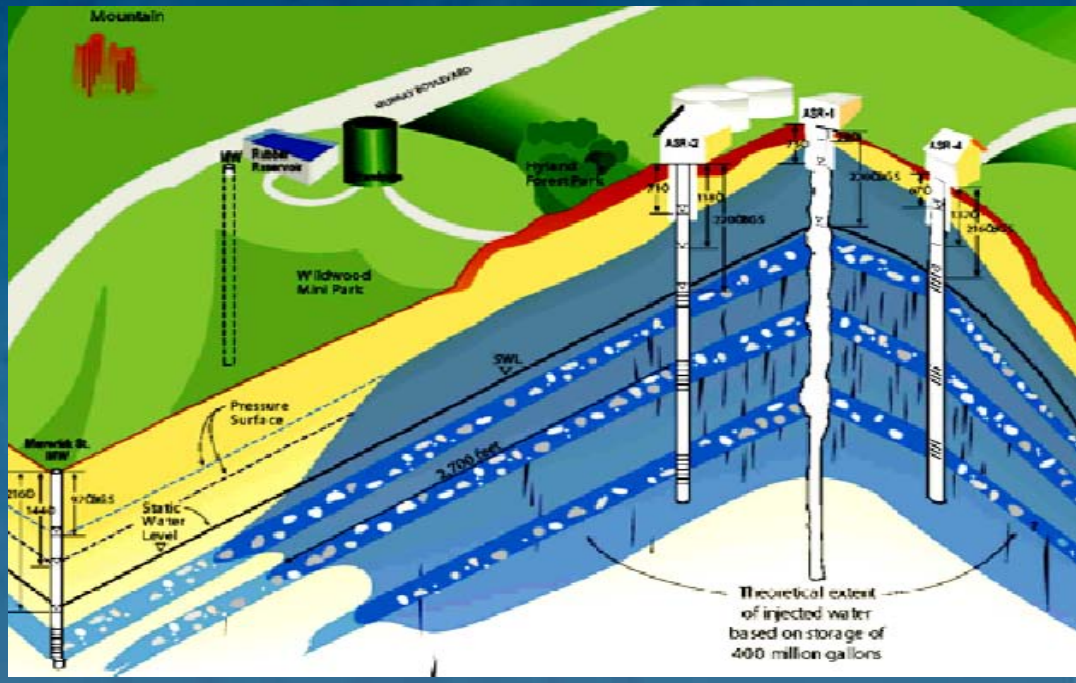
Aquifer Storage & Recovery:
A Safe Drinking Water Act Perspective

Anna Zaklikowski
HDR Engineering, Inc.

2010 Annual Forum of the
Groundwater Protection Council
September 28, 2010

Presentation Overview

- Injection water quality needs
- Raw water sources / quality issues
- Impact of treatment on finished water quality
- Regulatory environments and issues
  - Oregon
  - Washington
- Case Study: Boise White Paper LLC Pulp & Paper Plant (Wallula, WA)



Beaverton, OR ASR system

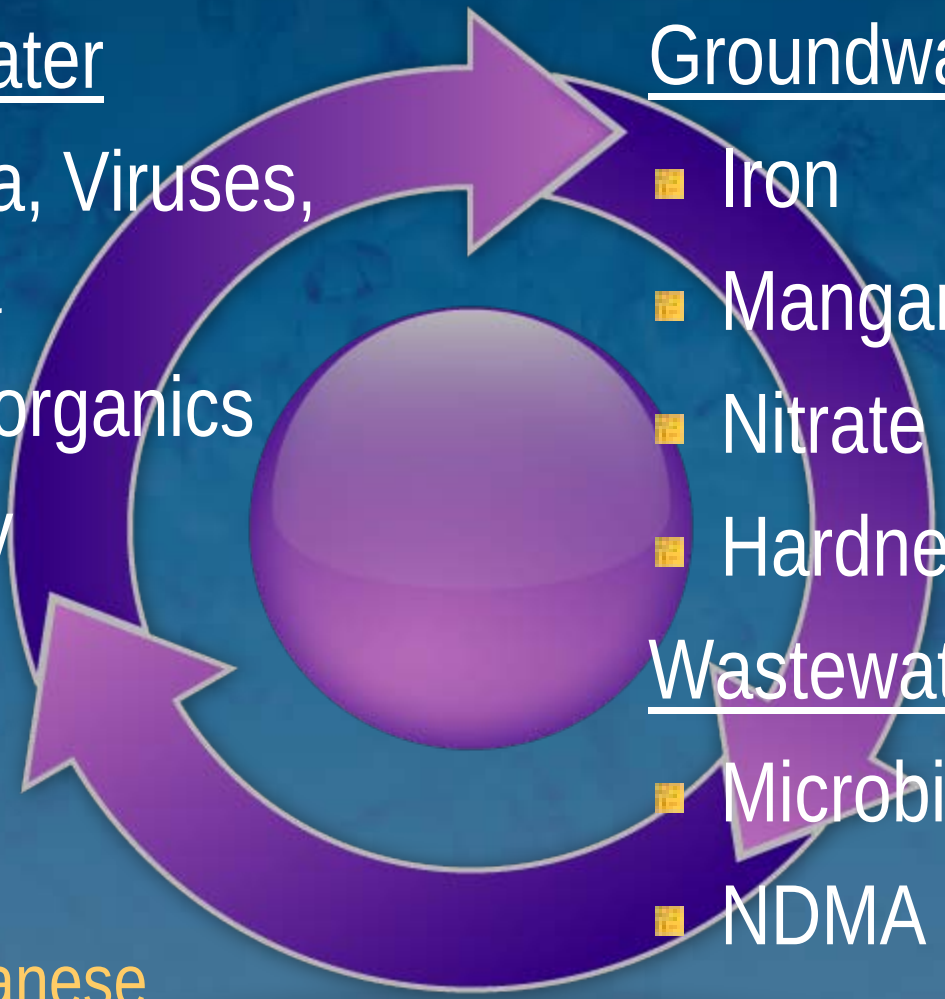
Typical injection water quality requirements

