Special Considerations for Small Drinking Water Systems

Ontario Water Works Association

Small Systems Committee

WCWC Walkerton Clean Water Centre

Brian Jobb – MS Filter Inc.

MSF

Special Considerations for Small Systems

Equipment Selection Criteria:

- Meet Regulatory Requirements?
- Low Life-Cycle Cost?
- Operator Skill Level Required?
- Simple Process?
- Treatment Chemicals?
- Serviceable by Local Trades?

Special Considerations for Small Systems

Basic Requirement:

Technology must meet regulatory standards

- Federal Guidelines
- Provincial Objectives or Legislation
- Voluntary (Partnership for Safe Water...)

Special Considerations for Small Systems

Federal-Provincial-Territorial Committee on Drinking Water

- Responsible for Federal Guidelines (GCDWQ)
- Representatives of Health Canada and all Provinces/Territories
- Provinces generally adopt Federal Guidelines
- Guidelines based on available health effects information

Special Considerations for Small Systems

GCDWQ - Turbidity

Chemically-assisted Filtration:

≤0.3 NTU IN 95% OF SAMPLES; NEVER>1.0 NTU
(PREVIOUSLY ≤0.5 NTU)

Slow Sand Filtration or DE:

≤1.0 NTU IN 95% OF SAMPLES; NEVER > 3.0 NTU
(UNCHANGED)

Membranes:

≤0.1 NTU IN 99% OF SAMPLES; NEVER > 0.3 NTU
(PREVIOUSLY 95% OF SAMPLES)

Special Considerations for Small Systems

GCDWQ - Disinfection Byproducts (DBPs):

- Total Trihalomethanes: 100 µg/L (0.1 mg/L)
- Bromodichloromethane: 16 µg/L (0.016 mg/L)
  - Also included in the Total THMs
- Haloacetic Acids: 80 µg/L (0.08 mg/L)
  - (proposed)

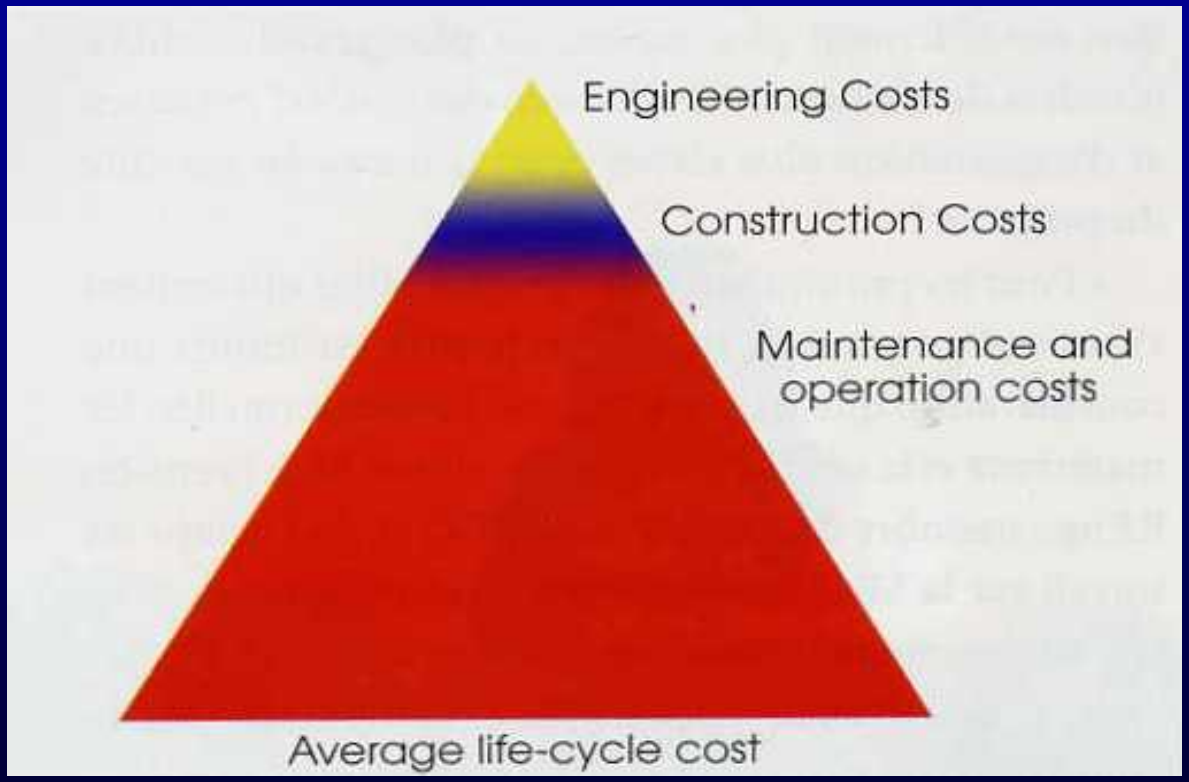
... To Be Continued

Special Considerations for Small Systems

Technology Should Have Low Life Cycle Costs which Include:

- Engineering Costs (1 -2 % of total)
- Construction Costs (6 – 18 % of total)
- Operations and Maintenance Costs (**80 – 93%** of total life cycle cost)

LIFE CYCLE COST



Source: Consulting Engineers of Canada

Special Considerations for Small Systems

Operations and Maintenance Factors

- Operations:
  - Utilities (Hydro, Heat)
  - Costs (Chemicals, Replacement Components)
  - Operating Contract
  - Ease of Operation (Operator Skill Level)
  - Operator Time Required (Labour Cost)
  - Wastewater and Sludge Handling Costs

Special Considerations for Small Systems

Operations and Maintenance Factors

- Maintenance:
  - Frequency of Maintenance
  - Cost (Local Labour or Service Call?)
  - Is Contract Required to Maintain Warranty?
  - Ease of Maintenance (Operator Skill Level)
  - Operator Time Required (Labour Cost)

Special Considerations for Small Systems

Common Problems for Small Systems:

- Limited Resources for O & M (Capital Cost Typically Subsidized)
- Operator has Multiple Responsibilities
- Expensive Service Calls by OEM
- Obtaining Required Operator Training
- Complex Treatment Chemical Systems

Special Considerations for Small Systems

Common Problems for Small Systems:

- Attracting & Retaining Skilled Operators
  - Overall Shortage of Qualified Operators (35% Eligible to Retire Within 10 Years)
  - Operators must also be Electronics Technicians
  - Comparatively Low Compensation
  - High Level of Responsibility

