams
- FBRR also allows States to evaluate recycle practices and identify any potential problems.

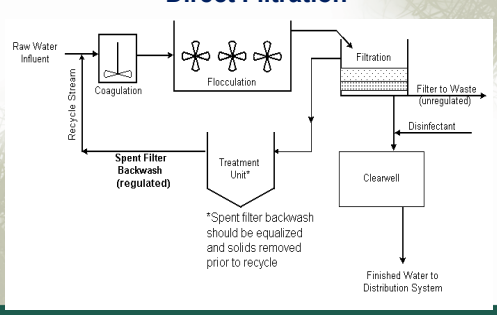
Systems Covered by FBRR §141.76(a)

- SW and GWUDI (Subpart H) systems that employ conventional or direct filtration and
- Recycles one or more of the following:
  - Spent Filter Backwash Water
  - Thickener Supernatant
  - Liquids from Dewatering Processes

Conventional Treatment Plant

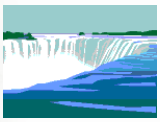


Direct Filtration



What is Filter Backwash Water?

- Resulting water pushed back through the filter in the cleaning process
- Filter backwashing is an integral part of treatment plant operation



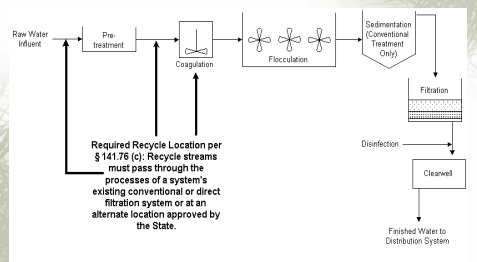
What is Thickener Supernatant? What are Liquids from Dewatering Processes?

- Thickener Supernatant
  - The "clear water" that exits sedimentation basins and clarifiers after particles have been allowed to settle out
- Liquids from Dewatering Processes
  - Dewatering processes remove water from waste solids "sludge" in order to reduce the solids volume to be disposed

Key Components

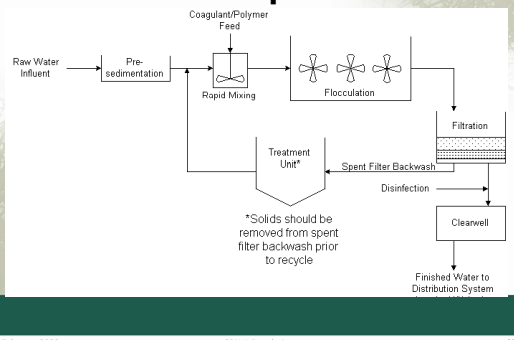
- Submit Data to State
  - Plant schematic
  - Plant and recycle flow rates
  - State-approved operating capacity of plant
- Appropriate Recycle Return Location
  - Through all processes of a system's conventional and direct filtration treatment
  - State-approved alternate location
- Maintain Specific Records

Recycle Return Location

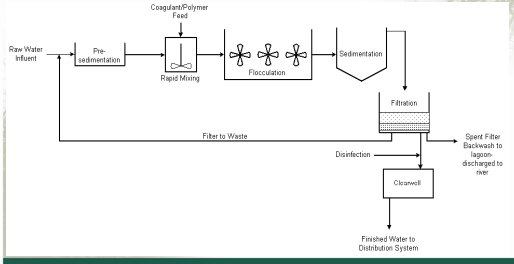


Regulated Recycle Streams: Spent filter backwash water, thickener supernatant and liquids from dewatering processes.

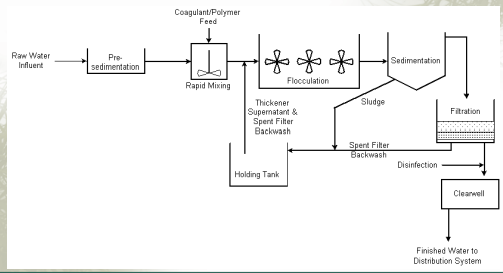
Example 1



Example 2



Example 3

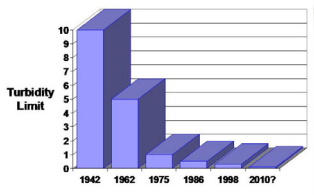


Stage 1 and 2 Disinfection/Disinfection Rules (Stage 1 DBPR & Stage 2 DBPR)

January 24, 2005

Treatment Goals

- Stage 2 D/DBP Rule
  - Remove natural organic matter
- Long Term 2 ESWTR
  - Remove particles/turbidity
  - Turbidity goal: 0.1 NTU



Monitoring Requirements

Monitoring Frequency and Number of Sites

Stage 1 DBPR:
- *Plant-based*
- *Dependent on number of treatment plants or wells*

Stage 2 DBPR:
- *Population-based*
- *Dependent on population served*

Disinfectants and Disinfection Byproducts (D/DBP) Rules

- Applies to any CWS/NTNC system that adds a disinfectant
- Effective dates:
  - Stage 1 D/DBP Rule - January 2002 (>10,000 SW)
  - Stage 1 D/DBP Rule - January 2004 (SW<10,000 and GW)
  - Stage 2 D/DBP Rule – January 2006 – October 2013 (all populations; SW and GW)
- Balance benefits of acute microbial protection against risks of chronic exposure to disinfection byproducts

Disinfectant and Disinfection Byproducts (DBPs)

- **Disinfectants**
  - **Chlorine**
  - **Chloramines**
  - **Chlorine Dioxide**
- **Maximum Residual Disinfectant Level (MRDL)**
  - Level of a disinfectant added for water treatment that may not be exceeded at the consumer's tap without an unacceptable possibility of adverse health effects

Disinfectants and Disinfection Byproducts (DBP)

Regulated DBP Contaminants	MCL (mg/L)	MCLG (mg/L)	Regulated Disinfectants	MRDL* (mg/L)	MRDLG* (mg/L)
Total Trihalomethanes (TTHMs)	0.080		Chlorine	4.0 as Cl_2	4
Chloroform		-			
Bromodichloromethane		Zero			
Dibromochloromethane		0.06			
Bromoform		zero			
Five Haloacetic Acids (HAA5)	0.060		Chloramines	4.0 as Cl_2	4
Monochloroacetic acid		-			
Dichloroacetic acid		Zero	Chlorine dioxide	0.8	0.8
Trichloroacetic acid		0.3			
Bromoacetic acid		-			
Dibromoacetic acid		-			

Disinfectants and Disinfection Byproducts (DBP)

