Water Quality and Drinking Water Regulations

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February 25, 2020

http://www.divexprt.com/HDRphotography/Drones/ColoradoFall2015/GrandJunction/GrandJunction.html
https://www.gettyimages.com/videos/grand-junction-colorado?sort=mostpopular&phrase=grand%20junction%20colorado

Non-point Sources of Pollution

http://www.riverexchange.org/wildfire/ https://news.medill.northwestern.edu/chicago/video-sewage-in-the-chicago-river/
https://www.ibtimes.co.in/delhi-inhales-toxic-air-dangerous-fine-particles-level-exceeds-recommended-limit-by-21-times-629702 https://www.nationalgeographic.org/activity/preserving-soils/

Water Quality: Non-point sources

Multiple discharge points

- Storm water
  - Oil, grease
  - Metals
  - Chemicals
  - Pathogens
  - Particles
  - Salts
- Agricultural runoff
  - Fertilizers
  - Pesticides
  - Organics
  - Pathogens
  - Particles
  - Salts
- Combined sewers
  - Combined sewer overflow (CSO)
  - Storm water + organics + more pathogens
- Atmospheric deposition
  - Chemicals
  - Metals
  - Particles
- Natural systems
  - Particles
  - Organics
  - Pathogens
  - Heat

https://www.kunc.org/post/across-midwest-farm-fields-pesticide-exposure-tracked-unevenly-or-not-all#stream/0
https://www.tripadvisor.com/Attraction_Review-g33342-d1868448-Reviews-Penny_Hot_Springs-Carbondale_Colorado.html

Water Quality: Point Sources

Industrial wastes

Oil refineries, mills, chemical/electronics/automobile manufacturers

- Oil, grease
- Metals
- Chemicals
- Organics
- Pathogens
- Particles
- Salts
- Heat

Municipal sewage

Both domestic sewage and industrial wastes

- Chemicals
- Organics
- Salts

Power generation facilities

- Heat
- Metals
- Nutrients
- Particles

https://www.mycoloradoparks.com/road-trips/iron-mountain-hot-springs

https://www.thrillist.com/news/nation/truck-spills-liquid-chocolate-on-arizona-highway

https://www.nrdc.org/stories/water-pollution-everything-you-need-know

Water Quality

Abandoned mines

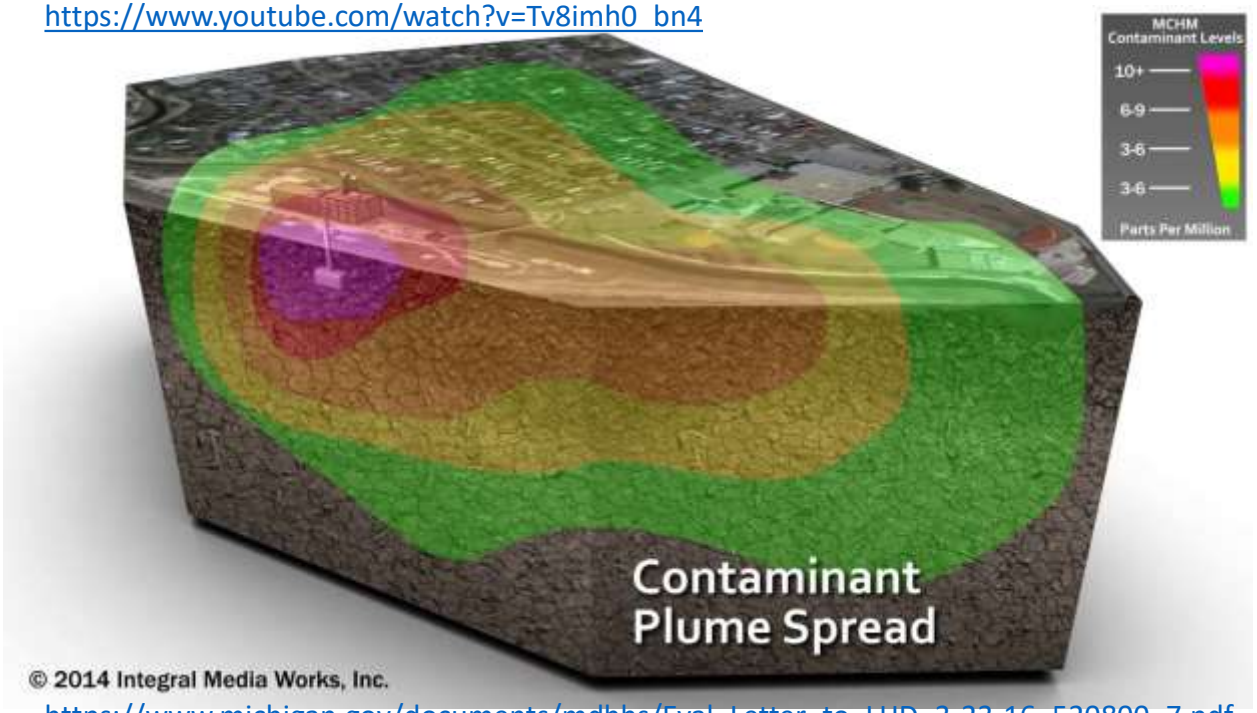
- Point source
- Non-point source

Water Quality

Groundwater contamination

- Point source
- Non-point source

https://www.youtube.com/watch?v=Tv8imh0_bn4



https://www.michigan.gov/documents/mdhhs/Eval_Letter_to_LHD_3-23-16_520800_7.pdf

Water Quality

Key water quality concerns for ecosystems

Man-made or man-introduced contaminants

- Oxygen-demanding material
- Nutrients
- Invasive species
- Pathogenic microorganisms
- Suspended solids
- Salts
- Metals
- Inorganic chemicals
- Organic compounds
- Radionuclides
- Emerging contaminants
  - endocrine-disrupting compounds
  - pharmaceutical and personal care products
  - microplastics
- Heat
- Disinfectants
- Disinfection byproducts

https://www.hatchmag.com/articles/fish-made-river-famous/7714823

Water Quality

Key water quality concerns for the outdoor industry

Man-made or man-introduced contaminants

- Oxygen-demanding material
- Nutrients
- Invasive species
- Pathogenic microorganisms
- Suspended solids
- Salts
- Metals
- Inorganic chemicals
- Organic compounds
- Radionuclides
- Emerging contaminants
  - endocrine-disrupting compounds
  - pharmaceutical and personal care products
  - microplastics
- Heat
- Disinfectants
- Disinfection byproducts

https://www.coloradocanyonsassociation.org/programs

Water Quality

Key water quality concerns for industrial and agricultural users

Man-made or man-introduced contaminants

- Oxygen-demanding material
- Nutrients
- Invasive species
- Pathogenic microorganisms
- Suspended solids
- Salts
- Metals
- Inorganic chemicals
- Organic compounds
- Radionuclides
- Emerging contaminants
  - endocrine-disrupting compounds
  - pharmaceutical and personal care products
  - microplastics
- Heat
- Disinfectants
- Disinfection byproducts

https://newsroom.intel.com/articles/update-intel-manufacturing-site-planning/

https://e360.yale.edu/features/running-dry-new-strategies-for-conserving-water-on-the-colorado