Special Considerations for Small Systems

Special Considerations for Remote Locations

- High Travel Costs for Service Workers
  - High Costs for **all** Supplies and Replacement Components (Freight)
  - Training Costs can be Extremely High
  - Skilled Operators may Simply not be Available

Special Considerations for Small Systems

Special Considerations for Remote Locations

Chemical Costs:

- Freight can be > 75% of total chemical costs!
- Bulk supply reduces freight costs, but requires large storage tanks and heated storage
- Many chemicals have a shelf life
- Emergency supply of chemicals may require air transportation under certain circumstances

Special Considerations for Small Systems

Complexity of Treatment Chemical Addition

- Safety Concerns - Handling and Storage
- May Contain Contaminants and Carcinogens
- Difficult to Obtain in Small Quantities
- High Level of Attention and Skill Required
- Main Component of Sludge
- Can be a BIG Problem for Small Systems

Special Considerations for Small Systems

Conventional Slow Sand Filtration Meets Regulatory Requirements for Filtration of Surface Waters

- USEPA - Slow Sand Plants Average 99.9% (3-log) removal of *Cryptosporidium* oocysts*
- Ontario MOE, Roughing Filter + Slow Sand (No Ozone) Credited with 2.5-log *Giardia* Removal*
- *Similar Credit as Full Conventional Treatment
- Documented ability to remove protozoan cysts and oocysts - 99.999% (5-log) removal possible

Special Considerations for Small Systems

Conventional Slow Sand Filtration Meets Requirements for Filtration

But

Conventional Slow Sand Filtration May Not Reduce DBPs to acceptable levels

Special Considerations for Small Systems

Disinfection By-Products:

Formed when chlorine and/or bromine combines with organic compounds:

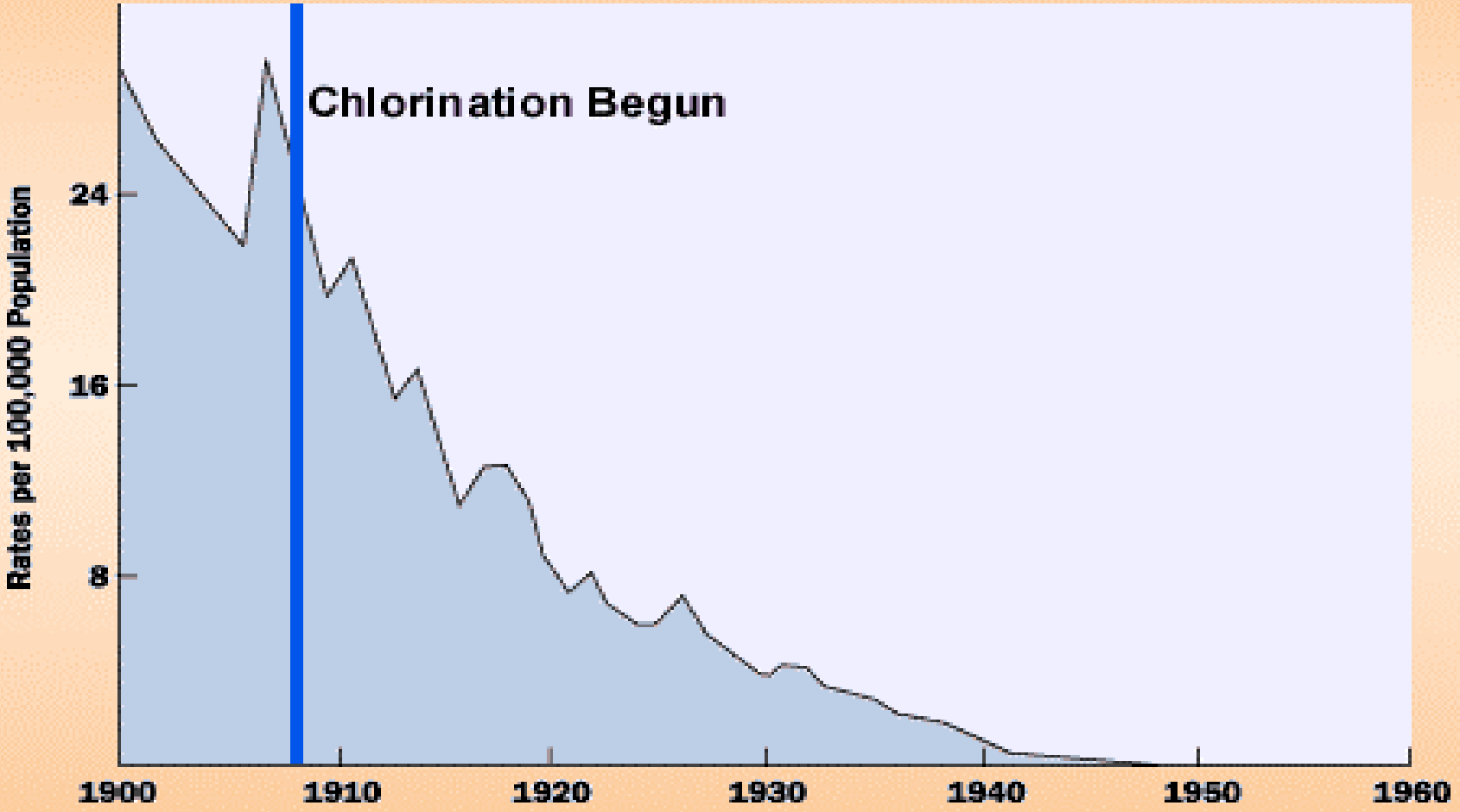
- Trihalomethanes (THM)
- Haloacetic acids (HAA_5)
- Haloacetonitriles (HAN)
- Other chlorinated organics

Special Considerations for Small Systems

Balancing Disinfection with DBP Formation

- Disinfection must take priority; pathogens can affect many people very quickly
- Health risk from DBPs based on long-term exposure – over 70 year period
- DBP reduction strategies must ensure adequate disinfection at all times