- Turbidity < 0.5 ntu
- Noncorrosive
- Geochemical compatibility
- Redox compatibility
- Others

Potential injection water sources

- Surface water
  - River
  - Lake
- Ground water
  - Alluvial aquifer
  - Adjacent aquifer
- Wastewater effluent

Typical source water quality issues



Surface water

- Protozoa, Viruses, Bacteria
- Natural organics
- Turbidity
- Lake
  - Algae
  - Iron
  - Manganese

Groundwater

- Iron
- Manganese
- Nitrate
- Hardness, CO_2

Wastewater

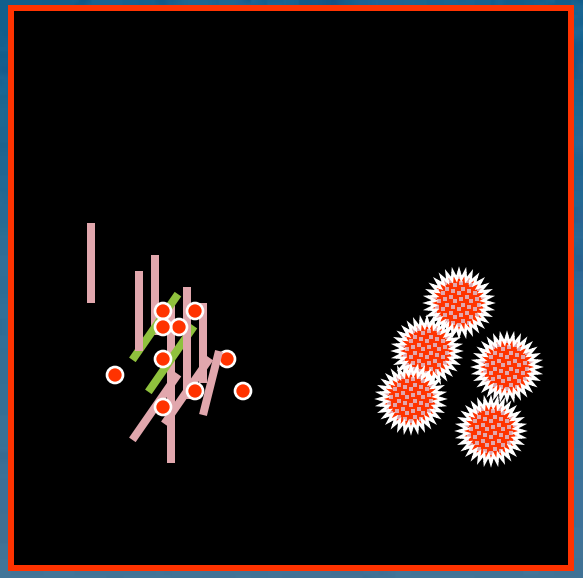
- Microbial pathogens
- NDMA
- Micro pollutants

Water Treatment Key Objective: Removal / Inactivation of Microbial Pathogens

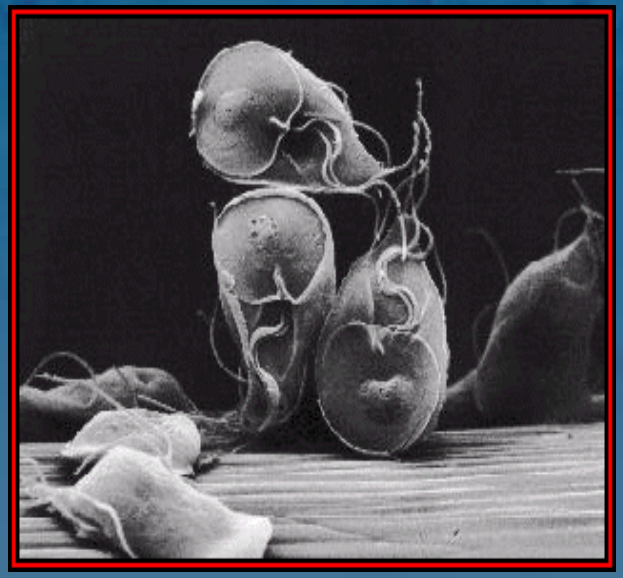
Pathogenic bacteria, viruses and protozoa in *water and* wastewater represent potential risks to public health.