Water Quality

Key water quality concerns for drinking water

Natural and man-made contaminants

- Oxygen-demanding material
- Nutrients
- Invasive species
- Pathogenic microorganisms
- Suspended solids
- Salts
- Metals
- Inorganic chemicals
- Organic compounds
- Radionuclides
- Emerging contaminants
  - endocrine-disrupting compounds
  - pharmaceutical and personal care products
  - microplastics
- Heat
- Disinfectants
- Disinfection byproducts

Background of Drinking Water Regulations

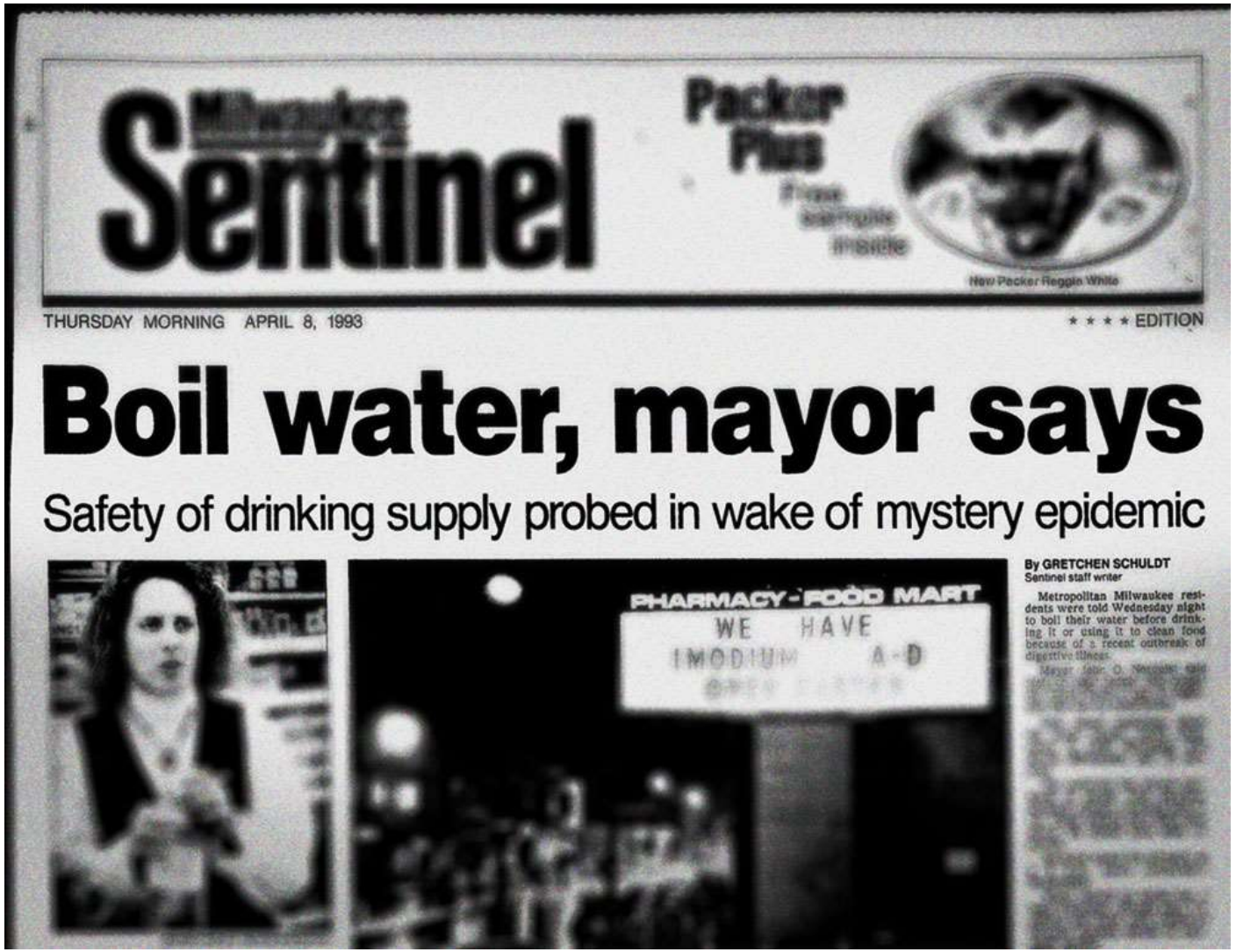
- 1974 Congress enacted the Safe Drinking Water Act (SDWA)
  - Authorizes the EPA to promulgate health-based drinking water standards
  - Requires drinking water to meet maximum contaminant levels (MCLs)
    - physical, chemical, biological, and radiological substances
- EPA was slow to implement
- 1986 EPA set MCLs for 23 contaminants and had failed to prescribe any treatment techniques
- Many states received variances and exemptions under the SDWA
- A majority of public water systems did not meet minimal national standards

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1446258/

Background of Drinking Water Regulations

- SDWA amendment 1986
  - Required to regulate 25 contaminants every 3 years
- Surface Water Treatment Rule (SWTR) 1989
  - Set disinfection requirements, filtration criteria, and new MCL goals for pathogens
- SDWA amendment 1996
  - Repealed mandate of regulating 25 contaminants every 3 years
  - Required to select > 5 contaminant every 5 years
  - Required to rely on heath data and risks (and good science)