Death Rate for Typhoid Fever
United States, 1900-1960



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

Special Considerations for Small Systems

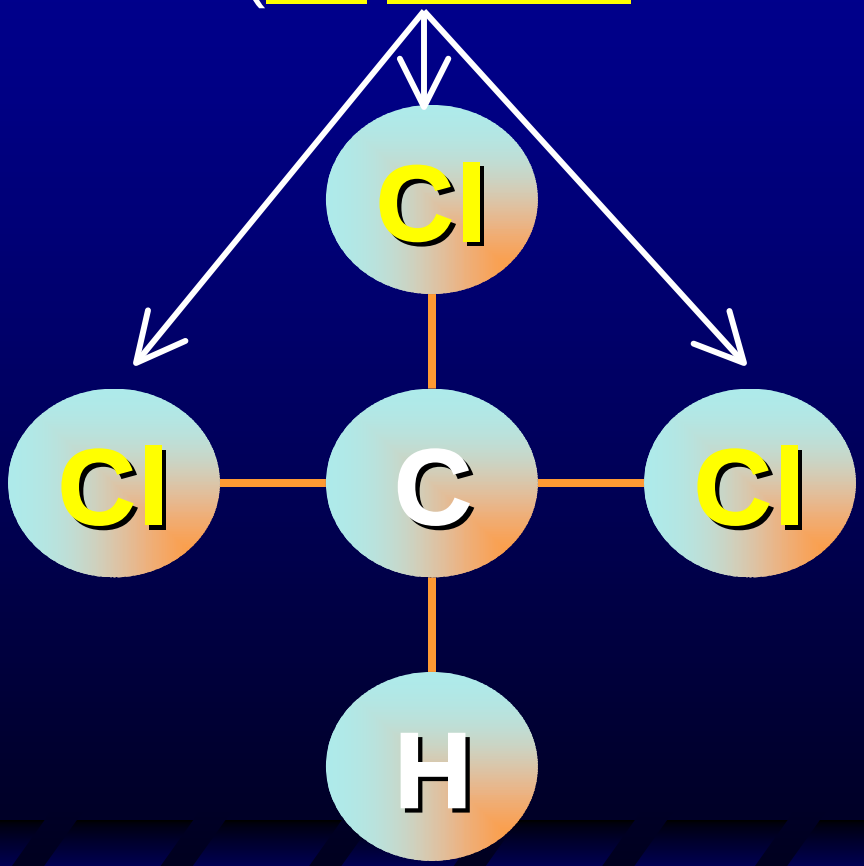
Trihalomethanes (THMs)

Predominant in Higher pH Waters

- Chloroform
- Bromo dichloro methane*
- Dibromo chloro methane
- Bromoform

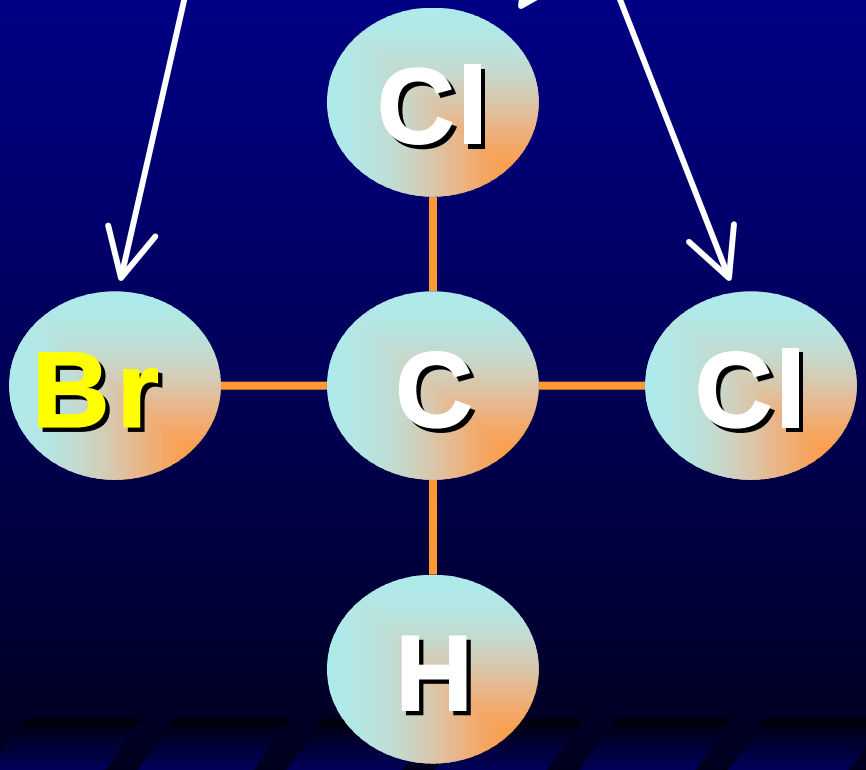
Special Considerations for Small Systems

CHLOROFORM (TRI CHLORO METHANE)



Special Considerations for Small Systems

BROMO DI CHLORO METHANE

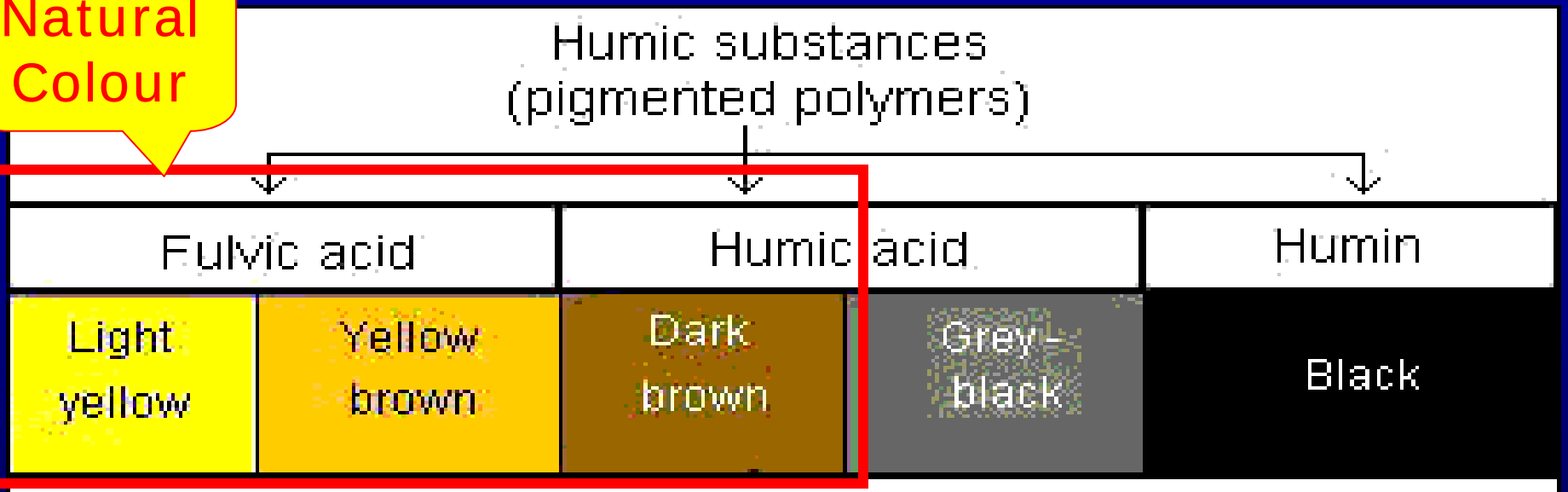


Origin of Organic Compounds

- Natural Sources
  - Decomposing plants and animals
- Human Sources
  - Industry
  - Agriculture
  - STP Effluents