Regulated DBP Contaminants	MCL (mg/L)	MCLG (mg/L)		MRDL* (mg/L)	MRDLG* (mg/L)
Bromate (plants using ozone)	0.010	Zero	*Stage 1 DBPR includes maximum residual disinfectant levels (MRDLs) and goals (MRDLGs) which are similar to MCLs and MCLGs but for disinfectants		
Chlorite (plants using chlorine dioxide)	1.0	0.8			
Treatment Technique					
Enhanced coagulation/enhanced softening to improve removal of DBP precursors (See Step 1 TOC Table for systems using conventional filtration treatment)					

IDSE – 40/30 Certification

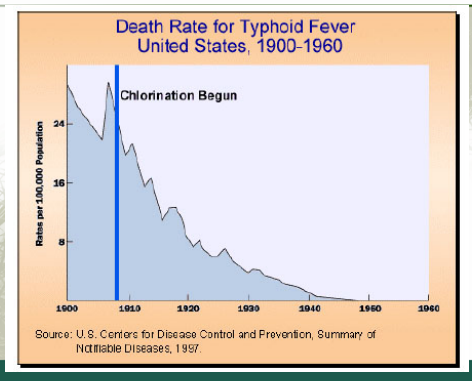
- For systems with consistently low DBP levels, the IDSE requirements may be waived. The State will identify the waiver status in the system's monitoring schedule.

40/30 Certification

- Eligibility
  - All required Stage 1 DBPR (Subpart L) compliance samples have been taken
  - No individual sample exceeded 0.040 mg/L for TTHM.
  - No individual sample exceeded 0.030 mg/L for HAA5
  - No TTHM or HAA5 monitoring violations.
- MDE will review data & Determine 40/30 waivers, if applicable
  - Refer to monitoring schedules each year for changes.

Disinfection

- Goal
  - To destroy or inactivate pathogenic microorganisms including bacteria, cysts, algae, spores and viruses.
- Problem
  - Forms disinfection byproducts



Methods of Disinfection

Chemical Oxidation	Physical Means
Chlorine	**Ultraviolet light**
Ozone	Heat
Peracetic Acid (new)	Membranes

Comparative Effectiveness of Disinfectants

	Crypto	Giardia	Viruses	Residual
Chlorine	**NE**	**G**	**E**	**G**
Chlorine dioxide	**P/F**	**G**	**G**	**F**
Ozone	**P/F/G**	**E**	**G/E**	**P**
Chloramines	**NE**	**P**	**P**	**G**
UV	**E**	**E**	**F**	**none**

NE – not effective; P – poor; F – fair; G – good; E - excellent

Comparative Effectiveness of Disinfectants

Treatment Process	Microorganisms		
	Viruses	Bacteria	Protozoans
Free chlorine	Very effective	Very effective	Less effective
Chlorine dioxide	Effective	Very effective	Effective
Iodine	Effective	Effective	Not effective
UV light	Effective	Very effective	Very effective
Natural sunlight	Effective	Effective	Less effective
Boiling	Very effective	Very effective	Very effective
Membrane Filtration	Variably effective	Very effective	Very effective

Chlorine

- Most widely used disinfectant
- Saved millions of lives and eliminated waterborne diseases such as cholera and typhoid
- Relatively easy to use
- Safety concerns for liquid chlorine cylinders or tank cars (chlorine gas)
- Relatively inexpensive
- Major disadvantages:
  - production of THMs, HAAs, other chlorinated disinfection byproducts
  - must dechlorinate wastewater

Disinfection Performance Goal

Disinfection Goal:

Maintain ≥ 0.20 mg/L free chlorine
At all monitoring sites in the distribution system, at all times.

- Regulatory Requirements:
  - Minimum of 0.20 mg/L free chlorine
  - Maximum of 4.0 mg/L free chlorine

Site Specific Conditions

- Chlorine Disinfection
  - Disinfectant Residual Cannot Be < 0.2 mg/l for More Than 4 Hours (or > 4.0 mg/l)
    - Unless Caused by "Unusual and Unpredictable Circumstances"
  - Disinfectant Residual in the Distribution System Cannot Be Undetectable in More Than 5 Percent of Monthly Samples for Any Two Consecutive Months

Disinfection – Regulatory Goals

- EPA's regulatory framework requires systems using surface water (or groundwater "under the direct influence" of surface water) to:
  - **Disinfect** their water **and/or**
  - **Filter** their water or meet criteria for avoiding filtration so that the following contaminants are controlled at the following levels
    - † Cryptosporidium - 99 percent (2-$\log_{10}$) removal
    - † Giardia lamblia - 99.9 percent (3-$\log_{10}$) removal/inactivation
    - † Viruses - 99.99 percent (4-$\log_{10}$) removal/inactivation

General Requirements

- Establishes **Treatment Techniques** That Must Achieve:
  - At Least 99.9 Percent Removal And/or Inactivation of *Giardia lamblia* Cysts
  - At Least 99.99 Percent Removal And/Or Inactivation of Viruses
    - Between a Point Where the Water Is Not Subject to Contamination by Surface Water Runoff and a Point Before the First Customer

Removal Efficiency is Dependent on Microbial Type

- *Giardia* and *Cryptosporidium*
  - Filtration is best
    - Large size
    - Resistant cyst and oocyst
- Bacteria and Enteric Viruses
  - Disinfection is ultimate barrier
  - Filtration and coagulation also help via adsorption to particles
    - Dependent on surface charge of virus

Disinfection Basics

- The chlorine dose required depends on two considerations: the chlorine demand and the desired chlorine residual.
- Dose = Demand, mg/L + Residual, mg/L
- The chlorine demand is the amount used up reacting with various components of the water such as harmful organisms and other organic and inorganic substances
- When the chlorine demand has been satisfied, demand reactions stop

CHLORINE CHEMISTRY

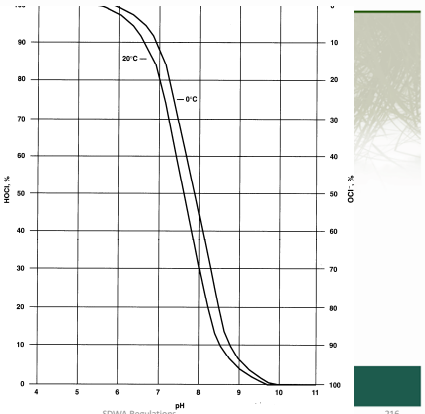
- Cl_2 + H_2O -> HOCl + HCl
- Which one is the bacteria killer ?

  hypochlorous acid = HOCL "Killer"
- HOCl -> H+ + OCl-

  0……7……..14

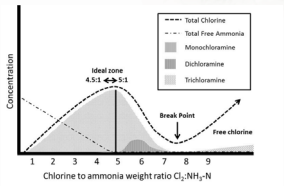
  pH
- How does pH effect the disinfection process ?