Bacteria (*E.coli*)

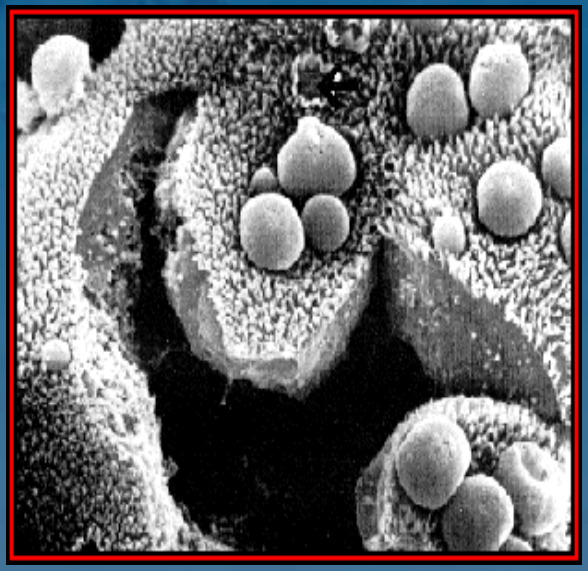
Viruses (Hepatitis, Polio)



Protozoa (*Giardia*)



(*Cryptosporidium*)

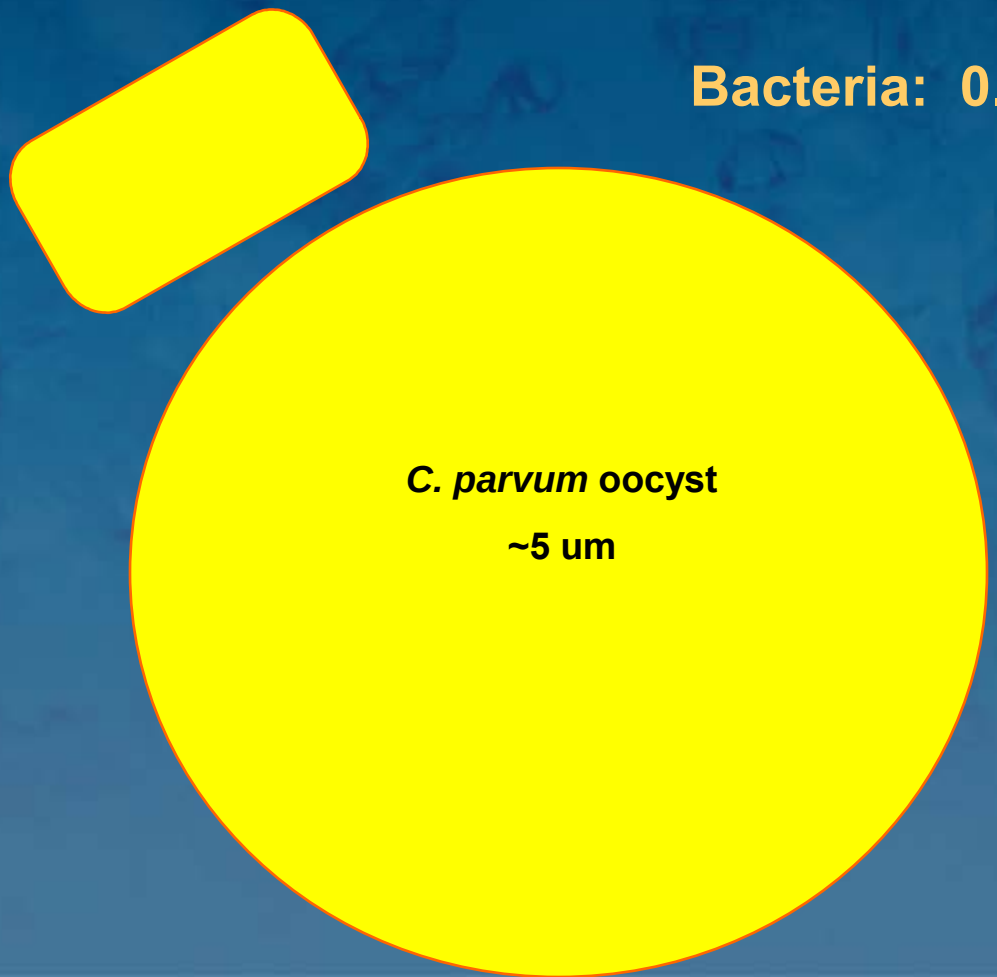


Classes of Microorganisms: The Microbial World

- **Viruses: smallest (0.02-0.3 µm diameter)**

Bacteria: 0.5-2.0 µm diameter (e.g. *E. coli*)