Cryptosporidium parvum outbreak



Milwaukee Sentinel

Packer Plus

Free samples inside

New Packer Reggie White

THURSDAY MORNING APRIL 8, 1993

★★★★ EDITION

Boil water, mayor says

Safety of drinking supply probed in wake of mystery epidemic

PHARMACY - FOOD MART

WE HAVE

IMODIUM A-D

By GRETCHEN SCHULDT
Sentinel staff writer

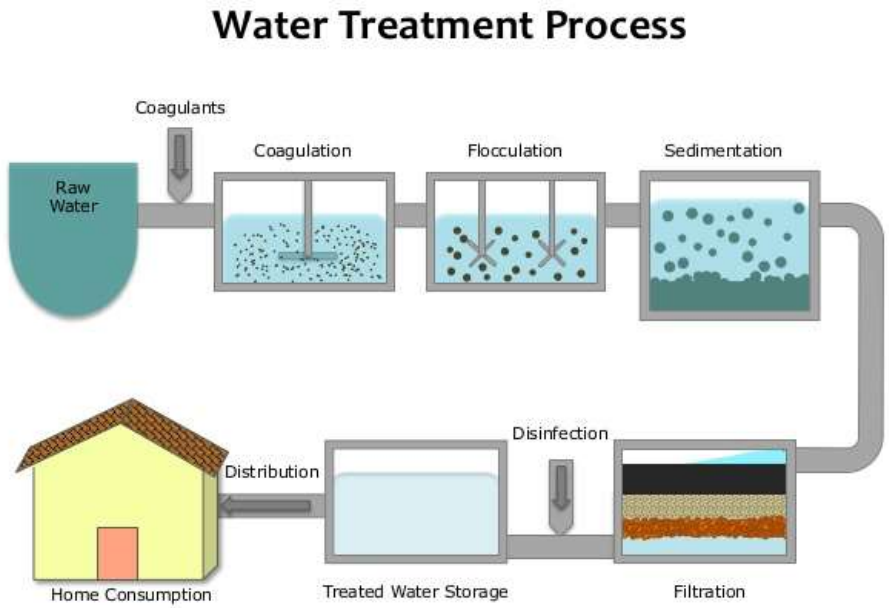
Metropolitan Milwaukee residents were told Wednesday night to boil their water before drinking it or using it to clean food because of a recent outbreak of digestive illness.

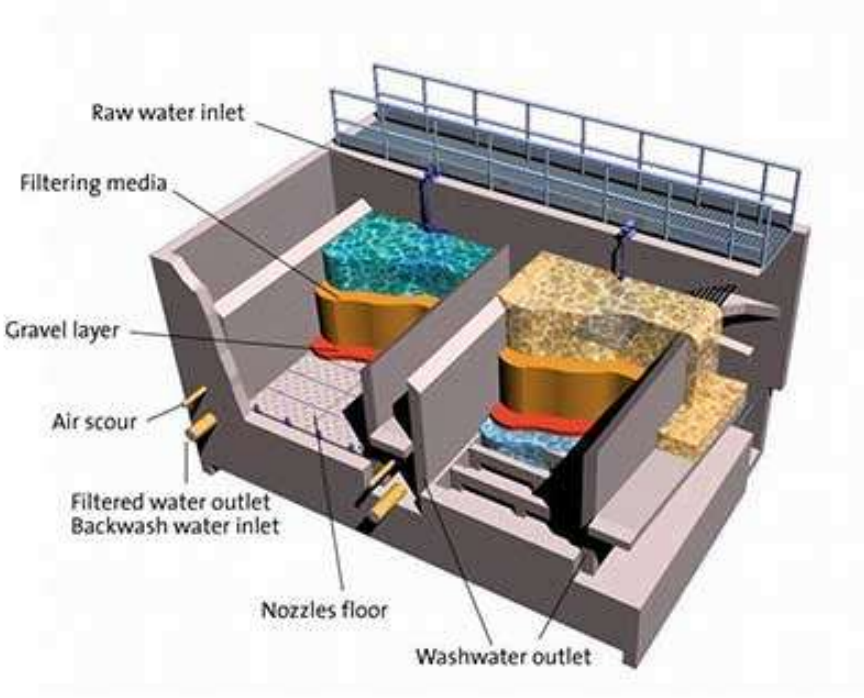
- Milwaukee, WI
- April 1993, 400,000 people became ill
- 104 people died
- Contaminated city water supply system

http://archive.jsonline.com/news/milwaukee/milwaukee-marks-20-years-since-cryptosporidium-outbreak-099dio5-201783191.html/

Milwaukee Water Treatment

- Severe spring storms
- Turbidity and bacteria increased in Lake Michigan
- Two water treatment plants intake in Lake Michigan
- Conventional water treatment
  - Make particles big
  - Remove them through settling and filtration
  - Disinfect water and distribute
- High turbidity in treated water
- Particle and *Cryptosporidium* oocysts breakthrough