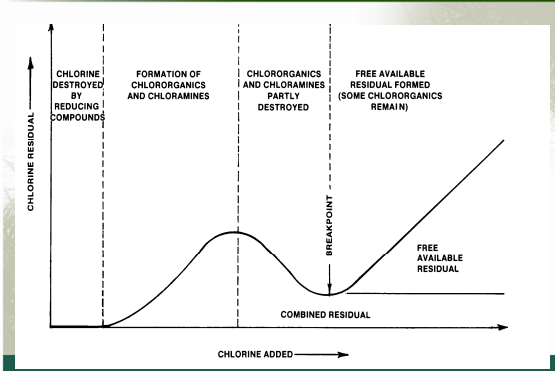
As pH goes up the amount of HOCl drops off.



Breakpoint Chlorination Curve

- Understanding breakpoint chlorination and chlorine interactions with ammonia are critical for understanding chlorine demand:
  - Total Chlorine
  - Total Free Ammonia
  - Free Chlorine
  - Monochloramines
  - Dichloramines
  - Trichloramines





Chlorine Dosages

	Min. Cl Dosage* Mg/L-min	Min. Contact Time, minutes	Min. Cl Residual mg/L	Max. Cl Residual mg/L
Typical	> 20	> 30	> 0.2	< 4.0
Virus inactivation	> 4	3-log reduction		
Giardia inactivation	> 100			

* Dosage to comply with EPA Filtration and Disinfection requirements

Waterborne Diseases

Bacteria	*Escherichia coli* (gastroenteritis) *Salmonella typhi* (typhoid fever) *Vibrio cholerae* (cholera) *Shigella* (dysentery)
Viruses	Norovirus (gastroenteritis) Rotavirus (gastroenteritis) Hepatitis A virus (infectious hepatitis) Adenovirus (respiratory, gastroenteritis)
Protozoa	*Giardia lamblia* (gastroenteritis) *Cryptosporidium parvum* (cryptosporidiosis)

Types of Disinfectant Systems

- Chemical agents
  - chlorine (Cl_2)
  - chlorine dioxide (ClO_2)
  - ozone (O_3)
  - chloramines
- Physical agents
  - UV radiation
  - membranes

CHLORINE CHEMICALS

- Chlorine, Cl_2 100%
  Gas compressed to liquid
- Sodium Hypochlorite, NaOCl 12% -15%
  Household bleach, 1% – 8 %
- Calcium Hypochlorite, $Ca(OCl)_2$ 65%
  HTH is used primarily in swimming pools
  Tablets available for residential wells

Chlorine Disinfection

- Advantages:
  - Low cost
  - Easy to obtain??
  - Effective at low doses
- Disadvantages:
  - Residual harmful to environment
  - Toxic and hazardous to handle

Disinfection

- Effectiveness is based on "Dosage":

Dosage = "Dose" X "Time"

Where: **Dosage =** **rate of application of a dose**

Dose = Quantity:
- Chlorine residual concentration
- UV light Intensity

Time = Detention, contact, or exposure

Chlorine versus UV

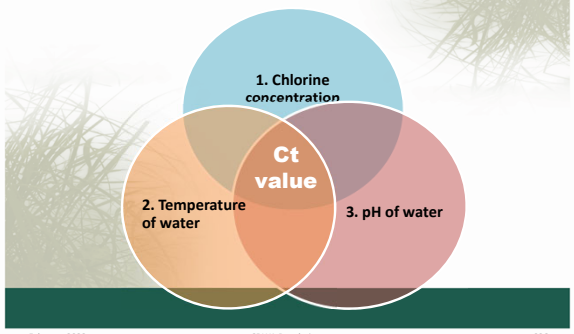
- ***Chlorine dosage (CT) = C x t***

Where, CT = Chlorine dosage, mg/L-min
C = Residual Chlorine concentration, mg/L
t = Contact time, minutes

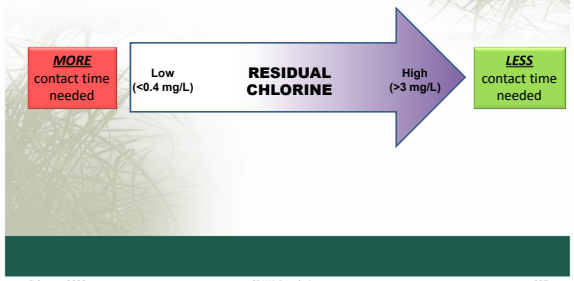
- ***UV dosage (D) = I x t***

Where, D = UV dosage, mW-sec/cm^2 or mJ/cm^2
I = UV intensity, mW/cm^2
t = exposure time, seconds

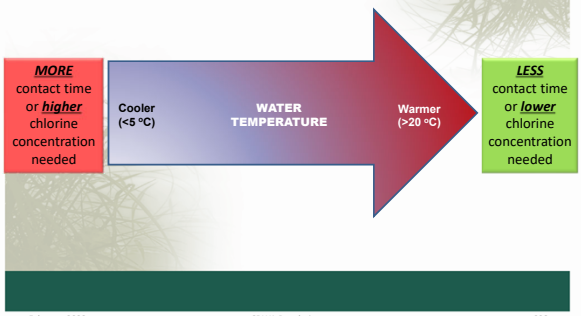
Factors Affecting Ct Value



Factors Affecting Ct, Chlorine Dose

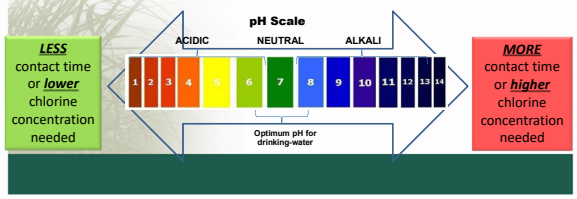


Factors Affecting Ct, Temperature



Factors Affecting Ct, pH

- pH measures acid or alkaline (or basic) conditions in water
  - pH 7 considered neutral, pH <7 considered acidic and pH >7 considered alkali

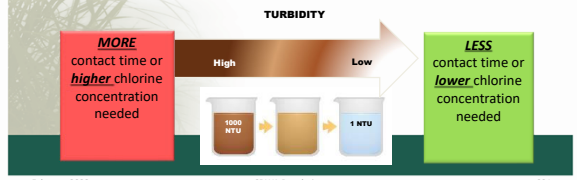


Factors Affecting Ct, pH

- **For effective chlorination, the pH of the water should be < pH 8.0**
- To balance water quality considerations, including chlorination, the optimum pH of drinking-water is generally between pH 6.5 and pH 8.5
- Where water is >pH 8.0, higher chlorine concentrations or more contact time will be required!