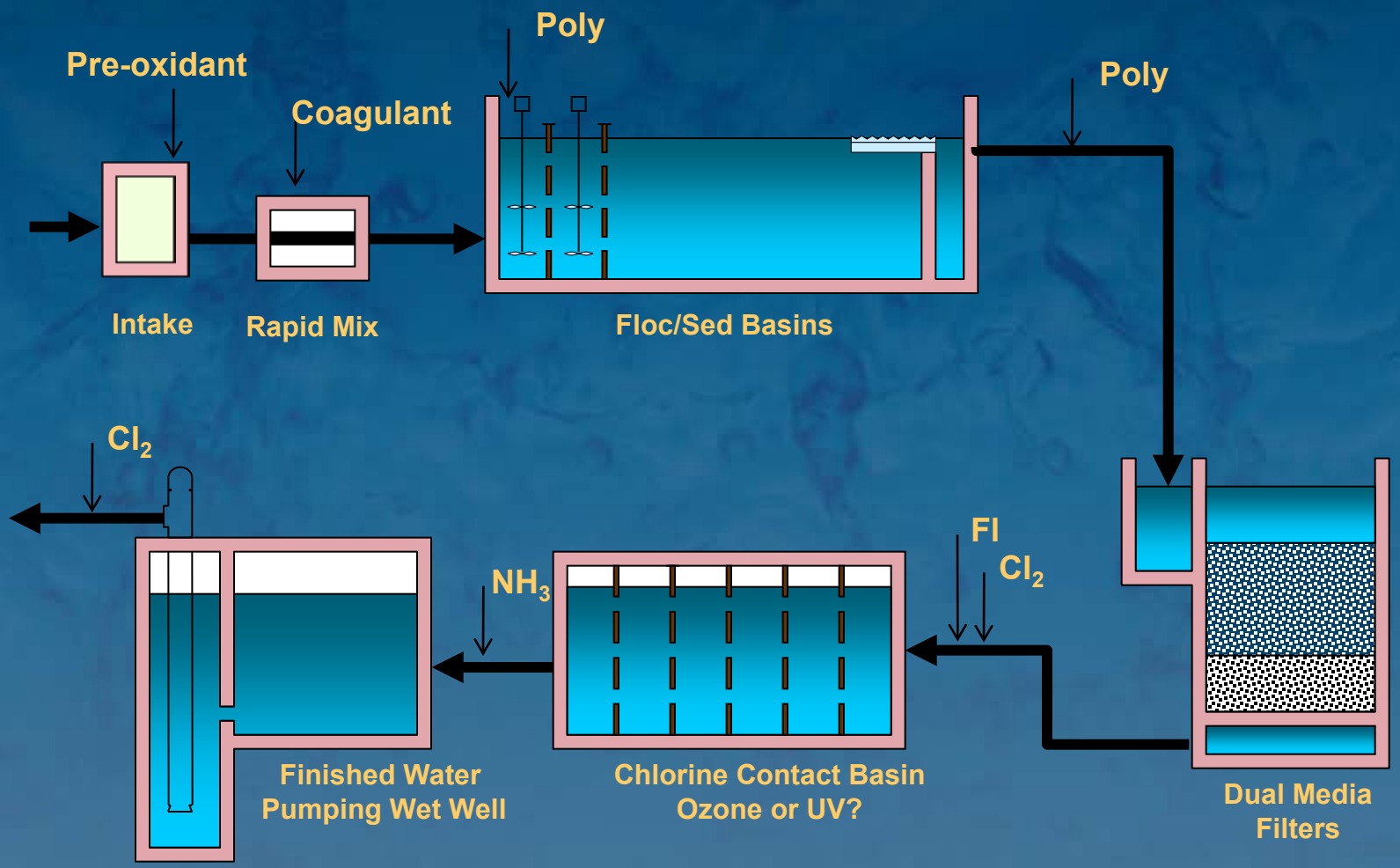
Protozoa: most >2 µm - 2 mm; (hardy cysts and oocysts)
(e.g. Giardia,Cryptosporidium)



Water treatment techniques / requirements

- Surface Water Treatment Rule (1986) "Multiple Barrier" treatment approach for surface water sources
  - Filtration: Removes some microbes (larger ones, *Cryptosporidium*)
  - Disinfection: Inactivates remaining microbes (bacteria, viruses)
- Ground Water Rule (2006)
  - Disinfection of GW generally not required
  - More utilities sourcing GW may be required to provide 4-log virus inactivation if significant deficiencies identified
- Disinfectants / Disinfection Byproducts Rule
  - Regulated trihalomethanes (THMs), haloacetic acids (HAAs), others
  - Enhanced coagulation: remove natural organics