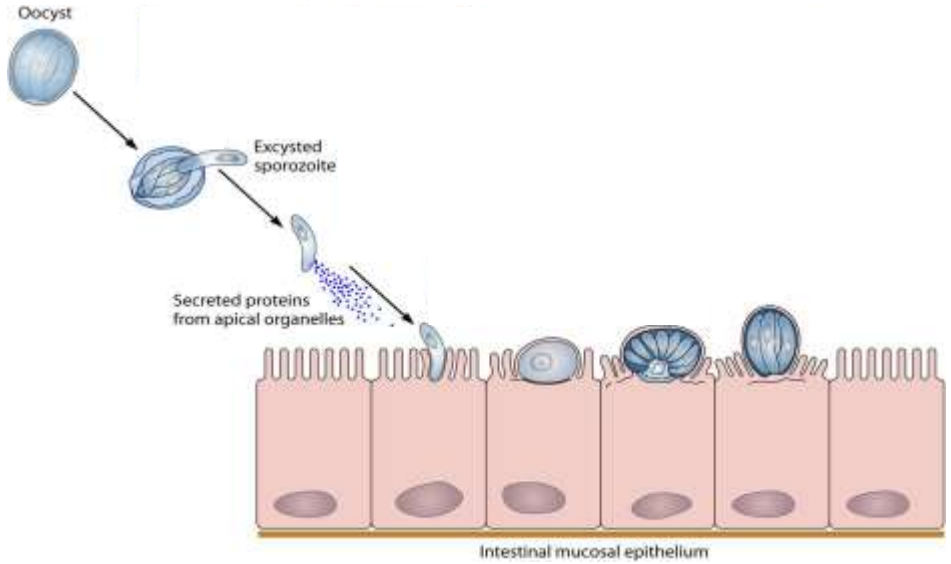


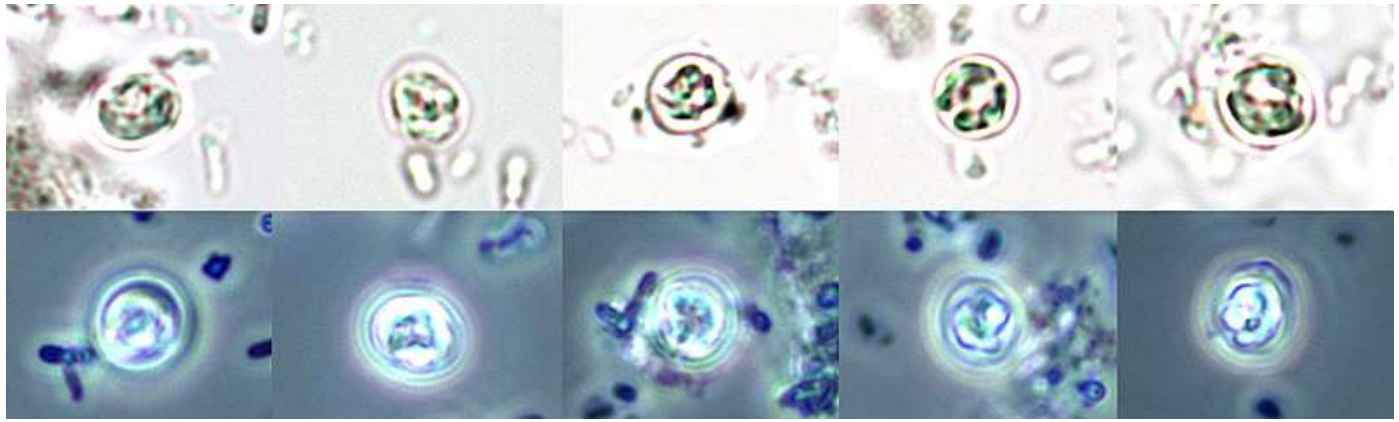
http://www.pumicefiltrationmedia.com/

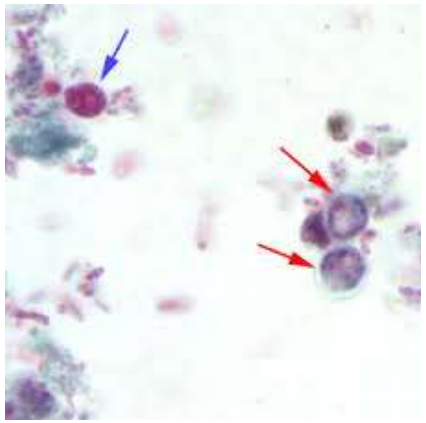
Filtration and Backwashing

Cryptosporidium parvum

- Low dose (~10 Oocysts) can cause infection
- Causes severe diarrhea
- 1993—1994: 71% of waterborne disease outbreaks caused by Giardia lamblia and Cryptosporidium
- Double walled cyst (Oocysts) can survive chlorine treatment
- Water must be filtered in order to remove *Cryptosporidium*
- Ultraviolet light inactivates *Cryptosporidium*



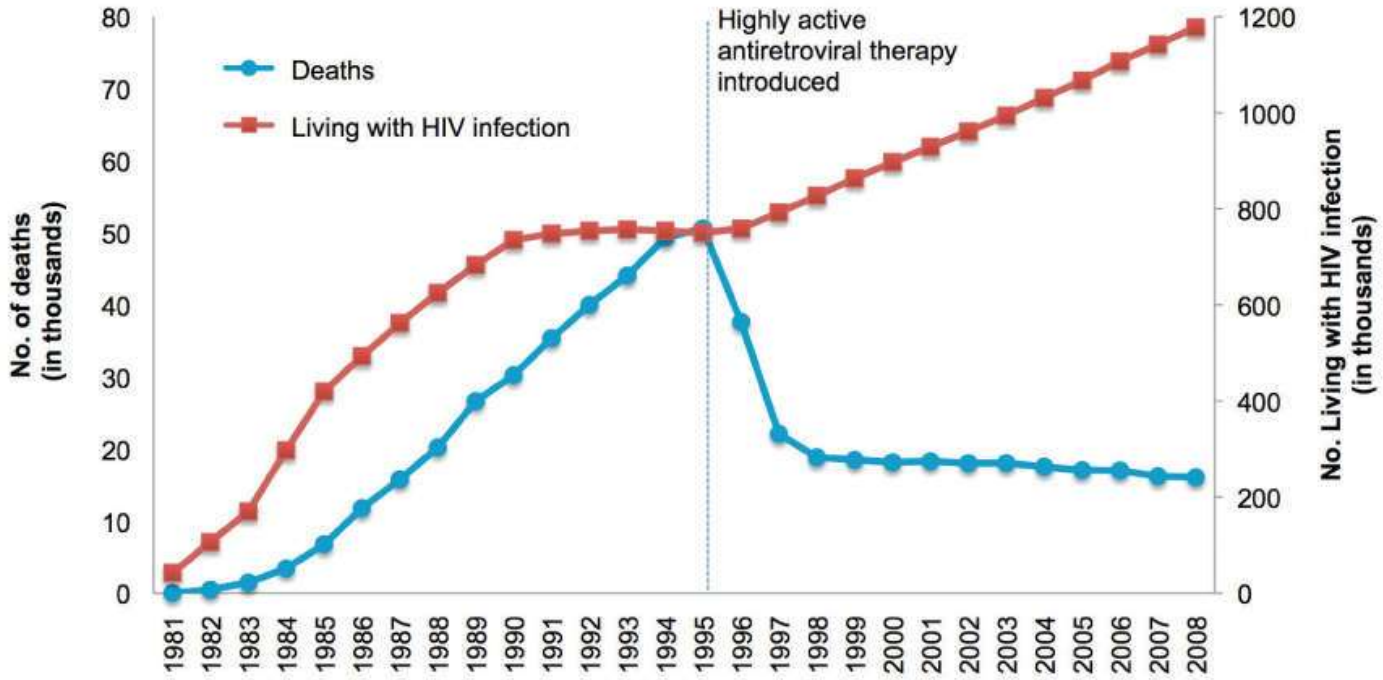




https://waterandhealth.org/healthy-pools/crypto-outbreaks-aquatic-facilities/

https://www.cdc.gov/dpdx/cryptosporidiosis/index.html

Vulnerable Populations



https://www.drugabuse.gov/publications/research-reports/hivaids/how-does-drug-abuse-affect-hiv-epidemic

Drinking water regulations related to *Crypto*

- 1998 Disinfectants and Disinfection Byproducts Rule (and again in 2006)
  - MCL goals and maximum residual disinfectant level goals
- 1999 Interim Enhanced Surface Water Treatment Rule
  - General filtration criteria, sanitary surveys, and enhanced record keeping
  - MCL goal for Cryptosporidium of zero
  - Specific filtration requirements for Cryptosporidium oocysts
- 2001 Filter Backwash Recycling Rule (FBRR)
  - Requires recycled filter backwash water to go through all processes of treatment
  - Filter-to-waste requirement

Drinking water regulations related to *Crypto*

- 2002 Long Term 1 Enhanced Surface Water Treatment Rule (LT1ESWTR)
  - Sets a 2-log *Cryptosporidium* removal requirement for systems that filter
- 2006 Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR)
  - Targets additional *Cryptosporidium* treatment requirements to higher risk systems
  - UV inactivation guidelines for inactivation of *Cryptosporidium*

How are regulations set?