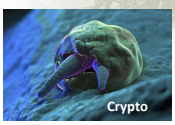
Factors Affecting Ct, Turbidity

- Chlorine reactive substances may consume chlorine and increase chorine demand
- May also 'shield' microorganisms from inactivating chlorine effects



Factors Affecting Ct, Microorganism





BACTERIA VIRUSES PROTOZOA

LESS contact time or ***lower*** chlorine concentration needed

MOST EFFECTIVE LEAST EFFECTIVE

MORE contact time or ***higher*** chlorine concentration needed

SEWAGE

Potential Health Issues?

- Microbial Health Concerns
  - Cryptosporidiosis and Giardiasis
    - Vomiting and diarrhea, potentially life threatening for immune compromised, elderly and young
- Disinfection By-Product Health Concerns
  - Cancer
    - Bladder, colon and rectal
  - Reproductive
    - Neural tube defects and miscarriages
  - Brominated compounds are thought to pose a greater health risk than chlorinated compounds
  - Nitrogenated compounds may be even worse???

How we know the disinfection process is working

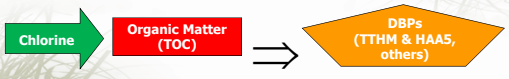
- Coliform testing
  - State and Federal law requires testing
  - Number of tests is based of population served
- Federal Surface Water Treatment Rule
  - Requires all surface water systems to use a "treatment technique" to remove or inactivate disease causing organisms

The Disinfection Barrier:
What's not working…

- Distribution system evaluations indicate:
  - Water systems aren't monitoring throughout their systems
  - At critical sites, free chlorine residual is not maintained ≥ 0.2 mg/L.

The Flip Side:
Disinfection Byproduct (DBP) Formation

- DBPs are formed when chlorine (or other disinfectant) reacts with organics (total organic carbon) in the water



- Formation is impacted by:
  - Reactions within the bulk water (due to increased chlorine, temperature, organics, etc.)
  - Reactions within the distribution system infrastructure (e.g., biofilm, etc.)
  - Water age (time)

Risks Must be Balanced

Increase Chlorine = Increase DBPs

Decrease Chlorine = Increase Microbial Risk

Disinfection By-products (DBPs)

- By-products of reactions between disinfectant (chlorine, ozone, etc.) and natural organic matter present in source water

All disinfectants form DBPs

- Chlorine – TTHMs, HAA5, other chlorinated DBPs (haloacetonitriles, haloketones, etc)
- Chloramines – N-nitrosodimethylamine (NDMA), other nitrogenous DBPs
- Chlorine dioxide – chlorite, chlorate
- Ozone – bromate, aldehydes, keytones, etc.

DBP Formation

NOM = natural organic matter

NOM + Cl_2 --------> THMs, HAAs, other chlorinated DBPs

NOM + Cl_2 + Br^- --------> brominated THMs, HAAs, other DBPs

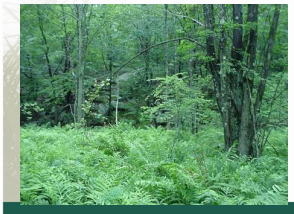
{Depends on chlorine dose, NOM concentration (and type), temperature, pH, time}

Natural Organic Matter (NOM)

- Present in all natural waters
- Consists of living organisms:
  - algae, protozoa, bacteria, viruses
- Consists of non-living material:
  - decayed vegetation, humic substances
- Usually measured as TOC or DOC
- Largest fraction of DOC is usually humic substances
- Can only identify about 20 % of the DOC

Stormwater Runoff – Major Source of Organic Matter

Forests and wetlands help control runoff and nutrients but ...



contribute color and organic compounds

Sources of Organic Matter

NOM Removal

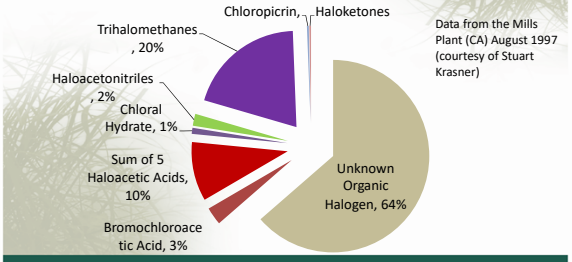
Why Do We Care?

- NOM is present in all surface waters
- Exerts a disinfectant demand
- **Precursor to THMs and HAAs and other DBPs**
- Coagulant demand – NOM controls the optimum coagulant dose for most waters, *not turbidity*
- Source of color
- Fouling of membranes and GAC adsorbers
- Increases solubility of pollutants and heavy metals
- Carbon source for biofilm growth
- Can affect corrosion
- Source of tastes and odors

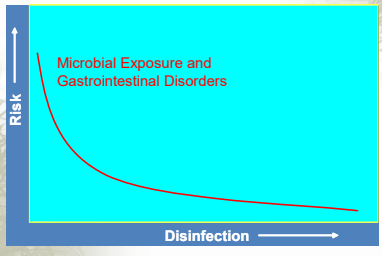
In most cases, we want to maximize NOM removal

Emerging Disinfection Byproducts

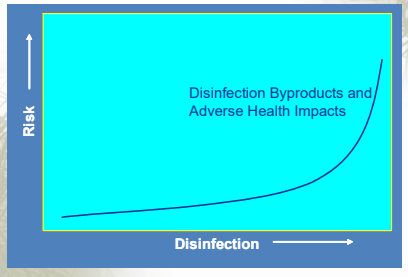
- What do we really know??



