

# Water and Environmental Health

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ENV H 111

11/15/11

# Water Overview

- This week
  - Tuesday, 11/15
    - History of Water
    - Drinking Water Regulations
    - Drinking Water Treatment & Distribution
  - Thursday, 11/17:
    - Water Contaminants
    - Wastewater Treatment
  - Friday, 11/18:
    - Fluoridation
- Next week
  - Tuesday, 11/22
    - Global Health and Water



# Water and Health

- Personal Exposure
  - Drinking
  - Bathing
  - Swimming
    - Beaches
    - Pools
- Resource management
  - Water catchment
  - Water /Wastewater Treatment
  - Distribution Systems
  - Recreational Waters

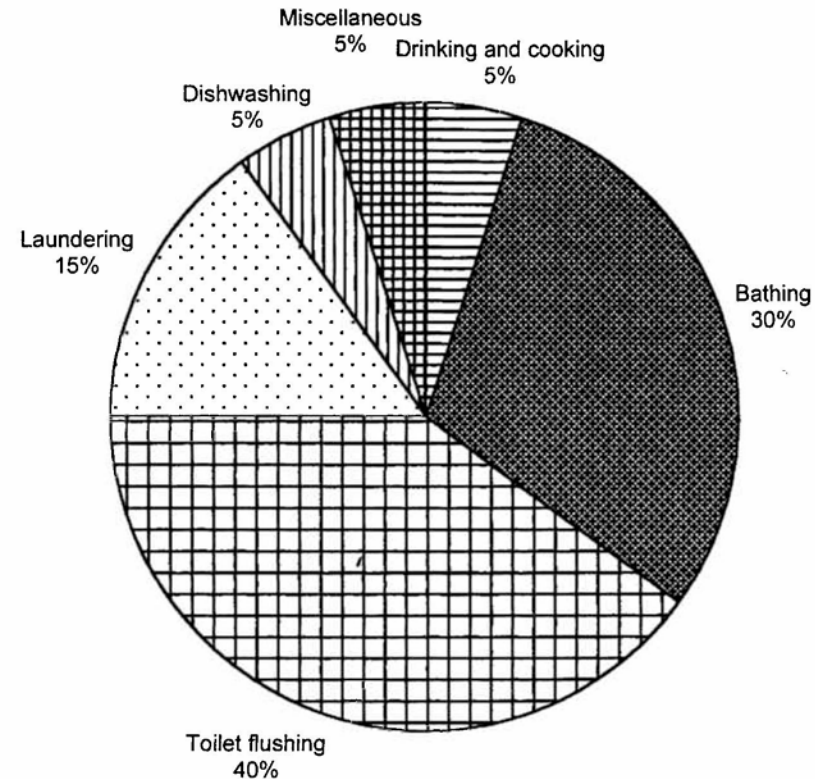


Figure 7.4 Relative distribution of uses of water within the home

# History of Drinking Water

- 1801 – Philadelphia
  - Provided piped drinking water to households
- Cholera pandemics (1820-1875)
  - 1832 – 1<sup>st</sup> Cholera outbreak in North America
  - 1849 – Cholera spread across U.S. during migration West
    - 10% of population of St. Louis died in 3 months
  - 1854 – London Cholera outbreak
    - 57,000 people died in one week
    - 500 people died in one day in Soho neighborhood
    - Dr. John Snow investigated by plotting deaths on map and identified the Broad Street pump as the source of the outbreak
    - City council removed pump and Cholera stopped spreading