Conventional treatment relies on chemical additives

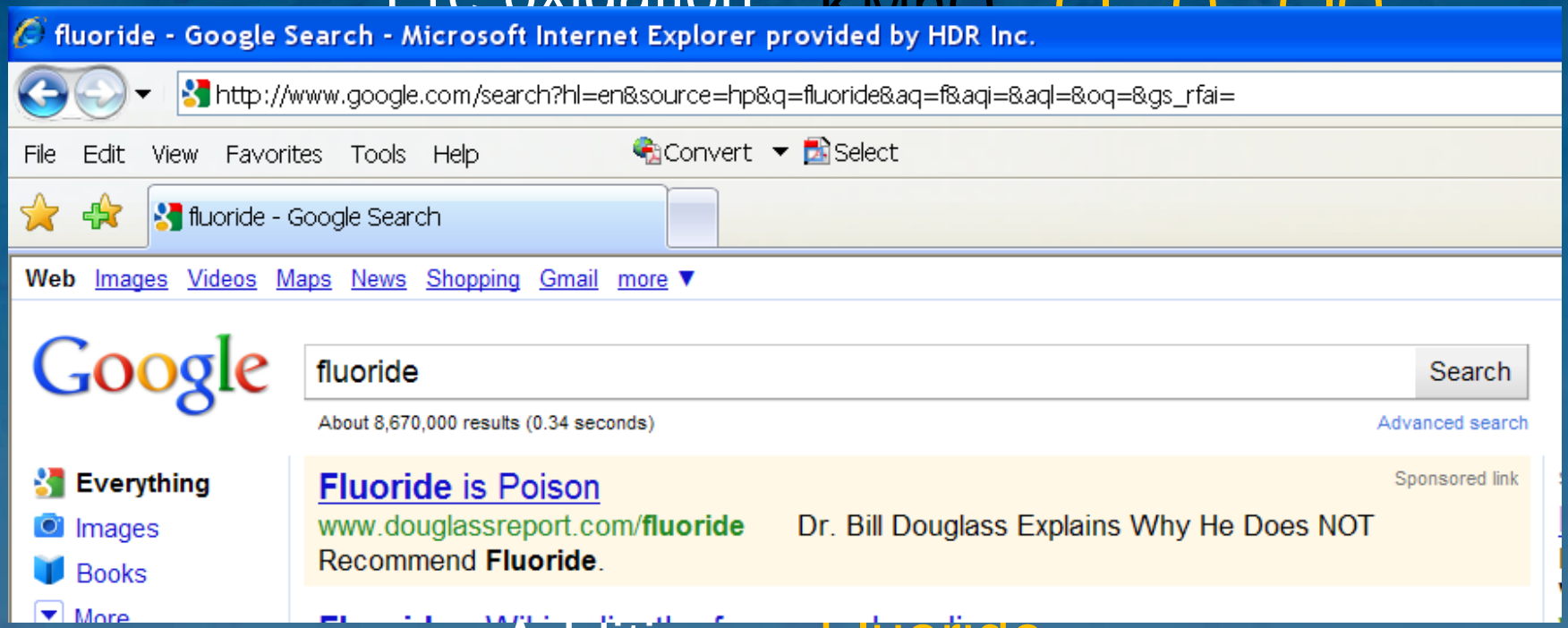


Water treatment techniques and chemical addition

Turn dissolved into particle:	Pre-oxidation
Turn dissolved into particle:	Coagulation
Make particles bigger:	Flocculation
Remove particles:	Sedimentation/Filtration
Inactivate microbes:	Primary disinfection
Protect finished water:	Secondary disinfection
Prevent tooth decay:	Additives like fluoride