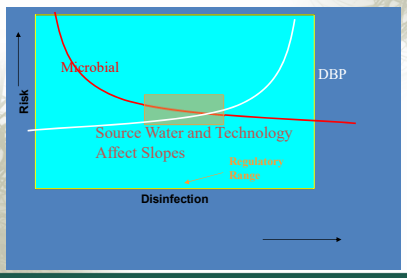
Microbial Risks



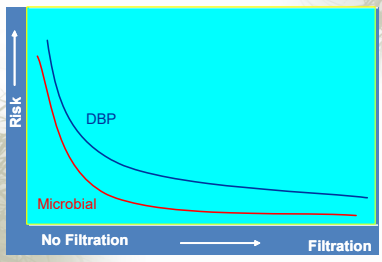
Disinfection Byproduct Risks



Microbial vs. DBP Risk Trade-Offs



Filtration Reduces both Microbial and DBP Risks



SDWA Individual Rules

- Stage 1 Disinfectants/Disinfection Byproducts Rule (DBP)
  - Increases requirements for some regulated DBPs
  - Sets new requirements for haloacetic acids, chlorite, and bromate

Specific Requirements MCLs and MRDLs

Compound(s)	Stage 1 & 2 (mg/L)
TTHMs	0.080
HAA5	0.060
Bromate	0.010
Chlorite	1.0
Chlorine	4.0
Chloramines	4.0
Chlorine Dioxide	0.8

Stage 1: System-wide Running Annual Avg. (RAA)

Stage 2: Locational Running Annual Avg. (LRAA)

MRDLs for Chlorine and Chloramines may be exceeded in response to public health problems

Stage 1 Sampling Frequency

Surface	Sampling Frequency	Ground
≥10,000	4/plant/quarter (1 max, 3 rep. RT)	
500 - <10,000	1/plant/quarter (max RT)	≥10,000
< 500	1/plant/year (warmest month)	< 10,000

Stage 1 D/DBP Monitoring Requirements

- Chlorine dioxide
  - Chlorine dioxide plants
  - Daily at entrance to distribution system
  - Compliance - Daily/follow up monitoring
- Chlorine/Chloramines
  - All systems
  - Same location and frequency as TCR monitoring
  - Compliance - Running annual average

Stage 1 D/DBP Monitoring Requirements

- **TTHM/HAA5 - Routine Monitoring**
  - Surface Water Systems >10,000 = 4/plant/Q
  - Surface Water Systems 500 – 9,999 = 1/plant/Q
  - Surface Water Systems <500 = 1/plant/Y* (warmest)
  - Ground Water Systems >10,000 = 1/plant/Q
  - Ground Water Systems <10,000 = 1/plant/Y* (warmest)
- Single sample represents the maximum residence time
- Multiple samples - 25% samples represent the maximum residence time
- Compliance - Running Annual Average
- *Increase to 1/Q if MCL is exceeded

Stage 1 D/DBP Monitoring Requirements

- DBP precursors – Total Organic Carbon
  - Conventional filtration systems
  - Monthly for total organic carbon and alkalinity
  - Compliance - Running Annual Average (RAA)
  - Systems that cannot achieve TOC removal requirements due to water quality parameters or operational constraints must apply to State for minimum TOC removal requirements within 3 months of not meeting requirements
  - If State does not approve, systems must meet TOC removal requirements

Stage 2 D/DBP Rule

- Provides greater public health and protection through:
  - Identifying locations with highest Disinfection Byproducts (DBPs)
  - Basing Compliance on Locational Running Annual Average (LRAA)
  - Requiring tests for connected and consecutive water systems
- Population Based Monitoring for all systems with disinfection

Stage 2 DBPR Requirements

- Purpose: to ensure that all locations in the distribution system comply with the MCLs – "environmental justice"
- Phase 2A
  - LRAA of 120/100 µg/L at Stage 1 locations
  - Continue to meet system-wide RAA of 80/60
- Phase 2B
  - LRAA of 80/60 at new "representative" high locations
- Initial Distribution System Evaluation (IDSE)
- Significant Excursions

D/DBP Rule: Stage 2

- Compliance Monitoring
  - Locational Running Annual Average (LRAA)
    - MCLs: 80/60
  - Monitoring for Large SW systems (> 10,000)
    - Quarterly sampling
    - At least one quarterly sample at peak month
    - 4-20 DS locations determined by IDSE *and* stage 1 locations
      - 2-8 at high THM sites, and 1-7 at high HAA sites
  - Monitoring for small SW systems (< 10,000)
    - 2 locations as determined by IDSE

SDWA Individual Rules

- Total Coliform Rule (TCR)
  - Objective: to monitor microbial contamination in the water distribution system
  - Establishes monitoring requirements and MCLs for indicator bacteria
  - TCR revision: final rule went into effect in 2016

Total Coliforms—Traditional Definition

- Aerobic and Facultatively Anaerobic
- Gram-Negative
- Non-Sporeforming
- Rod-Shaped
- Ferment Lactose With Gas and Acid Production
  - Within 48+/- 4 Hours at 35 +/- 0.5 C.

Fecal Coliform Bacteria—Traditional Definition

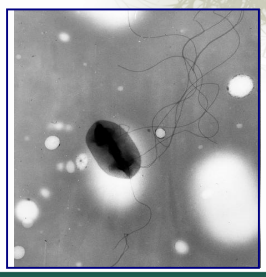
- Total Coliform Bacteria That:
  - Ferment Lactose at an Elevated Temperature When Using Standard (FC) Media
    - 44.5 +/- 0.2 C (Body Temperature)
- Short-Lived but Fecal Indicator
- *E. Coli* Is a Fecal Coliform

New Approach: Enzyme - Based Methods

- Lactose Fermentation Determined, In Part, By The Presence of β–galactosidase.
- Total Coliform's β–galactosidase Metabolizes ONPG or CNPG -- color reaction.
- E. coli's B-glucuronidase Metabolizes MUG – UV Fluorescence.

Escherichia coli

- Hundreds of Strains Known
- Most Strains Are Harmless and Live in the Intestines of Healthy Humans and Animals
- Strain O157:H7
  - Produces a Powerful Toxin
  - Causes Bloody Diarrhea and Occasionally Leads to Kidney Failure



E. coli 0157:H7

- Sources of Outbreaks
  - Undercooked Beef, Dairy Products, Raw Vegetables, Drinking Water
- Symptoms
  - Occur in 1-9 Days (3 Average); Recover in ~ 8 Days
  - Watery Diarrhea With Abdominal Pain/ Bloody Diarrhea; Little or No Fever
  - Some Develop Haemolytic Uremic Syndrome (HUS)
    - Kidney Failure May Occur, Some Cases are Fatal

E. coli 0157:H7 - Analytical Methods

- Detected Using Typical Total Coliform Methods
- Does Not Grow Well at 44.5 Degrees C
  - Fecal Coliform Incubation Temperature
- Does Not Cause A Positive Reaction With MUG
  - Does Not Cause UV Fluorescence
- Can Be Identified Using Specific Methods Followed by Serotyping.