Drinking Water Regulatory Process

- SDWA authorizes EPA to regulate contaminants in water provided by public water systems
  1. Identifying contaminants of potential concern
  2. Assessing health risks
  3. Collecting occurrence data and developing reliable analytical methods necessary to do so
  4. Making determinations as to whether a national drinking water regulation is warranted for a contaminant
- Cost-benefit analyses
- Draft rule and final rule
- 6-year review of the rule

1) Identifying Contaminants of Potential Concern

- Every five years, EPA is required to publish a list of contaminants known or anticipated to occur in public water systems (~40 to ~200 contaminants each year)
  - the greatest health concern
  - the most vulnerable subgroups (e.g., infants, pregnant women)
- CCL 1 (1998): technical experts of readily available information
- CCL 2 (2005): National Academy of Sciences – National Research Council and the National Drinking Water Advisory Council
- CCL 3 (2009) and 4 (2016): public nominations of contaminants and public participation with previous stakeholders
  - CCL 3 and 4: Perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) in drinking water
- After final CCL is published, EPA determines whether or not to regulate at least five contaminants from the CCL in a separate process

https://www.epa.gov/ccl/basic-information-ccl-and-regulatory-determination
https://www.nap.edu/catalog/10080/classifying-drinking-water-contaminants-for-regulatory-consideration#toc

Perfluoroalkyl acids (PFAAs)

- Components of Aqueous Film Forming Foam (AFFF) used by the Air Force to extinguish petroleum fires
- Persistent, bioaccumulative, and toxic (PBT) contaminants
- Water soluble and do not break down in the environment
- Difficult to remove in drinking water treatment

https://journals.plos.org/plosbiology/article?id=10.1371/journal.pbio.2002855

PFAAs in Colorado

Location	Notes
Boulder Mountain Fire Protection District	Found high PFAS chemical levels at a groundwater well at one of the district's stations. All residents located close to the station have been notified.
Buckley Air Force	Found PFAS chemical levels in groundwater wells on the base. Potential off site migration will be investigated. The public will be notified prior to investigation. No public water systems are known to be impacted. Remedial measures will be taken after the extent of contamination is determined.
Fort Carson	Found high PFAS chemical levels in groundwater wells on and off the base. All residents located near the base have been notified of the on base contamination and well sampling events that occurred off-base. No public water system has been impacted. Base is currently in the process of cleaning up the contamination and notifying off base impacted well owners of PFAS concentrations.
Peterson Air Force Base	Found PFAS chemical levels in groundwater wells on the base. All residents located near the base have been notified. Public water systems were impacted and are now treating for the chemical; PFAS chemical levels are below health advisory in treated drinking water. Base is currently in the process of cleaning up the contamination.
Schriever Air Force Base	Found PFAS chemical levels in groundwater wells on the base. Off base contamination has not been identified. Residents will be notified if off base contamination is identified. No public water system has been impacted. Base is currently in the process of cleaning up the contamination.
South Adams County Water and Sanitation District	PFAS chemical levels are below health advisory in treated drinking water, but the district found higher PFAS chemical levels in some groundwater sources. The district has treatment to remove PFAS chemical and shut down sources with higher PFAS chemical levels.
Sugarloaf Volunteer Fire District	Found PFAS chemical levels in groundwater wells at one of the district's stations. All residents located close to the station were notified.
Suncor	Found PFAS chemical levels in groundwater wells on site. All residents located near the site have been notified. No public water system has been impacted. Entity is currently in the process of cleaning up the contamination.
U.S. Air Force Academy	Found PFAS chemical levels in groundwater wells on the base. All residents located near the base have been notified. No public water system has been impacted. Base is currently in the process of cleaning up the contamination.

2) Assessing Health Data

- Goal is to estimate a contaminant health reference level or HRL
  - HRL is the benchmark against which to conduct the initial evaluation of the occurrence data
- Data collection of all relevant peer-reviewed, published studies
- Guidelines for cancer assessments: Guidelines for Carcinogen Risk Assessment and the Supplementary Children's Guidance
- Risk-specific doses (mg/kg of body weight per day)
  - estimated oral exposures of lifetime excess risk levels of one cancer in ten thousand (10^{-4}) to one cancer in a million (10^{-6})

https://www.epa.gov/sites/production/files/2014-09/documents/chapter_2_evaluation_of_health_and_occurrence_data.pdf

2) Assessing Health Data: HRL

- Health reference level*, HRL = [(RfD x BW)/DWI] x RSC*
  - RfD, estimate of the daily amount of a chemical exposure that does not cause adverse health effects over a lifetime
    - 10^{-4} to 10^{-7} risk increase is acceptable
  - RfD from epidemiology or toxicology studies
  - BW, Body Weight for an adult
  - DWI, Drinking Water Intake
  - RSC, Relative Source Contribution is the level of exposure from drinking water when compared to other sources (e.g., food, ambient air)

https://www.epa.gov/sites/production/files/2014-09/documents/chapter_2_evaluation_of_health_and_occurrence_data.pdf

Perfluoroalkyl acids (PFAAs)

- Toxic to liver, immune, endocrine, and male reproductive systems
- Toxic to developing fetus and neonate
- Low-dose effects include persistent delays in mammary gland development and suppression of immune response
- Health effects include high levels of fat and liver enzymes in blood, decreased vaccine response, and decreased birth weight
- HRL = 70 ng/L (70 ppt)

https://journals.plos.org/plosbiology/article?id=10.1371/journal.pbio.2002855

https://www.mountainhome.af.mil/News/Photos/igphoto/2000086099/

3) Collecting Occurrence Data

SDWA directs EPA to collect nationwide occurrence data for unregulated contaminants

- Unregulated contaminant monitoring rule (UCMR)
- Requires water systems operators to test for no more than 30 contaminants
- Monitoring of all public water systems serving >10,000 persons, plus a representative sample of smaller systems

Other data sources:

- USGS Pesticide Use Maps
- Toxics Release Inventory (TRI)
- USGS National Water Quality Assessment (NAWQA)
- VOC National Synthesis
- USGS Stormwater Studies
- Community Water System Survey (CWSS)