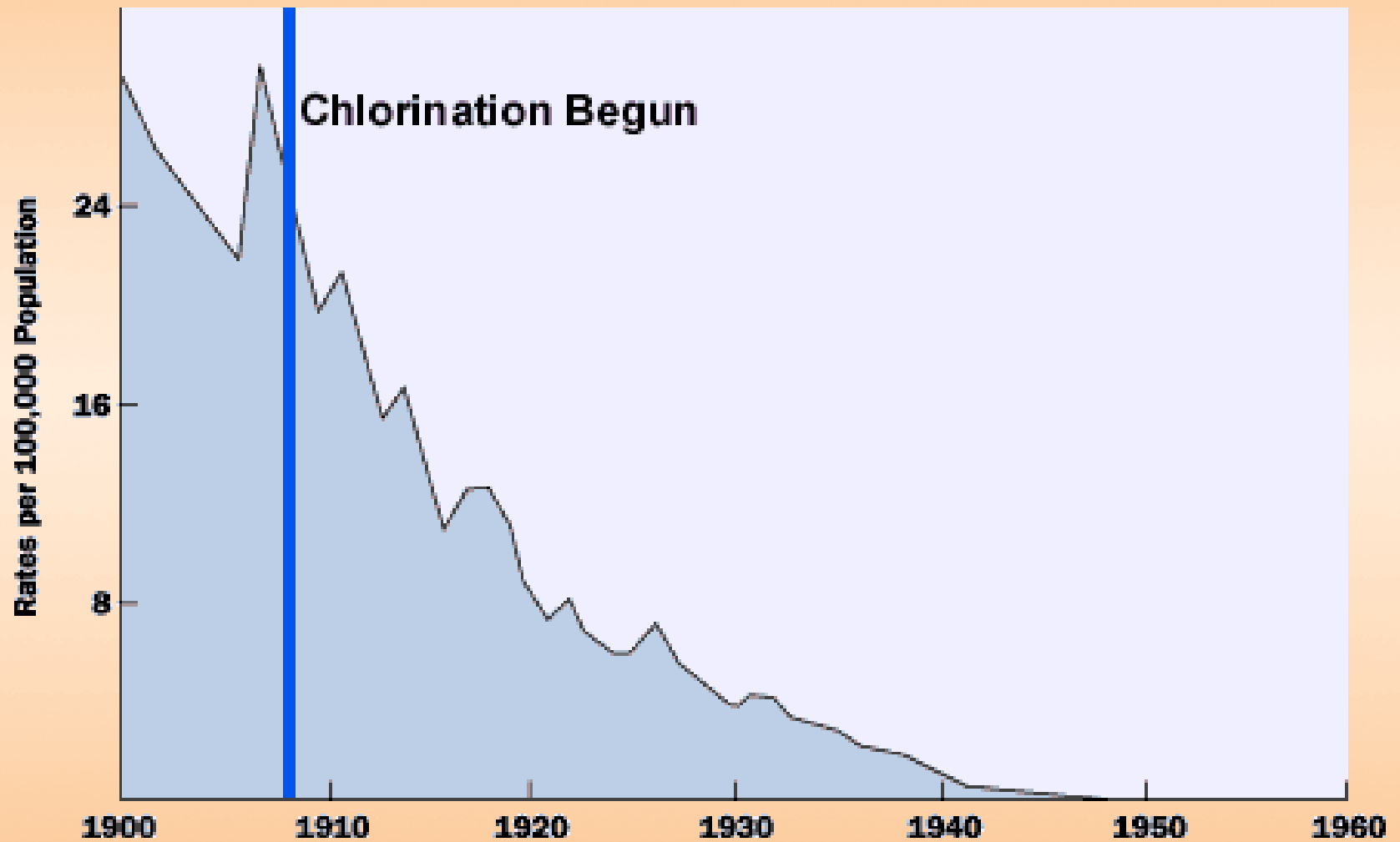
# History of Drinking Water

- 1881 – American Water Works Association (AWWA)
  - Founded to exchange information on contamination of source water to benefit the consumers and water utilities
- 1884 – Louis Pasteur & Robert Cook
  - proved “germ theory”
  - identified the Cholera organism, *Vibrio cholerae*
- 1892 – AWWA issued
  - “Memorial to Congress Praying for a National Law to Restrict Pollution of Streams From Which Water Supplies of Cities are Drawn”
- 1893 – Interstate Quarantine Act
  - US Public Health Service given authority for controlling the interstate transfer of communicable diseases

# History of Drinking Water

- 1901 – George Warren Fuller (AWWA) reported
  - Lower typhoid death rates for US cities using groundwater or filtered surface water
- 1900 to 1913 – Typhoid death rate cut in half
  - Filtration plants increases 8-fold
  - Chlorination introduced for disinfection of source waters
  - Typhoid vaccine developed
- 1902 – US Public Health Service sets first regulation
  - Bans “common cup” on ships, trains, buses
- 1914 to 1962 – Treasury Standards
  - Regulation of microorganisms (Total Coliform Rule), then chemical and physical standards
- 1928 – Water Environment Federation founded
  - To focus on wastewater treatment

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



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



# Conventional Water Treatment

- Multibarrier Approach
  - Use best source
  - Filtration
  - Disinfection
  - Maintain distribution system integrity
- US CDC: one of the top 10 great public health improvements of 20<sup>th</sup> century

# History of Seattle Drinking Water

- 1854-1890 Wells, springs and private water companies
- 1888 – tenfold population increase
- 1889 – “Great Seattle Fire” destroys business district due to lack of water supply
- 1890 – Seattle purchased 2 private water companies that pumped water from Lakes Union and Washington
- 1901 – Opening of Cedar River pipeline, pumping water to Volunteer Park & Lincoln reservoirs
- 1964 – South fork of the Tolt River serves north and eastside of King County
- 1987-90 Wells added from Highline Well Field