Revised Total Coliform Rule (RTCR)

- Final February 2013
- Applies to all PWSs
  - Maximum Contaminant Level (MCL)
  - Treatment Technique Triggers (TTT)
    - Level 1 – Total Coliform MCL violations
    - Level 2 – E. coli MCL violations
- Effective April 1, 2016
- **Sampling siting plan NLT March 31, 2016**
- Beginning CY 2017, annual site visits

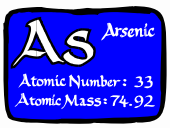
Arsenic Rule

USPHS, 1942

EPA, 2002

Arsenic Rule

- Establishes monitoring requirements
- Establishes MCL of 0.010 mg/L



Arsenic

- Number 1 deadliest poison known to humans

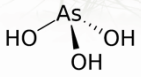
Arsenic

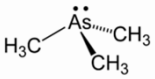
- Chlorine gas, aka mustard gas, is number 2…!

Chlorine Gas

Inorganic and Organic Arsenic

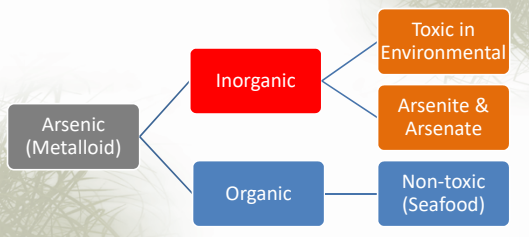
- Humans are exposed to arsenic in two forms:
  - Inorganic:
    - Arsenic compounds that contain no carbon
    - Highly toxic
    - Carcinogenic
  - Organic:
    - Arsenic compounds that contain carbon and hydrogen
    - Low to no toxic effects





Trimethylarsine: low toxicity

What is Arsenic?



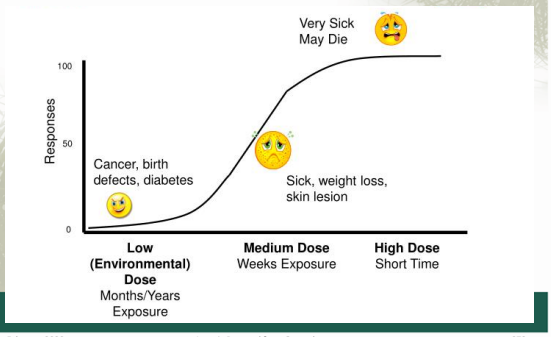
Arsenic Standard – USPHS

- In 1942, an arsenic drinking water standard of 0.05 mg/L (equal to 50 µg/L) was initially adopted by the United States Public Health Service (USPHS)
- The standard remained in effect well after EPA was form in 1970
- In the 1980s and 1990s, EPA studied lowering the standard

Health Effects of Arsenic

- Cancer
  - Bladder cancer
  - Lung cancer
- Non-Cancer
  - Heart disease
  - High blood pressure

Body's Response to Arsenic



Arsenic Rule – EPA

- In the 1996 amendments to the SDWA, Congress directed EPA to propose a new arsenic standard by January 2000
- In June 2000, EPA proposed lowering the maximum contaminant level (MCL) for arsenic from 50 µg/L to 5 µg/L or 0.005 mg/L…!
- Before finalizing, EPA requested public comments on three standard options:
  - 3 µg/L, 10 µg/L and 20 µg/L

Arsenic Rule – EPA

- In 2001, EPA adopted a lower standard for arsenic in drinking water that applies to both community water systems and non-transient non-community water systems
- The new arsenic standard of 10 µg/L (10 ppb) replaced the old standard of 50 µg/L (50 ppb)

Arsenic Rule Making

Proposed Arsenic Rule	Final Arsenic Rule

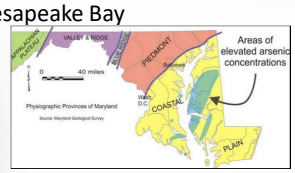
• June 22, 2000
• 5 µg/L standard
• EPA requested comments on three optional standards:
  – 20 µg/L
  – 10 µg/L
  – 3 µg/L
	• January 22, 2001
	• 10 µg/L standard adopted
	• Effective date:
	  February 22, 2002
	• Compliance date:
	  January 23, 2006

Arsenic Regulation

- Arsenic standard set at 10 ppb
  - Some states considered alower MCL
- New standard became effective 1/23/06
  - Extensions were available for smaller systems, <3,300 (up to 9 additional years possible)
  - In MD, 19 systems in Non-compliance; 12 systems with exemption; 32 MCL violations (5 systems); 28 monitoring violations as of 10/31/08

Arsenic in Maryland Groundwaters

- Arsenic concentrations exceeding 10 µg/L current drinking water standards have been detected in Maryland's Coastal Plain ground water on both sides of the Chesapeake Bay

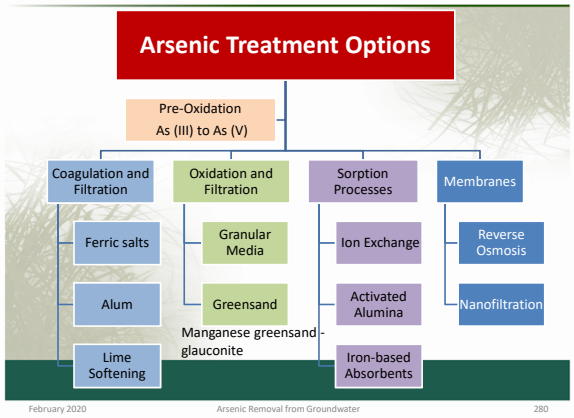


Source: Maryland Geological Survey 2008

Arsenic Removal from Groundwater

- Removal efficiency for Arsenite As(III) is poor compared to that for Arsenate As(V)
- For effective removal of arsenic from water, Arsenite As(III) forms need to be oxidized to Arsenate As(V) forms

Arsenic Treatment Options



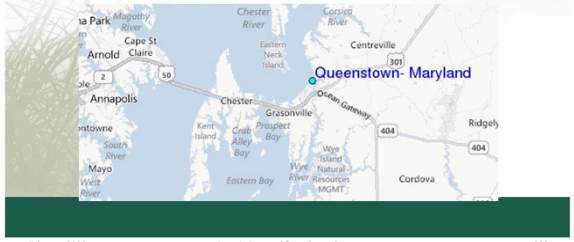
Arsenic Removal Processes

- Virtually all WTPs removing arsenic pre-oxidize first
- Most follow up with an iron-based arsenic coagulation or adsorption/filtration processes
- Approximately 80 percent use adsorptive medias, with 80 percent of the operating cost due to media replacement, e.g., throw-away media

Case Study

Queenstown, MD

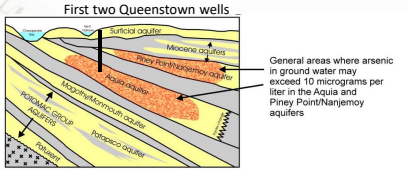
- Historic town located on the Eastern Shore of the Chesapeake Bay