3) Collecting Occurrence Data

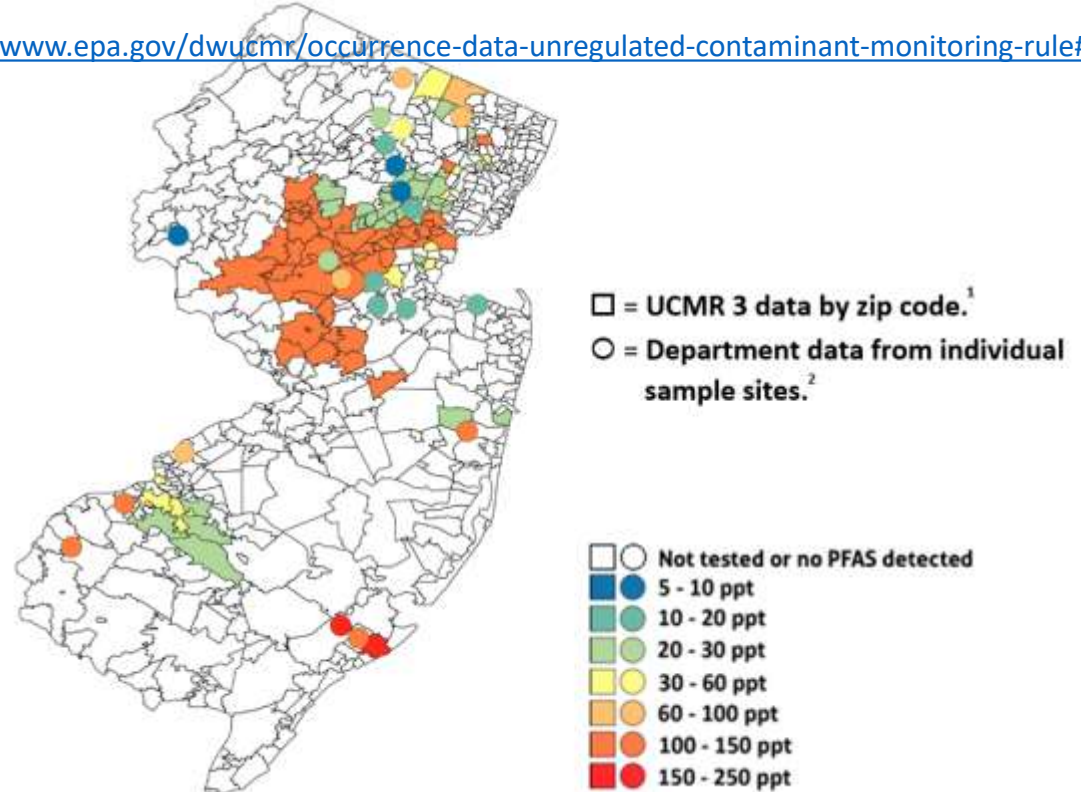
Data collection is designed to determine

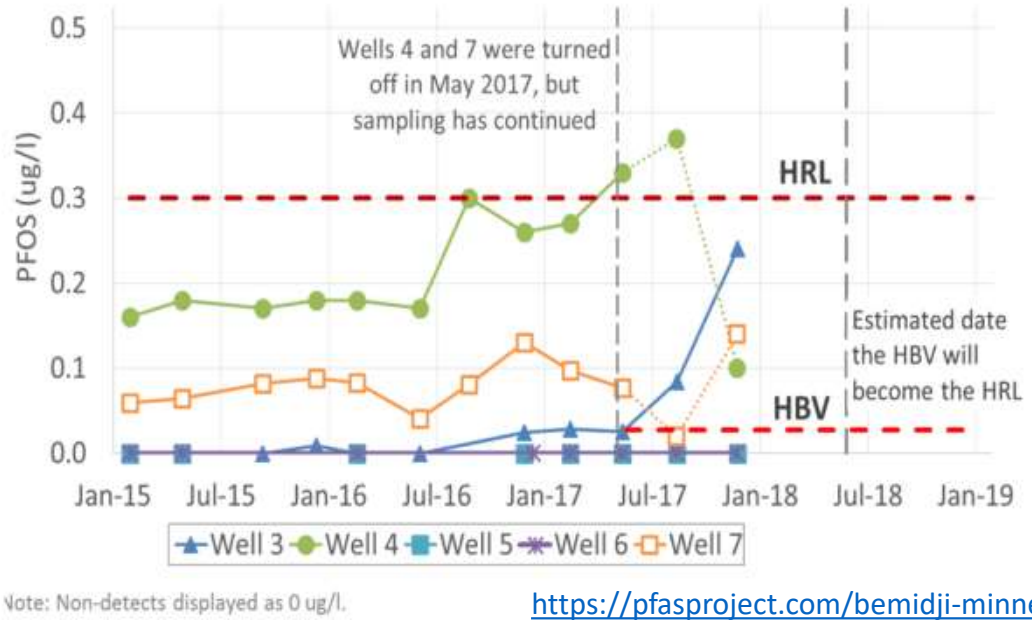
- the total number of systems and the total population served by monitored systems
- the number and percentage of systems with
  - ≥1 observed detection that has a concentration >0.5*HRL and
  - ≥1 observed detection that has a concentration >HRL
- the number of people and percentage of the population served by systems with
  - ≥1 observed detection that has a concentration >0.5*HRL and
  - ≥1 observed detection that has a concentration >HRL

PFOS and PFOA

- UCMR 3 (2012)
  - 5,000 water systems
  - January 2013 and December 2015
  - 63 water systems (1.3%) serving an estimated 5.5 million individuals detected PFOA and/or PFOS at levels above EPA's health advisory level of 70 ppt (separately or combined)

https://www.epa.gov/dwucmr/occurrence-data-unregulated-contaminant-monitoring-rule#3





https://pfasproject.com/bemidji-minnesota/

4) Making the determination to regulate

Requirements for regulation of a contaminant

1. A contaminant may have an adverse health effect;
2. It is known to occur or there is a substantial likelihood that it will occur in water systems at a frequency and at levels of public health concern; and
3. In the sole judgment of the Administrator, regulation of the contaminant presents a meaningful opportunity for reducing health risks.