# Source Water

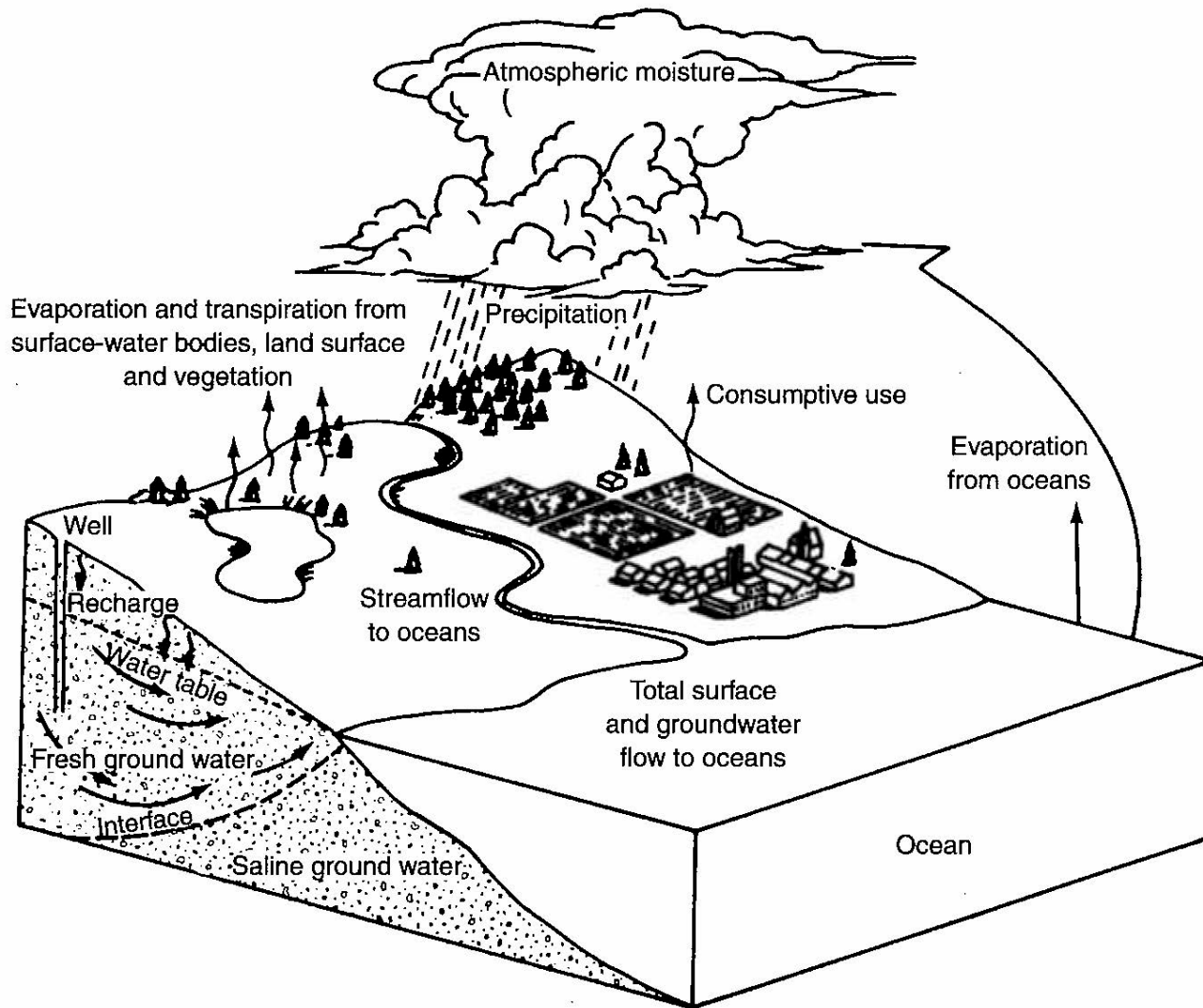
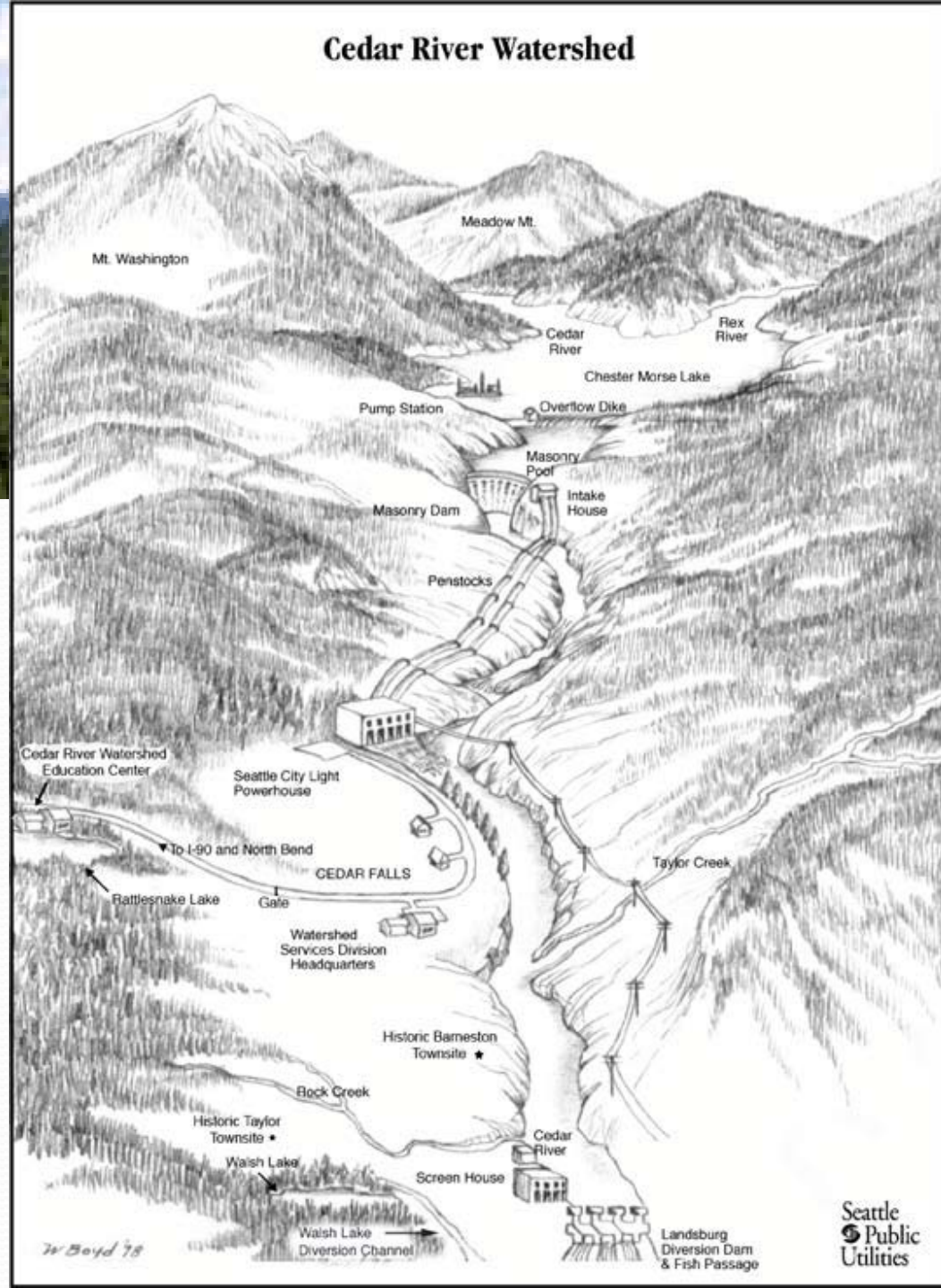