Case Study
Queenstown, MD

- Until 2009, the Town had two operating wells drilled into the Aquia aquifer (300 feet below ground surface)

First two Queenstown wells



General areas where arsenic in ground water may exceed 10 micrograms per liter in the Aquia and Piney Point/Nanjemoy aquifers

Case Study
Queenstown, MD

- Aquia aquifer wells were:
  - Del Rhodes Avenue Well: (MDE Permit ID – QA79G010); installed in 1932; capacity: 85,000 gallons/day
  - Queenstown Outlet Mall (MDE Permit ID – QA71G007); installed in 1988; capacity: 150,000 gallons/day
- As expected, both wells had occasional problems with arsenic levels; range 10 to 20 µg/L

Case Study
Queenstown, MD

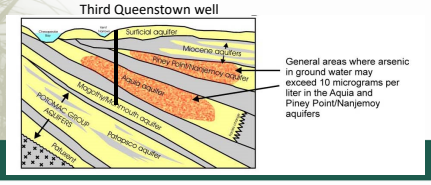
- When EPA adopted the new 10 µg/L Arsenic standard, the town had to make a choice:
  - Treat water at both wells to remove arsenic to less than 10 µg/L
  - Drill a third, but deeper well to reach the arsenic-free Magothy/Monmouth aquifer and blend it with water from the other two wells
- The Town decided to install the deeper third well to provide for future drinking water demand and fire service as well as deal with the arsenic problem

Case Study

Queenstown, MD

- A third well was drilled into the Magothy/Monmouth aquifer (650 feet below ground surface) at the Outlet Mall (Outlet Mall Well #2, MDE Permit ID – QA2008G018-01); installed in 2009; capacity: 70,000 to 100,000 gallons/day

Third Queenstown well

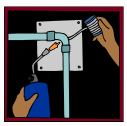


What is the Lead and Copper Rule?

The Lead Action Level is point zero one five milligrams per liter (0.015 mg/L) Sometimes you'll hear this referred to as 15 parts per billion or 15ppb. The copper action level is one point three milligrams per liter (1.3 mg/L) Which is sometimes referred to as 1.3 parts per million or 1.3ppm

SDWA Individual Rules

- Lead & Copper Rule
  - Sets action levels for lead and copper that prompt corrosion control measures if exceeded
  - Sets monitoring, testing, reporting requirements



What is the Lead and Copper Rule?

- The Lead and Copper Rule was first published in the Federal Register on June 7, 1991
- It became effective on December 7, 1992
- This rule can trigger treatment requirements when lead and/or copper in drinking water exceed certain action levels.

Lead and Copper

- Lead and copper are regulated by a treatment technique that requires systems to control the corrosiveness of their water
- If more than 10% of tap water samples exceed the action level, water systems must take additional steps
- For copper, the action level is 1.3 mg/L and for lead is 0.015 mg/L

Lead & Copper Rule

- Objective: optimize corrosion control to limit corrosion of lead and copper pipe
- Stabilize treated water by raising water pH/alkalinity or by adding phosphates
- Sample drinking water from faucets in homes

Washington, D.C.

- **Lead contamination in Washington, D.C., drinking water**, first discovered in 2001, left thousands of children with lifelong health risks, and led to a re-evaluation of the use of monochloramine in public drinking-water systems

Adverse Effects of Lead

- Infants and children:
  - Delays in physical or mental development
  - Children could show slight deficits in attention span and learning abilities
- Adults:
  - Kidney problems
  - High blood pressure

What is the Lead and Copper Rule?

Lead enters drinking water mainly from the corrosion of lead-containing household plumbing.

Lead and Copper Problems

- Washington, D.C.
  - 2001 – 2010
  - Chlorine to monochloramine use
  - Pinholes in copper piping
  - Water not stabilized
  - Lead connections (from main to homes - 25,000…!)
- Flint, Michigan
  - Change in water source
  - Water not stabilized

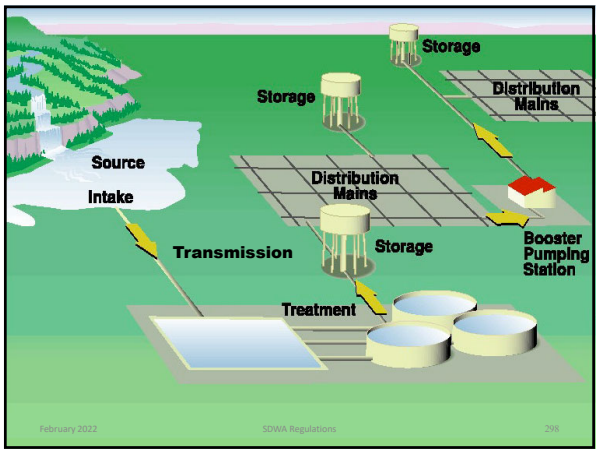
Ground Water Rule

- Final October 2006
- Periodic Sanitary Surveys
- Rule applies to groundwater systems only
- Source water monitoring for E. coli
- Sets trigger and action levels
- Take corrective actions where necessary
- Compliance monitoring

141.600

Combined Distribution Systems

- What is a Combined Distribution Systems (CDS)?
  - Defined as the interconnected distribution system consisting of the distribution systems of wholesale systems and consecutive systems that receive finished water from those wholesale system(s).
- What is a Consecutive system?
  - Defined as a public water system that receives some or all of its finished water from one or more wholesale systems.
    - NOTE: In addition to buying finished water, some consecutive systems also operate a treatment plant (meaning a plant that treats source water to produce finished water).



Combined Distribution Systems (CDS)

- What is a Wholesale system?
  - Defined as a public water system that treats source water as necessary to produce finished water and then delivers some or all of that finished water to another public water system. Delivery may be made through a direct connection or through the distribution system of another consecutive system.
    - NOTE: Under this definition, a consecutive system that passes finished water from a wholesaler to another consecutive system, and that does not also treat source water, is not a wholesale system. Rather, the system that actually produces the finished water is responsible for any wholesale system requirements.

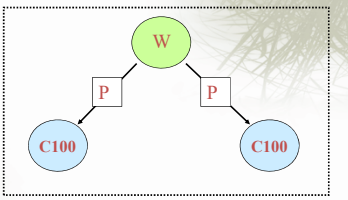
CDS Example #1

Symbol Key

W-Wholesaler

P-permanent connections

C100-consecutive system that receives all finished water from one or more W systems



Determination: All 3 systems are part of same CDS
Rationale: The connections between systems are permanent.