Water treatment techniques and chemical addition

Pre-oxidation: KMnO4 Cl2 O3 ClO2



Additives: Fluoride

Disinfection creates chemical byproducts

Chemical Disinfectant + **Precursor** = **DBPs**

Chlorine
Chloramines
Ozone
Chlorine Dioxide

+

Natural Organics
Bromide

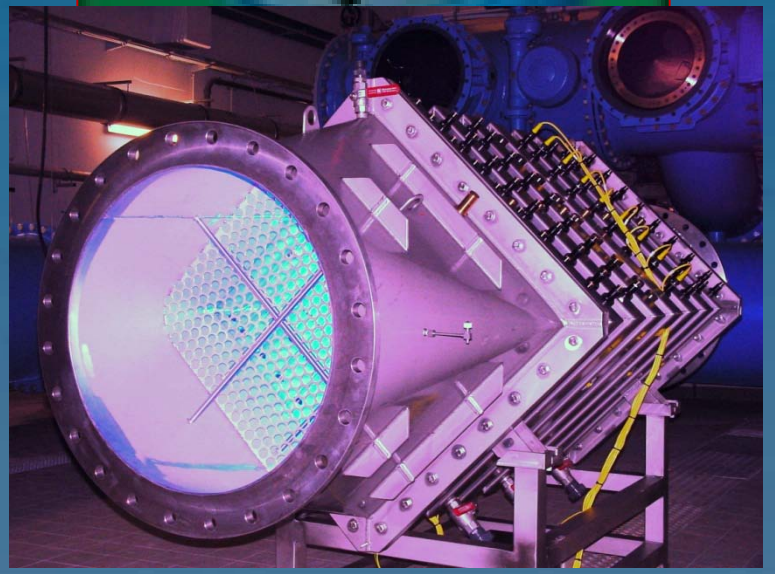
Trihalomethanes
Haloacetic Acids
Bromate
Chlorite / ate
Haloacetonitriles
Haloketones
Aldehydes
and many more

Disinfection: No Silver Bullet

	Chlorine	UV	Chloramines	Ozone	ClO2
Giardia	Fair (slow)	Excellent (fast)	Poor	Fair	Fair
Crypto	Ineffective	Excellent	Ineffective	Slow	Poor (slow)
Virus	Excellent	Poor to Fair (adenovirus resistance)	Poor	Excellent	Fair
DBPs?	Yes (THMs, HAAs)	No	No	Yes (bromate)	Yes (chlorite, chlorate)

Chemical-free treatment opportunities

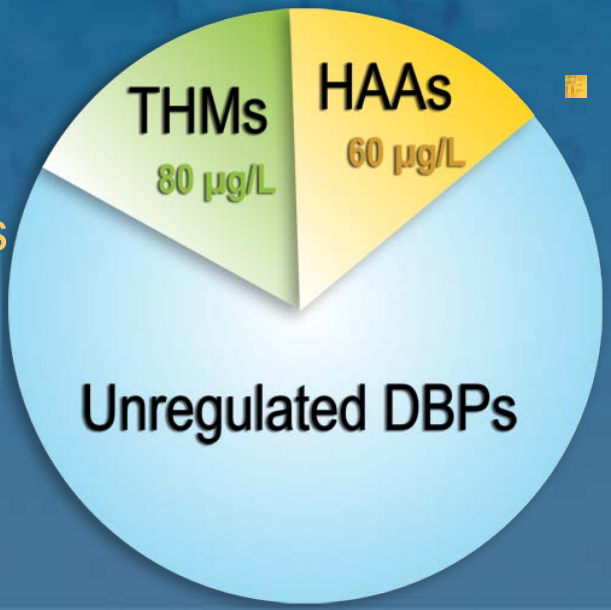
- Membrane filtration
  - Chemical free solids removal, including protozoa
  - Viruses may pass through
  - Dissolved substances like natural organics pass through
- Ultraviolet light disinfection
  - Chemical free disinfection
  - Certain viruses resistant
  - Need for secondary disinfection?