Figure 7.2 The hydrologic cycle



- Protected lands
- 22% watershed for drinking water
- 78% for salmon runs through Lake Washington, Lake Union, to Puget Sound



# Drinking Water Treatment



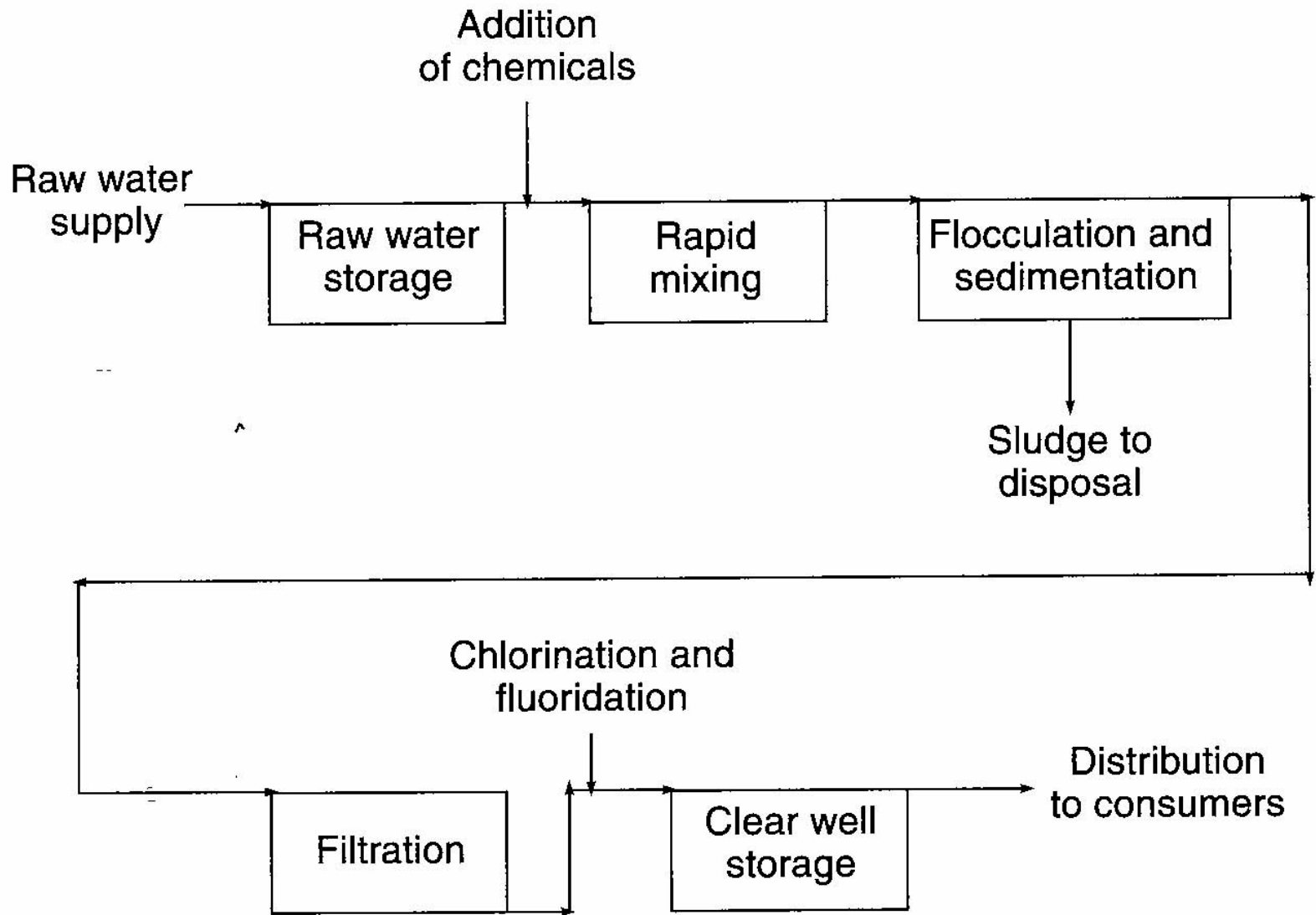
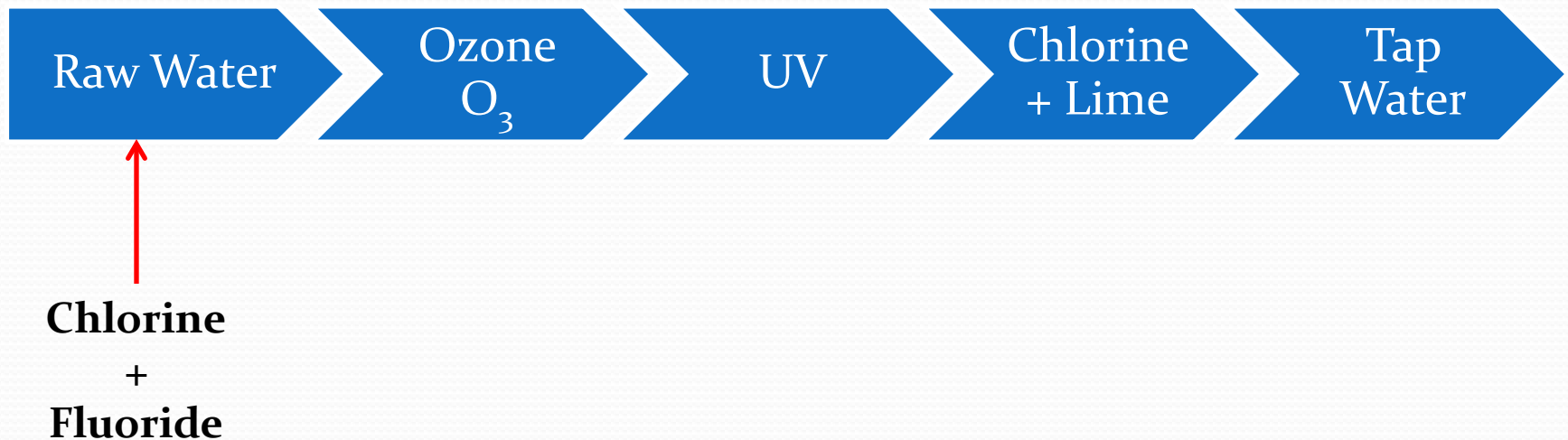


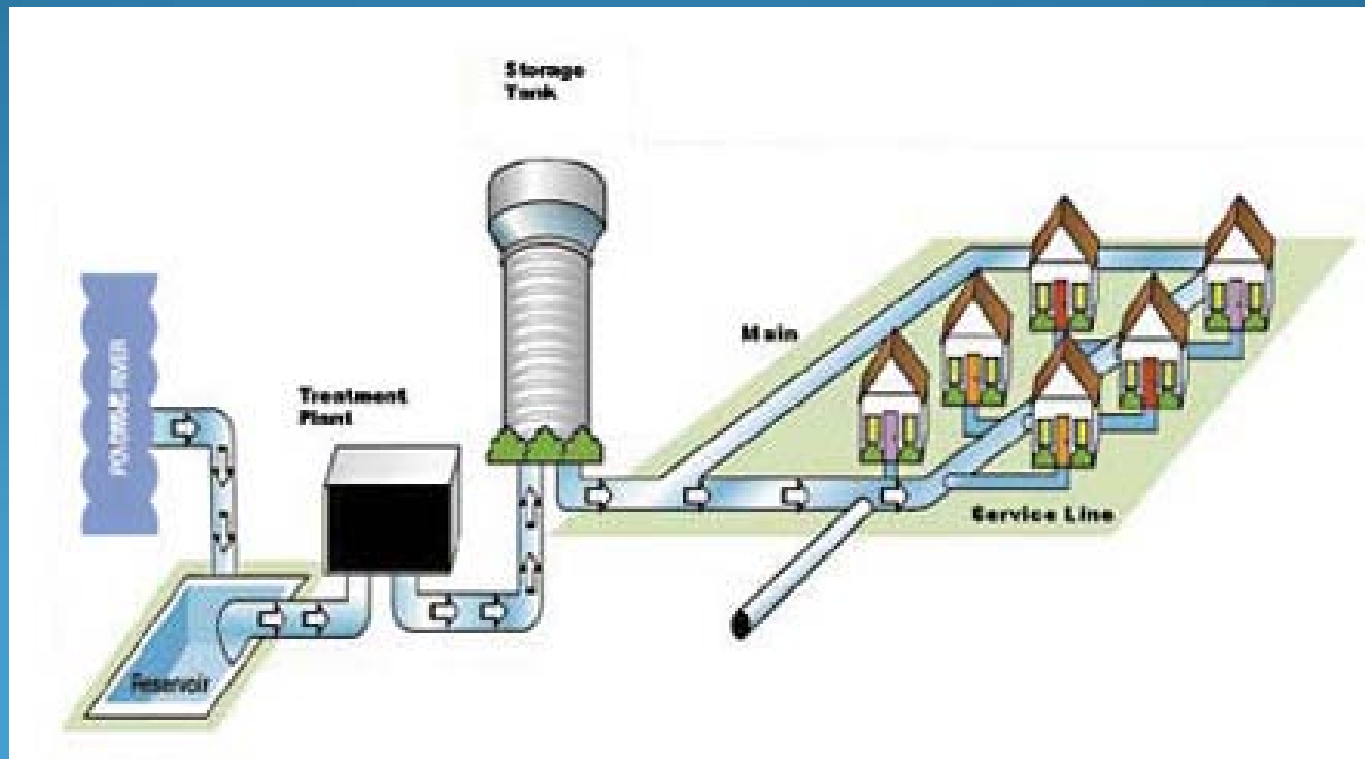
Figure 7.5 Principal steps in the water purification process