CDS Example #2

Symbol Key

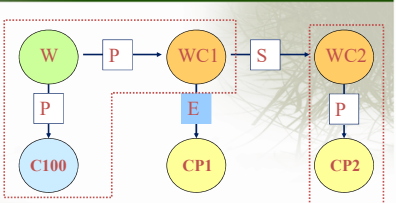
W-Wholesaler

P- Permanent connections

C100-consecutive system that receives all finished water from one or more W systems

CP- consecutive that allows produces its own finished water

E- Emergency Connections



Determination:
CDS-1: W,C100 and WC1
CDS-2: WC2, CP2
CP1: Independent system

Rationale:
WC2: Receives only 3% of total volume of water
WC2 & CP2: Part of a separate CDS
CP1: Emergency connection has never been used

SDWA Individual Rules

- Radionuclides
  - Sets uranium MCL
  - Revises monitoring requirements for combined radium 226/228, gross alpha particle and beta particle, and photon radioactivity

Radionuclides Rule

- Federal Rule Finalized 2000
  - Radon not included, will be a separate rule
- Standards for Radium 226, Radium 228,and Uranium
  - Combined Radium-226/Radium-228 5 pCi/L
  - Gross Alpha Particle activity 15 pCi/L
  - Uranium 30 ug/L
- Compliance deadline December 8, 2003

Two More Rules

- Public Notification Rule
  - Requires customer notification of violations
  - Specifies time frames based on seriousness of violation
- Consumer Confidence Report Rule
  - Required of all CWS
  - Yearly water quality report to customers

141.32 General Public Notification

- **Purpose:**
  - To Protect Public Health by Requiring Timely Public Notification When Contamination or Other Risks Occur
- **Requirements Available From EPA's Website**
  - www.epa.gov/safewater/pn.html

Public Notification Rule

- Objective: to notify the public of any acute or chronic health risks related to drinking water
  - Tier 1 notification – within 24 hours using appropriate communication methods
  - Tier 2 notification – within 30 days
  - Tier 3 notification – within 1 year

Subpart Q—Public Notification

- Initial Requirements Published May 4, 2000
- Effective Dates:
  - October 31, 2000 in Direct Implementation Arenas
  - May 6, 2002 in Primacy States
- Major Changes:
  - Tier 1 - Potential for Serious Short-Term Health Effects
  - Tier 2 Serious but Not Immediate
  - Tier 3 All Other Violations

Subpart Q—Public Notification: Public Notification Rule Major Changes

- Tier 1 Violations
  - Fecal Coli MCL
  - Response Time Reduced From 72 Hours to 24 Hours
- Tier 2 Violations (Other MCLs,TTs)
  - Serious but Not Immediate
  - Response Time Extended to 30 Days From 14 Days

Subpart Q—Public Notification: New PN Rule Major Changes (cont.)

- Tier 3 Violations (All Other Violations)
  - Less Serious and Long-Term Effects
  - Response Time and Repeats Extended to 12 Months From 3 Months
- Mandatory Health Effects Language Is Simplified

Consumer Confidence Report (CCR)

- Objective: to educate the public about contaminants found in their drinking water
- Annually send CCR to all customers (small pamphlet with website identified)

Part 141.31—Reporting Requirements

- 141.31 Reporting Requirements
  - Supplier of the Water Must Report to the State Within 48 Hours Failure to Comply With Any NPDWR, Including Monitoring Requirements.

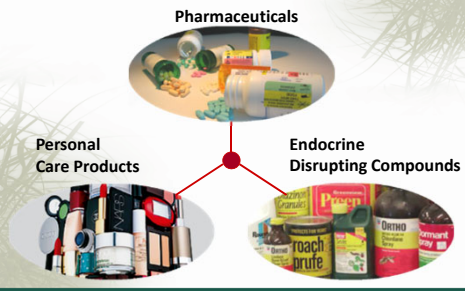
SAFE DRINKING WATER ACT REGULATIONS

Future Regulation Activity

"Emerging Contaminants"

- Pharmaceuticals and Personal Care Products (PPCPs)
- Pharmaceutically Active Compounds (PhACs)
- Trace Organic Contaminants (TOrCs)
- Endocrine Disrupting Compounds (EDCs) – Chemicals that interfere with the function of the endocrine system
- Contaminants of Emerging Concern (CECs)

Emerging Contaminants - Micro-constituents



Emerging Disinfection Byproducts

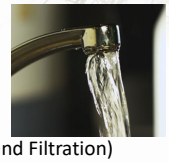
- Scientific community debating the toxicity and public health relevance of emerging DBPs
  - Concern about chloramine-related DBPs vs. chlorine-related DBPs
- Ideas have been floated at conferences:
  - Find and apply a better surrogate than THMs and HAAs?
  - Total Organic Halide (TOX) instead of THMs and HAAs?
  - Regulate more toxic DBPs (iodo- and bromo-compounds)?
  - Force GAC across all treatment plants as a TT?

Emerging Disinfection Byproducts

- Lots of potential techniques (a few are listed here)
  - Point of Chlorination, Chloramination
  - Enhanced Coagulation
  - UV or Ozone disinfection
  - GAC
  - Ion Exchange
  - High Pressure Membranes (RO or NF)

Manganese

- Under review at EPA—regulatory changes uncertain
- Potential Treatment:
  - Potassium permanganate
  - Chlorine Dioxide
  - Ozone
  - Free Chlorine
  - Oxide-Coated Filter Media (Greensand Filtration)
  - Lime-Soda Ash Water Softening
  - Biological Mn Removal



Microbial Contaminants

- Enteroviruses and Noroviruses are on UCMR3
  - Known outbreaks related to water
  - Mostly concerned with groundwater systems
  - Potential for concern with surface water systems
- Pathogens in biofilms
  - Premise plumbing in hospitals, hotels, schools, etc.
  - Examples: *Legionella, Naegleria fowleri*
- Controls??
  - Change in filtration or disinfection practices?
  - Distribution system residual disinfectant?
  - Private management of premise plumbing systems

Summary

- 94 chemicals and microbial contaminants are regulated under the SDWA
- Chlorine disinfection and final filtration are the two most important water treatment processes regulated by the SDWA
- EPA will be slow to promulgate any future drinking water standards
- D/DBPs and Perfluorinated chemicals likely to be regulated

The End

Questions?

Evaluation Survey – to be given prior to the final quiz:
https://form.jotform.com/211263553828154

Thank You

Final Quiz – to be timed (one submission per student):
https://form.jotform.com/211263353181144

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