Comparison of Regulatory Approaches for ASR Injection Water

Oregon

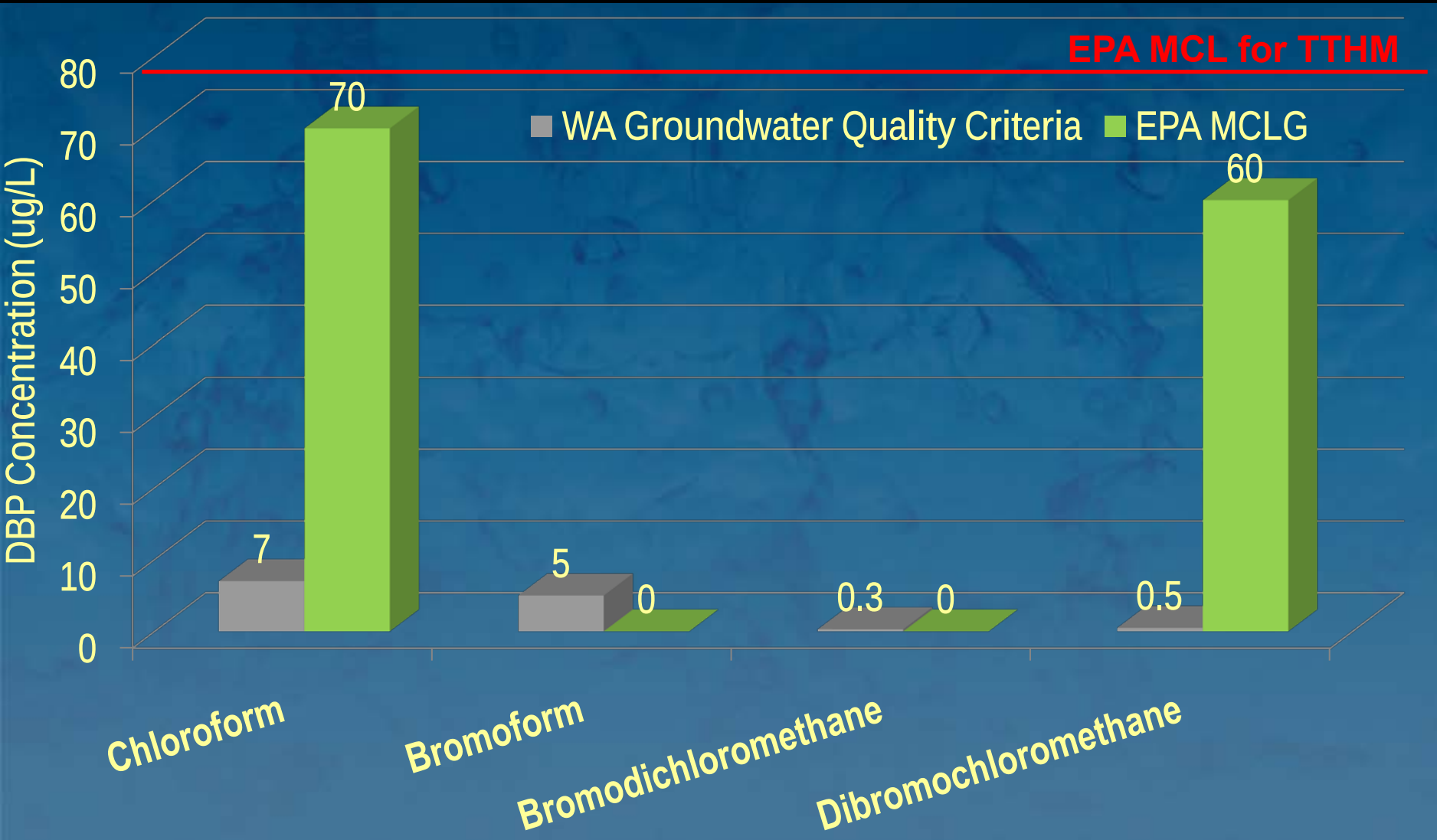
- Class V UIC
- Highest Beneficial Use
- Comply with SDWA MCLs, treatment requirements
- Injection water :
  - < MCLs for DBPs
  - < 50% of MCL for other contaminants



Washington

- Class V UIC
- Highest Beneficial Use
- Antidegradation Policy – Groundwater Quality Criteria, and
- SDWA MCLs and MCLGs
  - or if "overriding consideration of the public interest" can be demonstrated, perform AKART analysis

WA Anti-degradation regulations for THMs not consistent with SDWA



Case Study:
Boise-Wallula Pulp & Paper Facility

- Located on Columbia River
- 29.2 mgd water right ; primary use is cooling water
- $4.5M WA DOE grant
- Mutual benefits:
  - Preserve in-stream water rights
  - Use recovered water as cooling water source during summer; energy benefit
  - Reduce temp impacts to Columbia

Phase I: Well testing and observation; compare injection water with GW & WA criteria

WA GWQC Table 1 Contaminant Type	Table 1 Contaminant	Table 1 Criteria	Method Reporting Limit	Ground Water	Source Water	% of Criteria
IA. Primary Contaminants	Chromium (mg/L)	0.05	0.001	ND	0.001	2%
	Barium (mg/L)	1	0.001	0.012	0.028	2.8%
	Nitrate (as N) (mg/L)	10	0.1	ND	0.2	2%
IB. Secondary Contaminants	Iron (mg/L)	0.3	0.01	0.03	0.23	76%
	Sulfate (mg/L)	250	0.1	0.6	15.3	6%
	Zinc (mg/L)	5	0.001	0.002	0.003	0.06%
ND: Non-Detect						

- No parameter > WA Groundwater Quality Criteria
- Sulfide, fluoride, and radon higher in native GW
- Treatment requirements?