# Source: Cedar River Watershed

- Provides 2/3 of Seattle Drinking Water
- Protected watershed with natural filtration and low **Dissolved Organic Carbon (DOC)**
- Water Treatment Train:



# Distribution System



# From watershed to water glass



Drinking Water Map from Seattle Public Utilities

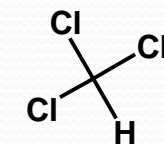
# Drinking Water Regulations

- US Public Health Service surveys community water systems
  - 41% did not meet standards of 1962
  - Lack of components of multi-barrier approach
- 1972 – Improvements in analytical methods
  - 36 synthetic organic chemicals (SOCs) in Mississippi River, source for New Orleans drinking water
- 1974 – J.J. Rook used chromatography
  - Discovery of disinfection byproducts (DBPs) in chlorinated water – Trihalomethanes (THMs)

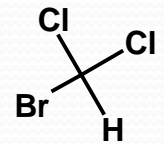
# Formation of Trihalomethanes

Source Water:  
Dissolved Organic Carbon  
and Bromide  
**DOC + Br<sup>-</sup>**

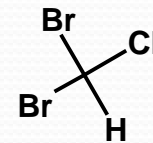
+ Cl<sub>2</sub> or HOCl



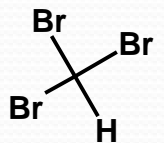
Chloroform



Bromodichloromethane



Dibromochloromethane



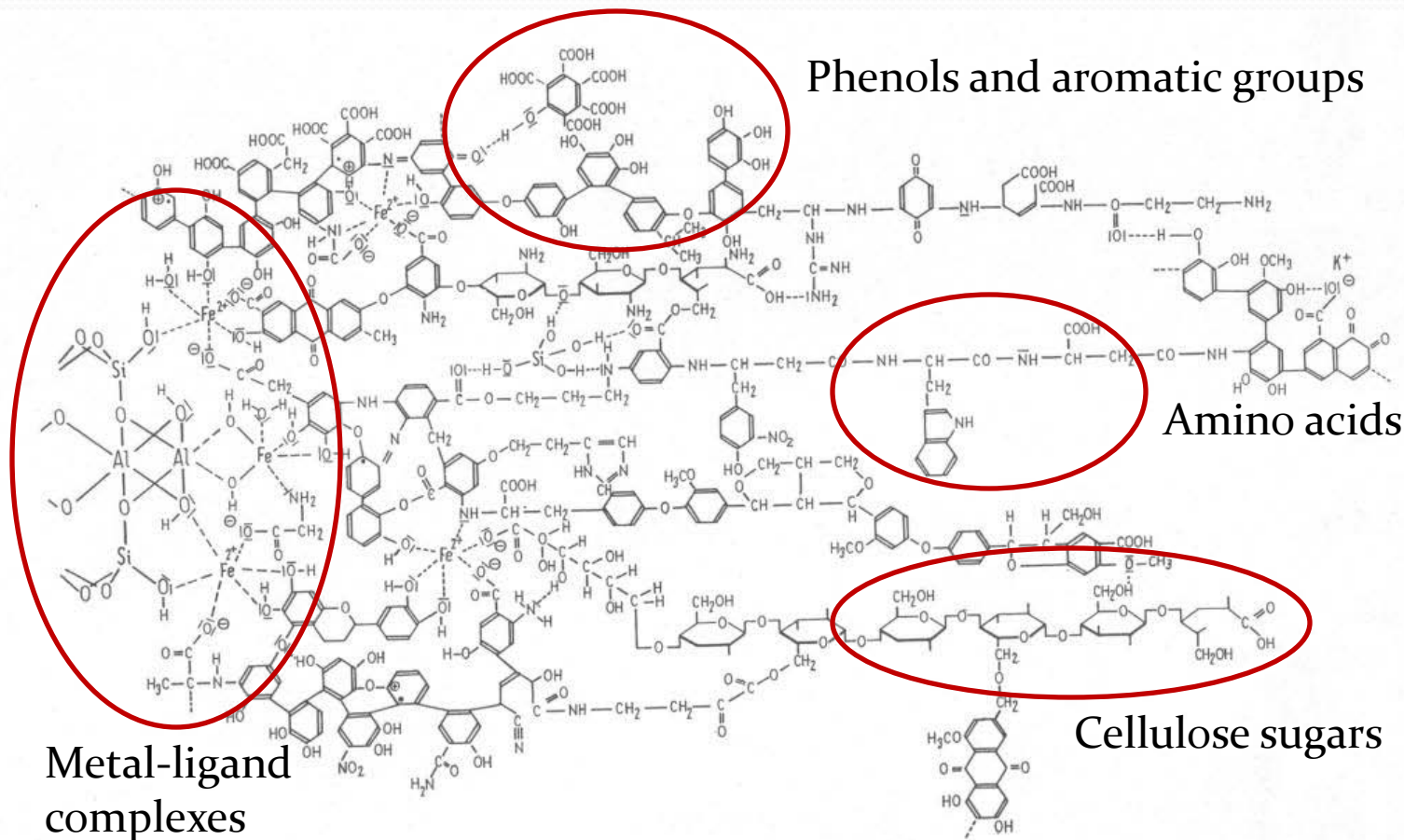
Bromoform

DOC is composed of Natural Organic Matter (NOM)



# Natural Organic Matter (NOM)

- Natural sources: algae or terrestrial plants and soil



# 1974 Safe Drinking Water Act

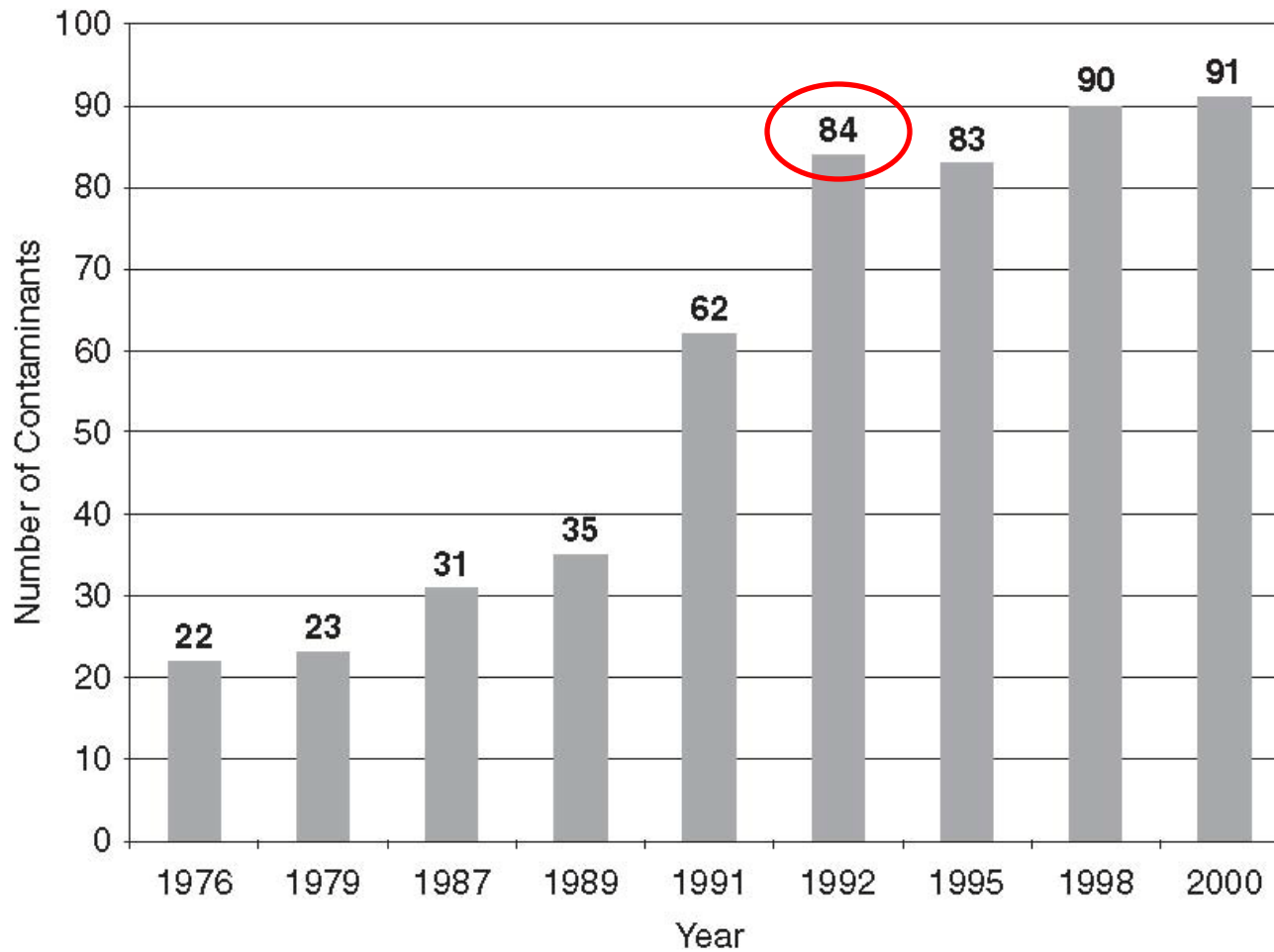
- US EPA conducts research to establish
  - National Primary Drinking Water Regulations
    - 1<sup>st</sup> Legally enforceable standards
    - Public Water Systems
      - 15 service connections, or
      - 25 residents served
    - Public health protection by limiting contaminant levels
      - Maximum Contaminant Levels (MCL)
      - Treatment Techniques (TT)
    - <http://water.epa.gov/drink/contaminants/index.cfm>