Special Considerations for Small Systems

Natural Colour

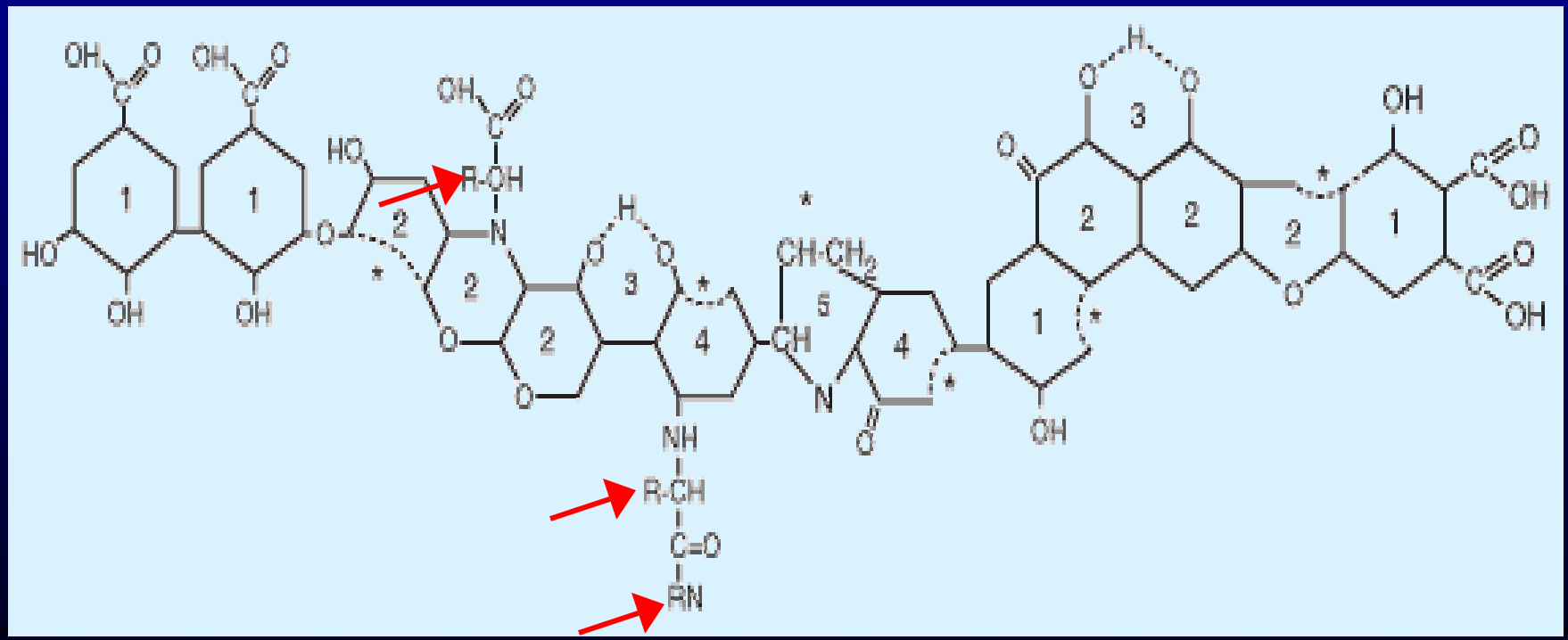


	increase in intensity of colour	→
	increase in degree of polymerization	→
2 000	increase in molecular weight	→ 300 000 ?
45%	increase in carbon content	→ 62%
48%	decrease in oxygen content	→ 30%
1 400	decrease in exchange acidity	→ 500
	decrease in degree of solubility	→

Soluble

Chemical properties of humic substances. (Stevenson 1982)

Humic Acid (hypothetical)




4-1.5mg03
Dec 9/07
BJ
1-Raw
Dec 9 07
BJ

Special Considerations for Small Systems

Haloacetic Acids (HAA_5)