Feb 20, 2020: From CCL 4 (2012) and UCMR 3 (2016) the EPA is making the preliminary determination to regulate perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) in drinking water

After determination to regulate

- EPA is required to propose a rule within 24 months
- EPA is required to promulgate a national primary drinking water regulation within 18 months after the proposal
- EPA may extend the deadline for up to nine months

Setting the health-based standard MCLG

- EPA sets a maximum contaminant level goal (MCLG) for every contaminant
- MCLG is the maximum level of a contaminant
  - No known or anticipated adverse effect on human health
  - Non-enforceable public health goals
- MCLG is set considering the adverse health risk to sensitive subpopulations

Setting the health-based standard MCLG

Dependent on type of contaminant

- **Pathogenic microbial contaminants:** MCLG is zero
- **Carcinogenic chemical contaminants:**
  - MCLG is zero if chemical may cause cancer AND if there is no safe dose
  - If a safe dose can be determined, MCLG is set at the safe level
- **Non-carcinogenic chemical contaminants:**
  - MCLG based on “No-observed-adverse-effect level” (NOAEL), a “lowest-observed-adverse-effect level” (LOAEL)

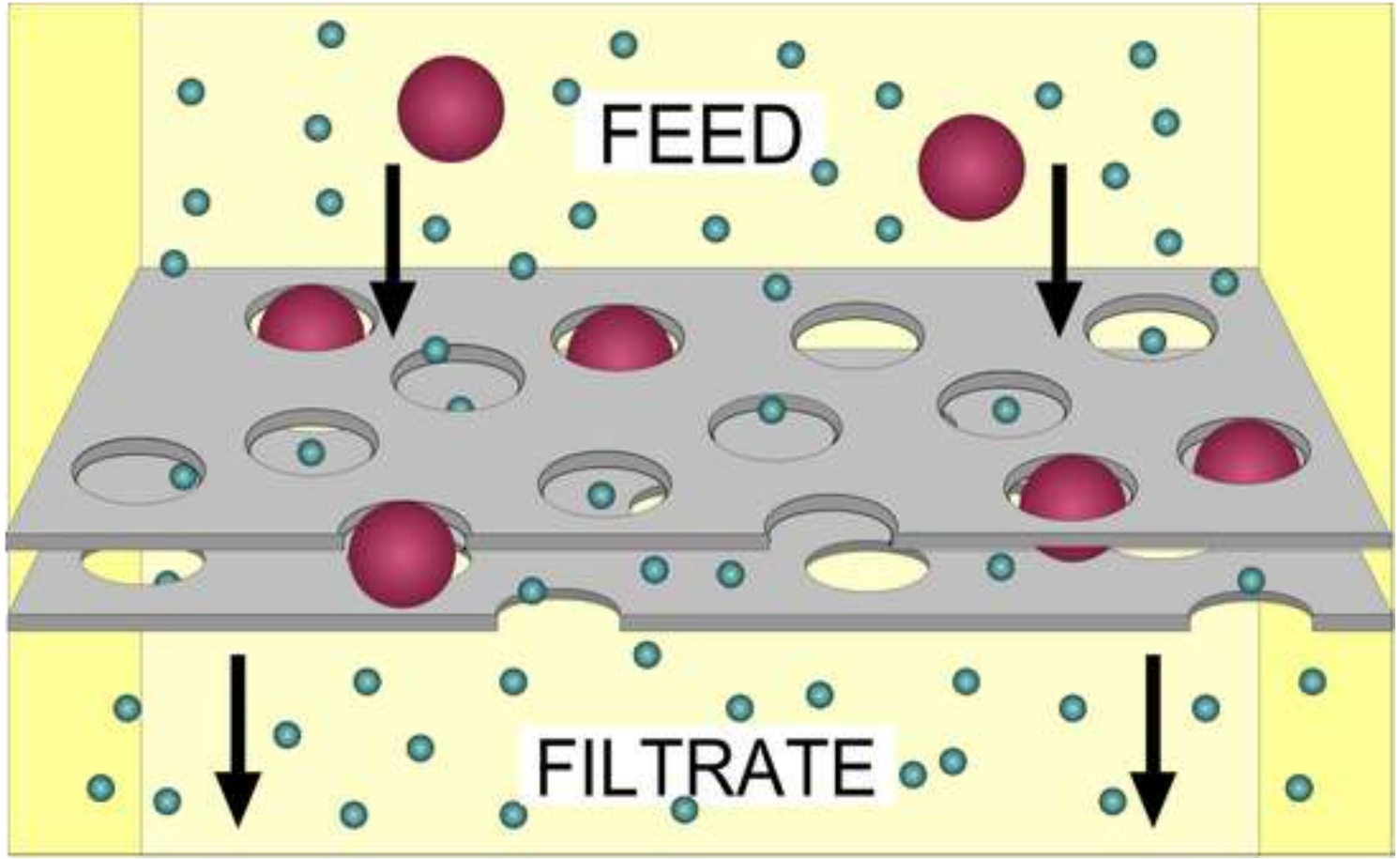
Setting health-based standards MCL

- SDWA directs EPA to set the MCL as close to the MCLG as is “feasible” using best available technology or other means available, taking costs into consideration
- Regulations must include analytical methods and feasible treatment methods

National Primary Drinking Water Regulations — EPA 816-F-09-004 | MAY 2009

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]
Fluoride	4.0	Bone disease (pain and tenderness of the bones); children may get mottled teeth	Water additive which promotes strong teeth; erosion of natural deposits; discharge from fertilizer and aluminum factories	4.0
Giardia lamblia	TT[7]	Short-term exposure: Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste	zero
Glyphosate	0.7	Kidney problems; reproductive difficulties	Runoff from herbicide use	0.7
Haloacetic acids (HAA5)	0.060	Increased risk of cancer	Byproduct of drinking water disinfection	n/a[9]
Heptachlor	0.0004	Liver damage; increased risk of cancer	Residue of banned termiticide	zero
Heptachlor epoxide	0.0002	Liver damage; increased risk of cancer	Breakdown of heptachlor	zero
Heterotrophic plate count (HPC)	TT[7]	HPC has no health effects; it is an analytic method used to measure the variety of bacteria that are common in water. The lower the concentration of bacteria in drinking water, the better maintained the water system is.	HPC measures a range of bacteria that are naturally present in the environment	n/a

Economical and technical feasibility



- Expenses to comply with new drinking water regulations
  - Install and operate contaminant removal technologies
  - Water monitoring and analyzing water samples
  - Management and oversight costs
  - Increased household water bill
- Avoided damages (morbidity and mortality) of regulatory action
  - Qualitative, quantitative, and monetary assessment

MCLs and Cost-Benefit Analyses

EPA, at the discretion of the Administrator, may establish less stringent MCLs if any of these apply:

- The costs of achieving the lowest feasible level are not justified by its benefits
- Achieving the MCL could result in an increase in health risks from other contaminants
- Meeting the MCL may interfere with the treatment processes used to comply with other SDWA regulations