# US EPA and AWWA Research Foundation Regulatory Development Process

- Toxicology and **health effects**
- **Occurrence** and exposure
- **Analytical methods**
- **Treatment technologies**
- Economic impacts
  - Monitoring and compliance by water utilities



1986 SDWA Amendments



**FIGURE 1-1** Number of regulated contaminants from 1976 through 2000. (Source: [www.epa.gov/safewater/contaminants/pdfs/contam\\_timeline.pdf](http://www.epa.gov/safewater/contaminants/pdfs/contam_timeline.pdf).)

**TABLE 1-1** National Primary Drinking Water Regulations

Promulgation date	Regulation
Dec. 24, 1975	National Interim Primary Drinking Water Regulations
Nov. 29, 1979	Total Trihalomethanes
April 2, 1986	Fluoride
July 8, 1987	Phase I Volatile Organic Chemicals
June 29, 1989	Surface Water Treatment Rule
June 29, 1989	Total Coliform Rule
Jan. 20, 1991	Phase II Synthetic Organic Chemicals (SOCs) and Inorganic Chemicals (IOCs)
June 7, 1991	Lead and Copper Rule
July 17, 1992	Phase V SOC and IOC
Dec. 16, 1998	Stage 1 Disinfection By-Products Rule
Dec. 16, 1998	Interim Enhanced Surface Water Treatment Rule
Dec. 7, 2000	Radionuclides
Jan. 22, 2001	Arsenic
June 8, 2001	Filter Backwash Recycling Rule
Jan. 14, 2002	Long Term 1 Enhanced Surface Water Treatment Rule
Jan. 4, 2006	Stage 2 Disinfection By-Products Rule
Jan. 5, 2006	Long Term 2 Enhanced Surface Water Treatment Rule
Nov. 8, 2006	Ground Water Rule

# Seattle Water from Cedar River Watershed: Disinfectants and Disinfection Byproducts (DBPs)

	Chlorine	Disinfection Byproducts
US EPA Drinking Water Regulations	MIN: 0.2 mg/L MAX: 4.0 mg/L	MAX: 80 µg/L Trihalomethanes
Average (Cedar)	0.95 mg/L*	31 µg/L
Water Quality & Health Effects	<ul style="list-style-type: none"> <li>• Bad taste &amp; odor</li> <li>• Stomach ache</li> <li>• Eye/nose irritant</li> </ul>	Potential human carcinogen
Treatment Techniques	<ul style="list-style-type: none"> <li>• Filtration (Granular Activated Carbon)</li> <li>• Alternative disinfectants (O<sub>3</sub>, UV)</li> </ul>	



Detected Compounds		EPA's Allowable Limits		Levels in Cedar Water		Levels in Tolt Water		Typical Sources
Units	MCLG	MCL	Average	Range	Average	Range		
Raw Water								
Total Organic Carbon	ppm	NA	TT	0.6	0.3 to 0.9	1.3	1.2 to 1.6	Naturally present in the environment
Cryptosporidium	#/100L	NA	NA	ND	ND	ND	ND	Naturally present in the environment
Finished Water								
Turbidity	NTU	NA	TT	0.4	0.2 to 2.6	0.07	0.05 to 0.19	Soil runoff
Fluoride	ppm	4	4	0.98	0.9 to 1.0	1.0	0.8 to 1.1	Water additive, which promotes strong teeth
Barium	ppb	2000	2000	1.2	one sample	1.0	one sample	Erosion of natural deposits
Nitrate	ppm	10	10	0.07	one sample	0.15	one sample	Erosion of natural deposits
Total Trihalomethanes	ppb	NA	80	31	26 to 38	35	22 to 52	By-products of drinking water chlorination
Haloacetic Acids(5)	ppb	NA	60	23	9 to 41	33	23 to 38	
Total Coliform	% positive samples	0	5%	Highest Month = 0.4% Annual Average = 0.07%				Naturally present in the environment
Chlorine	ppm	MRDLG = 4	MRDL = 4	Average = 0.95 Range = 0 to 2.2				Water additive used to control microbes