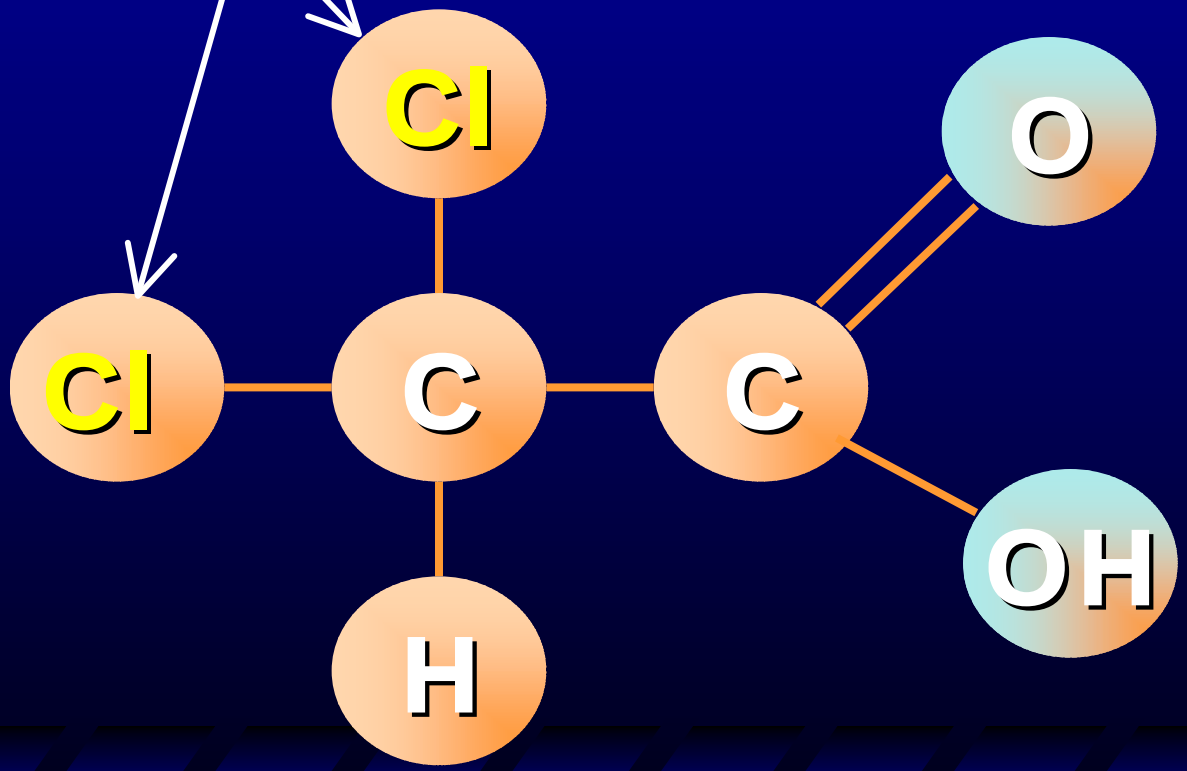
Predominant in Lower pH Waters

5 Regulated or proposed Haloacetic Acids

- Mono Chloro Acetic Acid
- Di Chloro Acetic Acid
- Tri Chloro Acetic Acid
- Mono Bromo Acetic Acid
- Di Bromo Acetic Acid

Special Considerations for Small Systems

DICHLORO ACETIC ACID



Special Considerations for Small Systems

THM & HAA_5 Formation Affected by:

- Total Organic Carbon levels
- Types of organic precursors
- Type of chlorine and dosage
- pH, Temperature
- Bromide level
- Reaction time (form slowly in distribution system)

Special Considerations for Small Systems

Enhancements or *Modifications* made to *conventional* Slow Sand Filtration to:

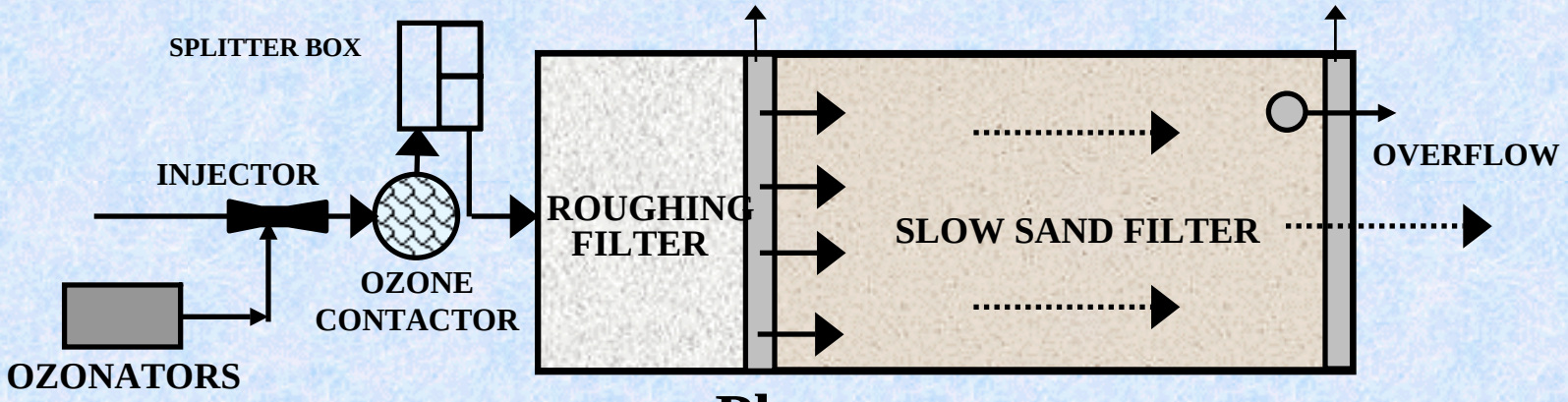
- Reduce DBPs
- Protect Slow Sand Filter From High Turbidity
- Maintain Simple Operations
- Reduce Exotic Contaminants
- Control Corrosiveness

Special Considerations for Small Systems

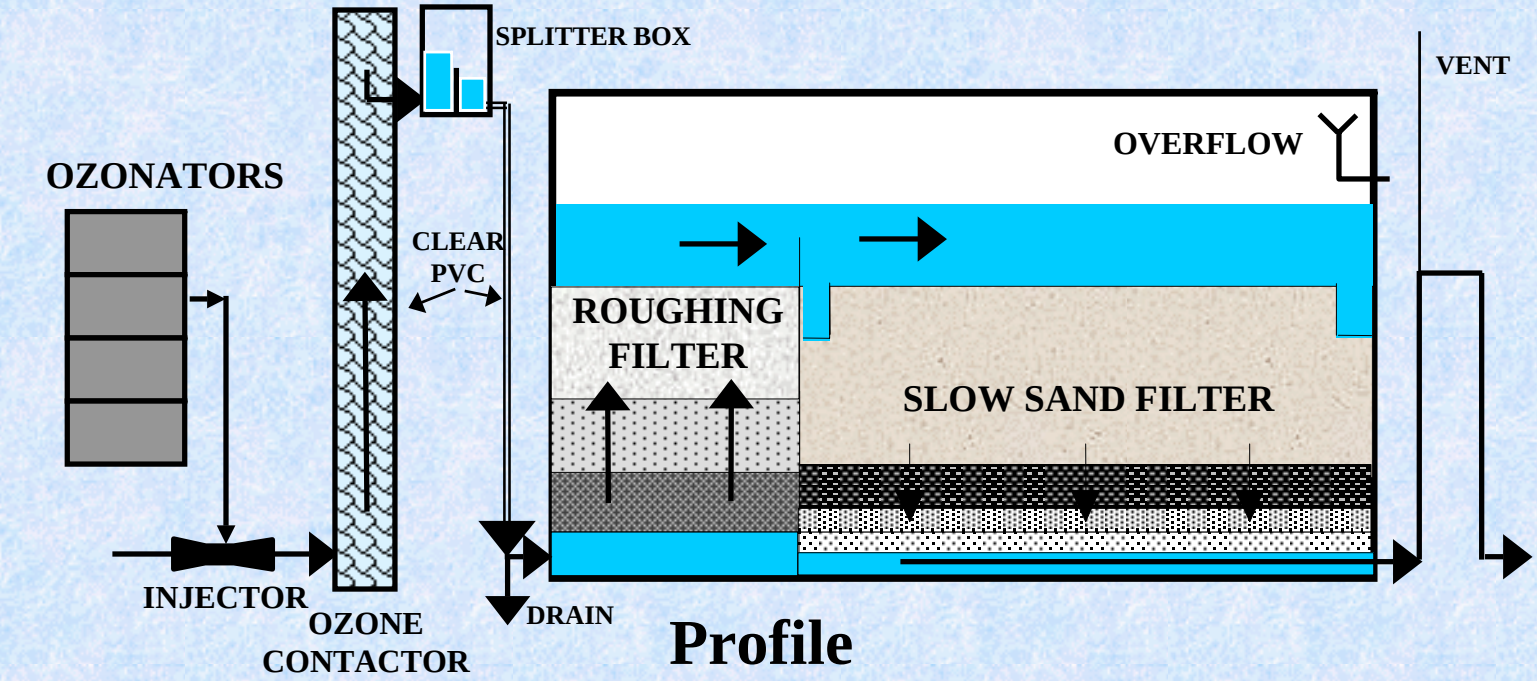
Modified Slow Sand Filtration can Include:

- Pre-Ozonation - Oxidation of organics and disinfection
- Roughing Filter - Protects slow sand filter from high turbidity or algae blooms
- Slow Sand Filter - Primary biological phase
- Biological GAC Filter - Secondary biological phase
- Post-treatment limestone contact - pH adjustment

Modified Slow Sand Filter



Plan



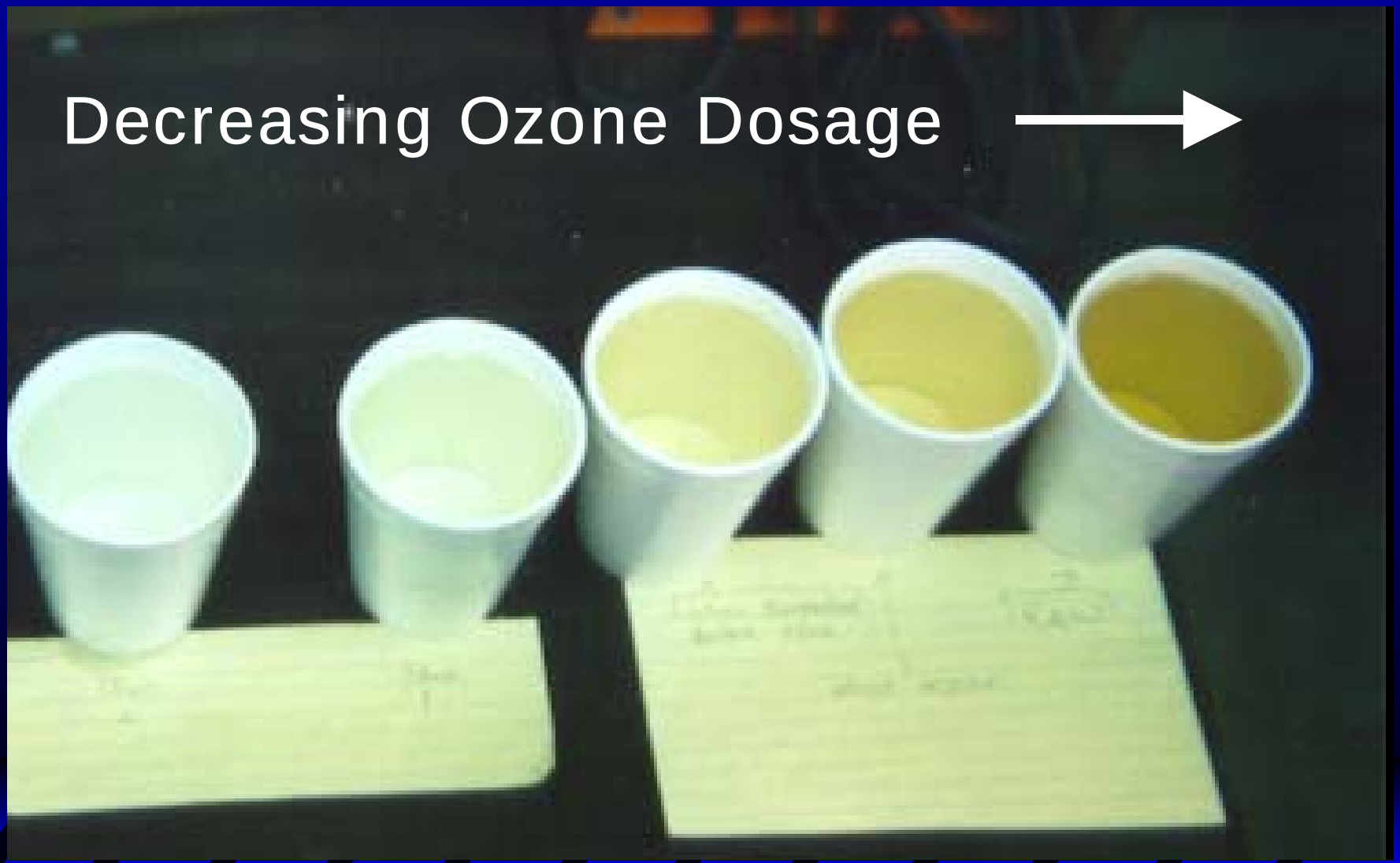
Profile

Special Considerations for Small Systems

Modified Slow Sand Filtration

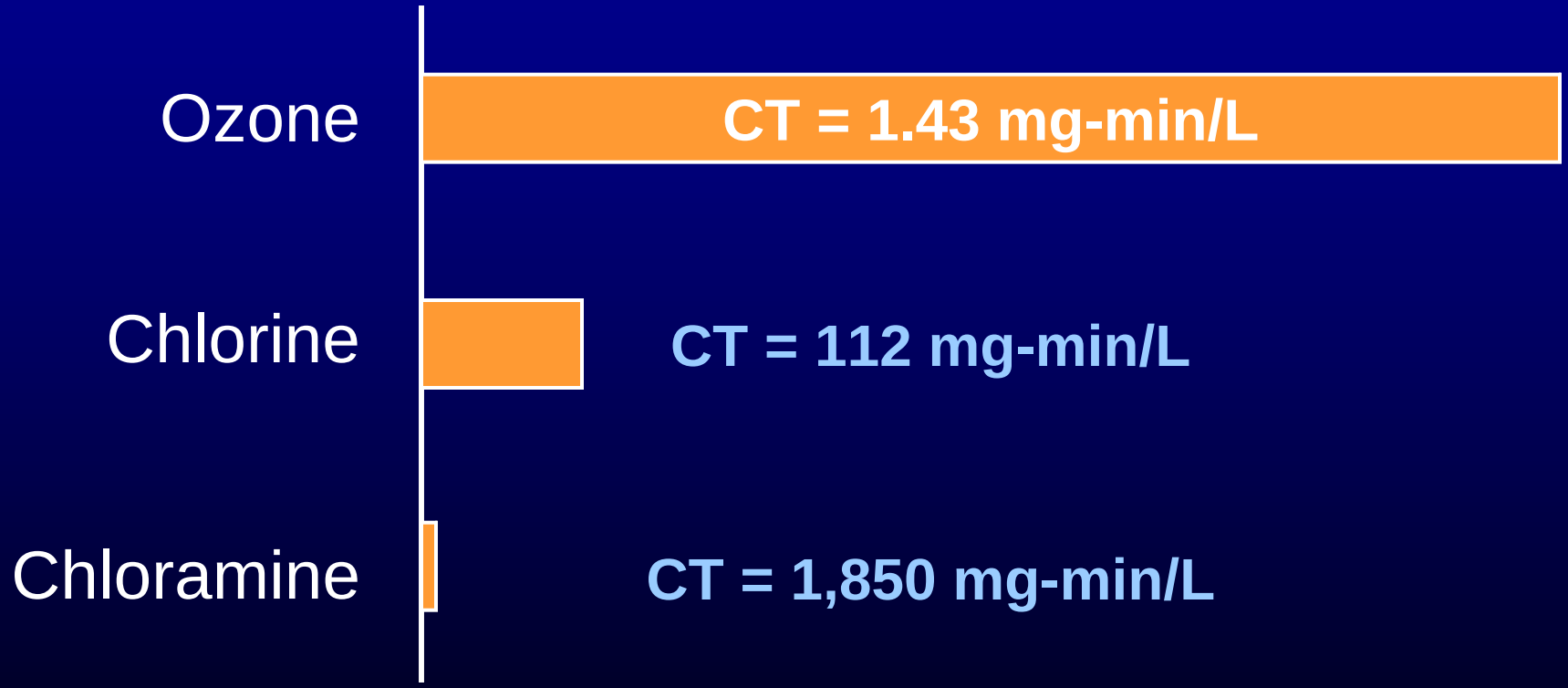
- Pre-Ozonation
  - Oxidizes large colour molecules -Creates BDOC
  - Oxidizes Fe, Mn, Taste & Odour, Exotics