For *Cryptosporidium*, the SDWA does not allow EPA to use cost and benefits to establish a treatment technique requirement or MCL

https://www.epa.gov/sdwa/sdwa-economic-analysis

Treatment techniques

- Cannot measure contaminant at concentrations relevant to public health (i.e., *Crypto*)
- Enforceable procedure or level of technological performance to ensure control of a contaminant
- Examples
  - Surface Water Treatment Rule (filtration and disinfection)

Drinking Water Regulatory Process

- SDWA authorizes EPA to regulate contaminants in water provided by public water systems
  1. Identifying contaminants of potential concern
  2. Assessing health risks
  3. Collecting occurrence data and developing reliable analytical methods necessary to do so
  4. Making determinations as to whether a national drinking water regulation is warranted for a contaminant
- Cost-benefit analyses
- Draft rule and final rule
- 6-year review of the rule

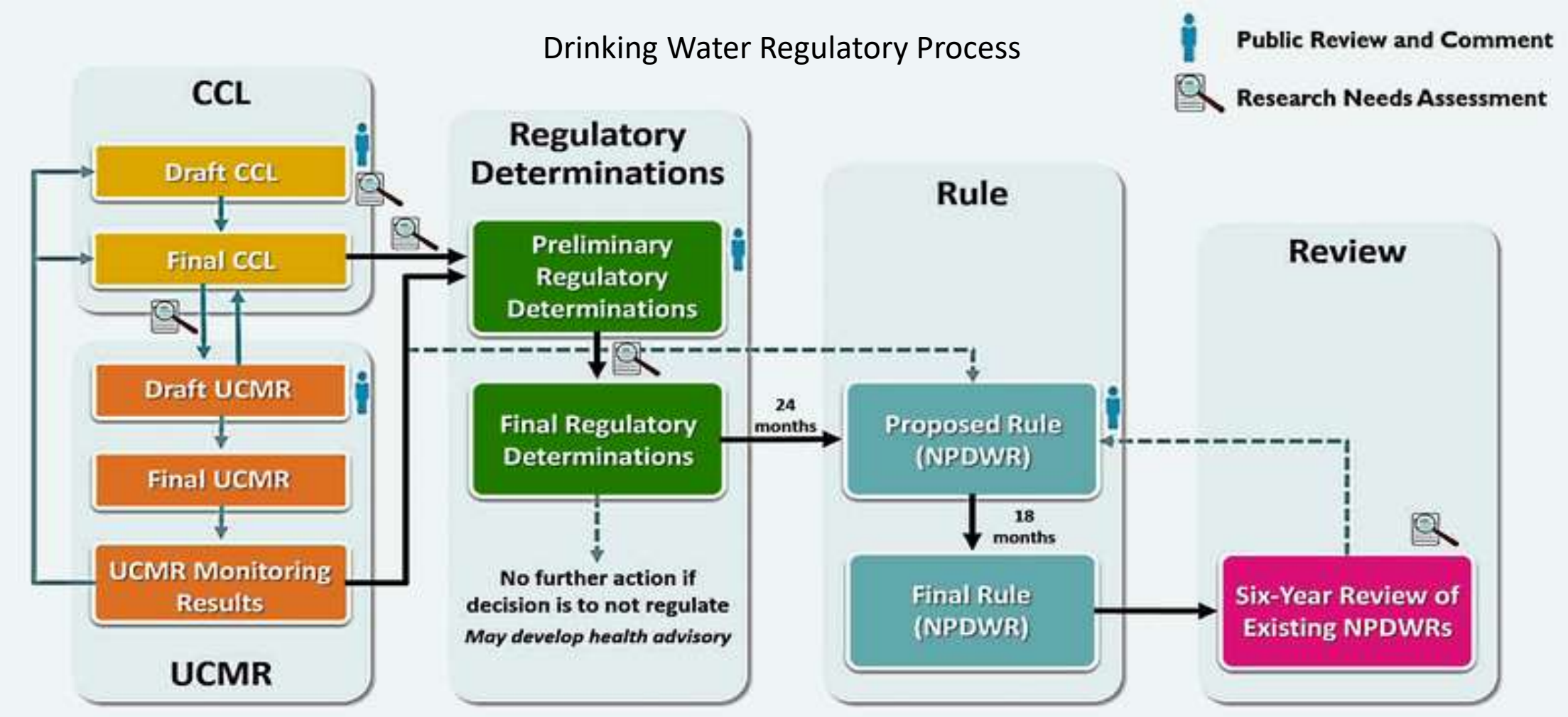
PFOS and PFOA moving forward

EPA's Action Plan identifies efforts related to evaluating PFAAs for potential regulation under SDWA

1. developing new analytical test methods to support monitoring of more PFAS and at lower levels (EPA has validated test methods for 18 PFAS)
2. preparing to use new test methods to include other PFAAs in the next UCMR in 2020 to assess their occurrence, and
3. expanding PFAAs toxicity information and providing more information about PFAAs treatment and costs

https://fas.org/sgp/crs/misc/IF11219.pdf

Thank you!


Drinking Water Regulatory Process
Public Review and Comment
Research Needs Assessment
CCL
Draft CCL
Final CCL
Draft UCMR
Final UCMR
UCMR Monitoring Results
UCMR
Regulatory Determinations
Preliminary Regulatory Determinations
Final Regulatory Determinations
No further action if decision is to not regulate
May develop health advisory
24 months
Rule
Proposed Rule (NPDWR)
18 months
Final Rule (NPDWR)
Review
Six-Year Review of Existing NPDWRs

All Drinking Water Regulations

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

NPDWR Secondary Standards

Contaminant	Secondary MCL	Noticeable Effects above the Secondary MCL
Aluminum	0.05 to 0.2 mg/L*	colored water
Chloride	250 mg/L	salty taste
Color	15 color units	visible tint
Copper	1.0 mg/L	metallic taste; blue-green staining
Corrosivity	Non-corrosive	metallic taste; corroded pipes/ fixtures staining
Fluoride	2.0 mg/L	tooth discoloration
Foaming agents	0.5 mg/L	frothy, cloudy; bitter taste; odor
Iron	0.3 mg/L	rusty color; sediment; metallic taste; reddish or orange staining
Manganese	0.05 mg/L	black to brown color; black staining; bitter metallic taste
Odor	3 TON (threshold odor number)	"rotten-egg", musty or chemical smell
pH	6.5 - 8.5	low pH: bitter metallic taste; corrosion high pH: slippery feel; soda taste; deposits
Silver	0.1 mg/L	skin discoloration; graying of the white part of the eye
Sulfate	250 mg/L	salty taste
Total Dissolved Solids (TDS)	500 mg/L	hardness; deposits; colored water; staining; salty taste
Zinc	5 mg/L	metallic taste