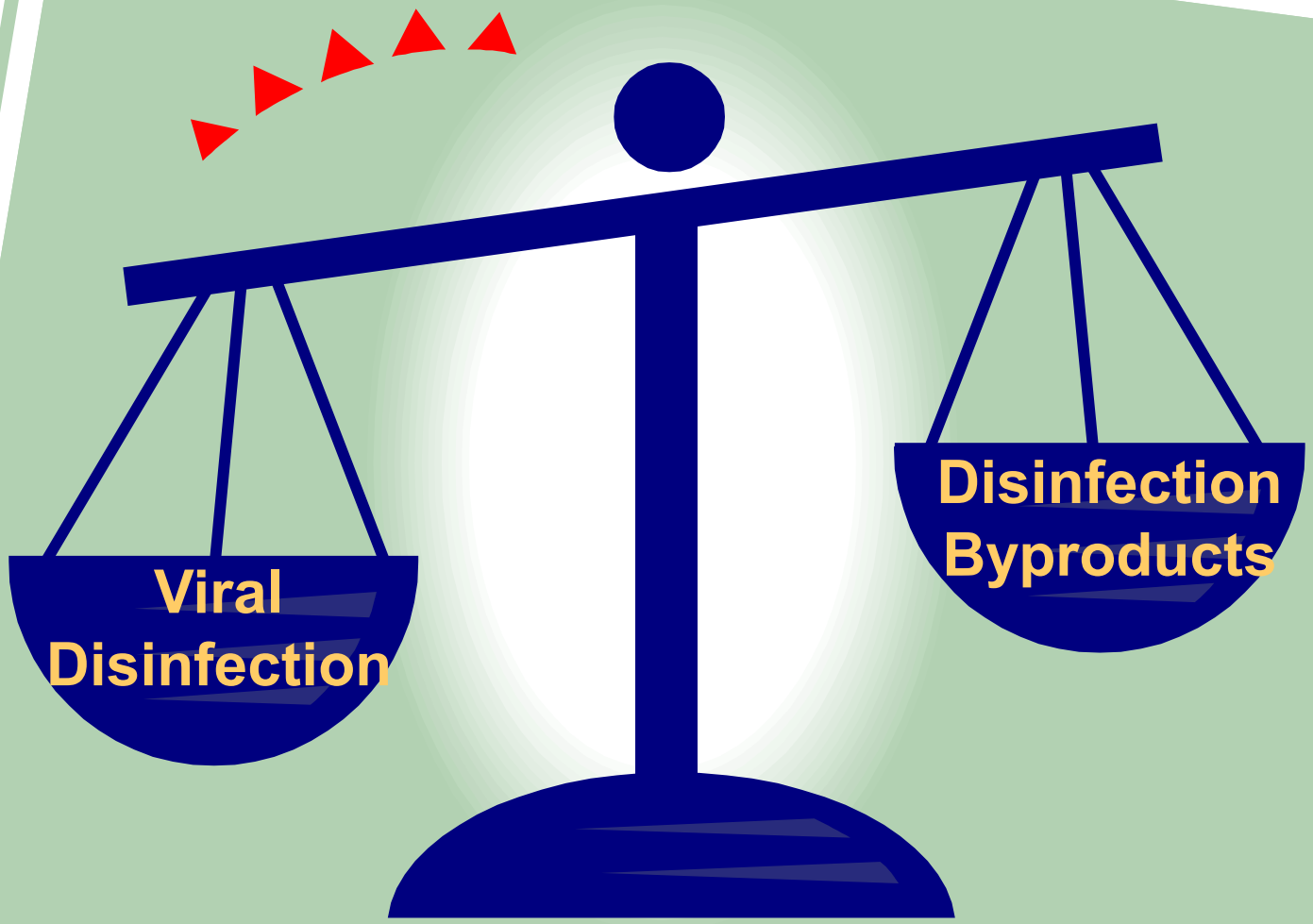
Define treatment for beneficial use

- Existing WTP at Boise White Paper plant does not have addn'l capacity
- Time-of-travel to plant site boundary is 150 days
- Period of storage < 120 days
- Are viruses/bacteria sufficiently reduced?

Can disinfection by avoided if bacteria/viruses are attenuated?

- Viral longevity is function of temperature
- Recovered water temp ranges from 7.8 – 14.4°C
- 4-log inactivation of bacteria will occur within 63 days.
- 4-log inactivation of viruses will occur within:
  - 41 days when > 10°C
  - 262 days when < 10°C

Disinfection / DBP balance



Acknowledgements

- Bryan Black and Michael Britton (HDR)
- GSI Water Solutions, Inc.
- Boise Cascade
- WA DOE

Questions?