  - Very Powerful Disinfectant
- Package Plant with “Automated” Cleaning
  - Eliminates removal of sand

Ozonated Raw Surface Water



Special Considerations for Small Systems

Ozone - Disinfection Power

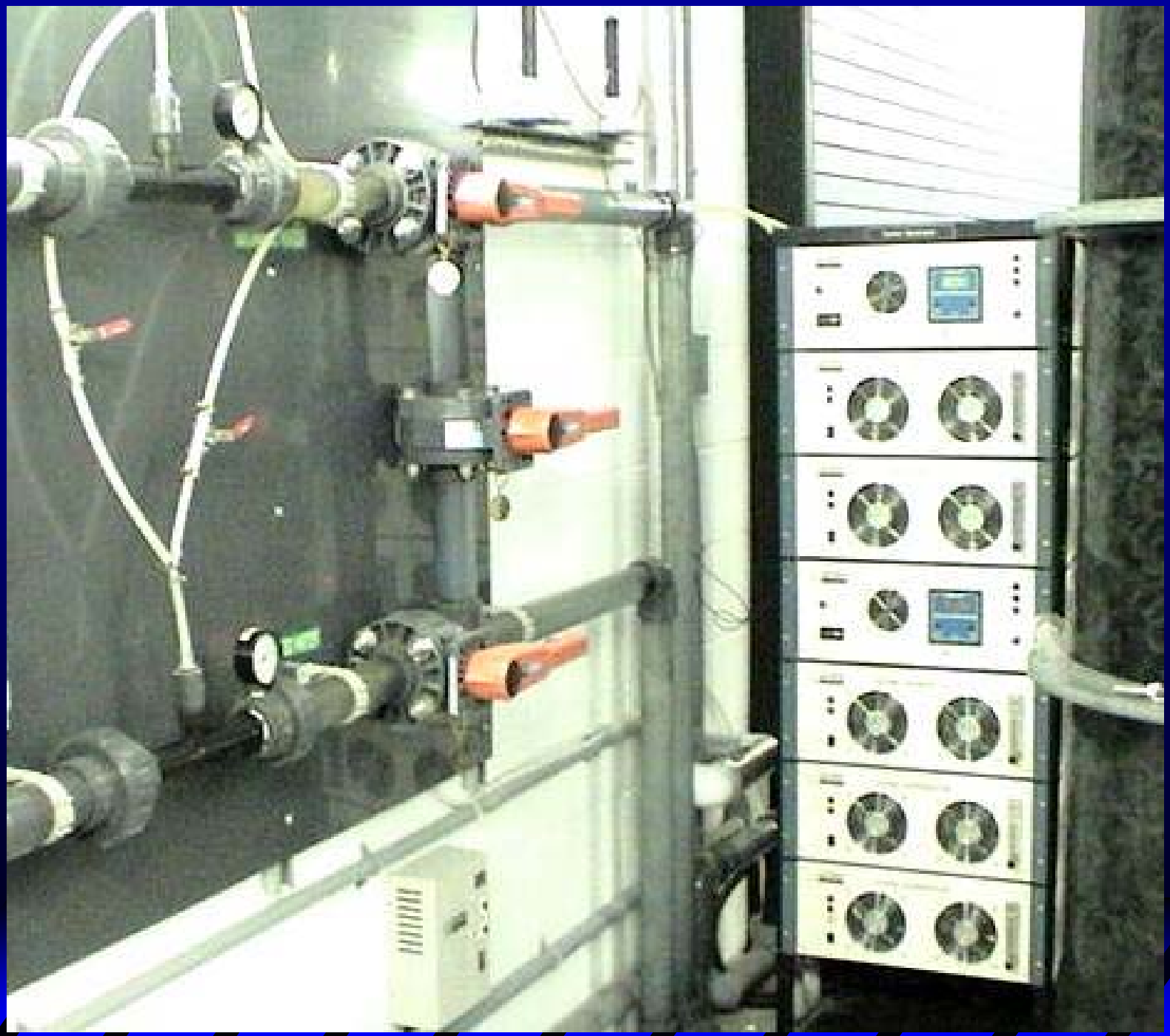


CT for 3-log *Giardia* cyst inactivation @ 10°C and pH 7

Special Considerations for Small Systems

Pre-ozonation

- Ozonation System
  - Air Preparation = Desiccant Dryer
  - Air Cooled
- Low Power Consumption
  - 408 Watts per generator
- Safety-Related:
  - Low Noise Levels
  - Ozone under negative pressure (no leaks)
  - Ozone-in-air monitor supplied



Special Considerations for Small Systems

Coagulation Required for Effective Conventional or Membrane Treatment

- Coagulation for Coloured, Soft Waters:
  - Pre-alkalinity adjustment
  - Primary Coagulant
  - Polymer - Coagulant aid
  - Post-pH Adjustment

Special Considerations for Small Systems

Coagulation Not Required for Modified Slow Sand Filtration

- Colour = Large Complex Molecules
    - Not Biodegradable
- Colour Oxidized into Biodegradable Molecules (BDOC)
- BDOC = Food Source for Microorganisms
- Coagulants = 90% of Sludge Residuals

Special Considerations for Small Systems

Roughing Filtration

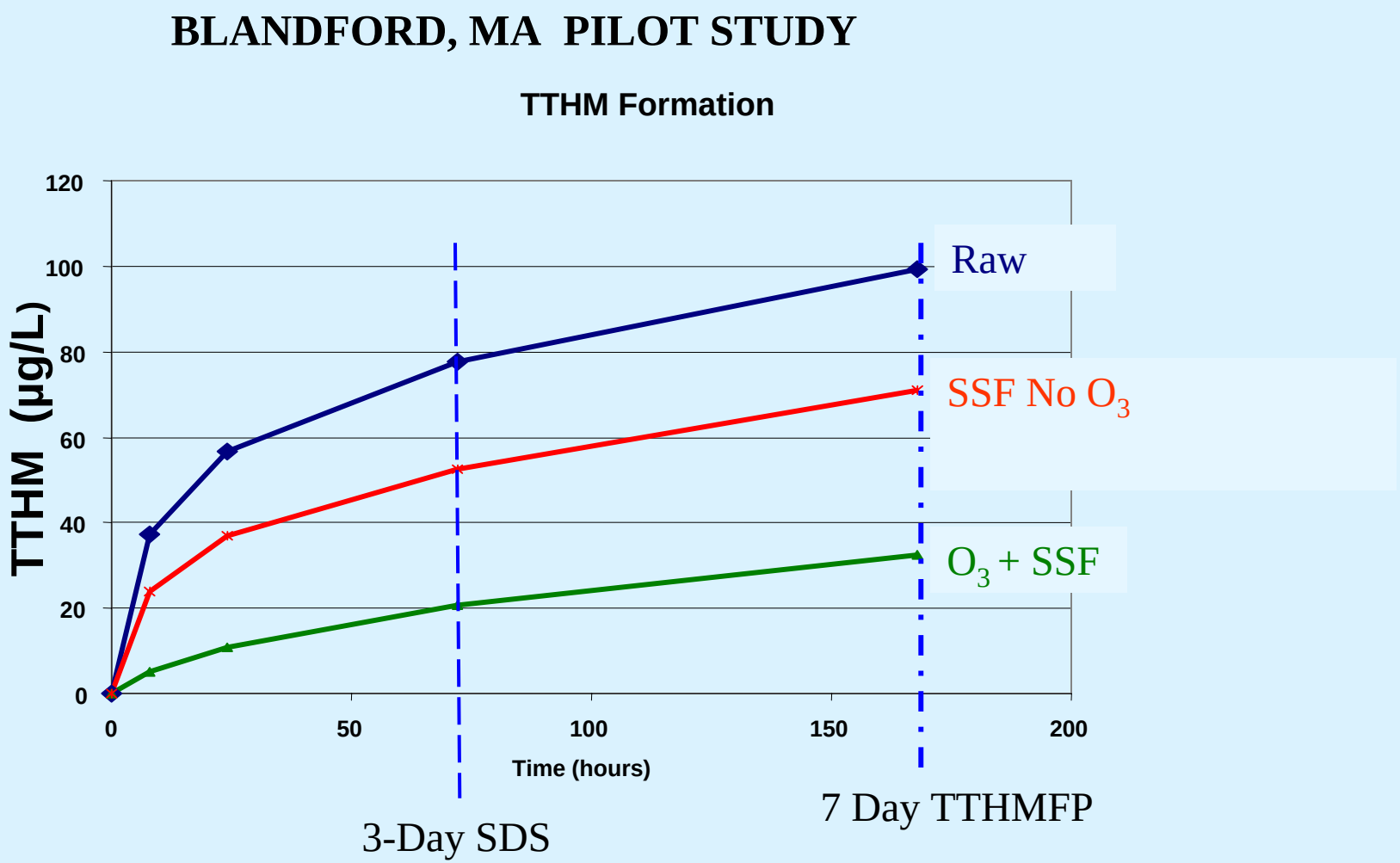
- Coarse Media – Gravel / Sand / BGAC
- Removes Turbidity and Algae
- Extends Range of Raw Water Turbidity
- Cleaning Independent of Slow Sand Filter
- GAC Layer Protects the organisms from Ozone

Special Considerations for Small Systems

Slow Sand and Biological GAC Contactor

- BDOC Removal Important
  - Can Lead to Regrowth
  - May Increase DBPs
  - Biological Treatment Very Effective
- TOC Removals Similar to Al Coagulation
- Excellent DBP Precursor Removal

Special Considerations for Small Systems



Special Considerations for Small Systems

Summary - Modified Slow Sand:

- Meets Current Regulatory Requirements
- Capable of Meeting Future Requirements*
- Safe, Simple Operation
- Very Low Operations and Maintenance Costs
- No Complex Coagulation Chemical Addition
- Minimal Sludge Generation
- Operator–Friendly Process


Black Lake, SK – Filtration Tanks

Black Lake - 788 m^3/day

Special Considerations for Small Systems

Ontario Water Works Association
Small Systems Committee

Thank You !

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Questions?

WCWC Walkerton Clean Water Centre