CORONA | ENVIRONMENTAL CONSULTING

Fundamentals of Chloramination

- Several brands are mentioned in this training material. That does not mean these brands or products are endorsed by CA/NV AWWA or Corona Environmental.

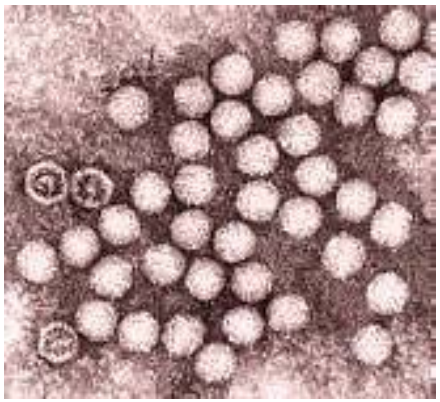
Learning Objectives

- Why we use chlorine
- How chlorine and ammonia work together
- What happens when chlorine/ammonia ratio is not ideal

Why Disinfect Source Water?

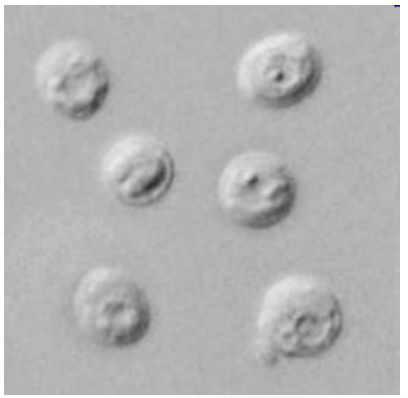
- To kill pathogens in water
- Prevent biofilm buildup in the distribution system
- Protect the public from waterborne disease

Virus



Bacteria (e.g. Total Coliforms)

Protozoa



What can happen with a loss of chlorination?

What are the Types of Disinfection?

- Chlorine
- Chloramines
- Chlorine dioxide
- UV (Ultraviolet disinfection)
- Ozone

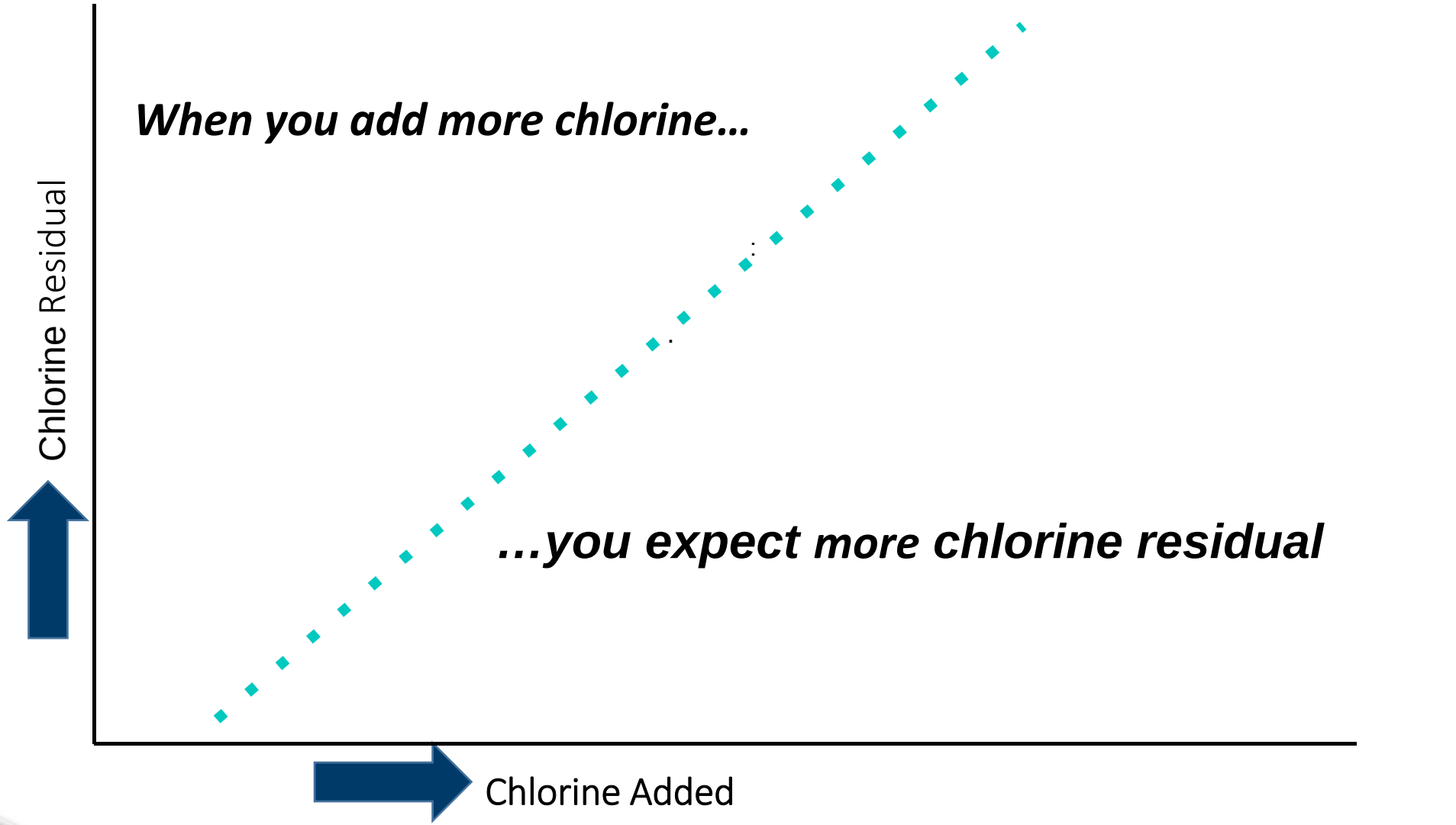
Which disinfectant(s) provide protection in the distribution system?

The good, the bad and the ugly

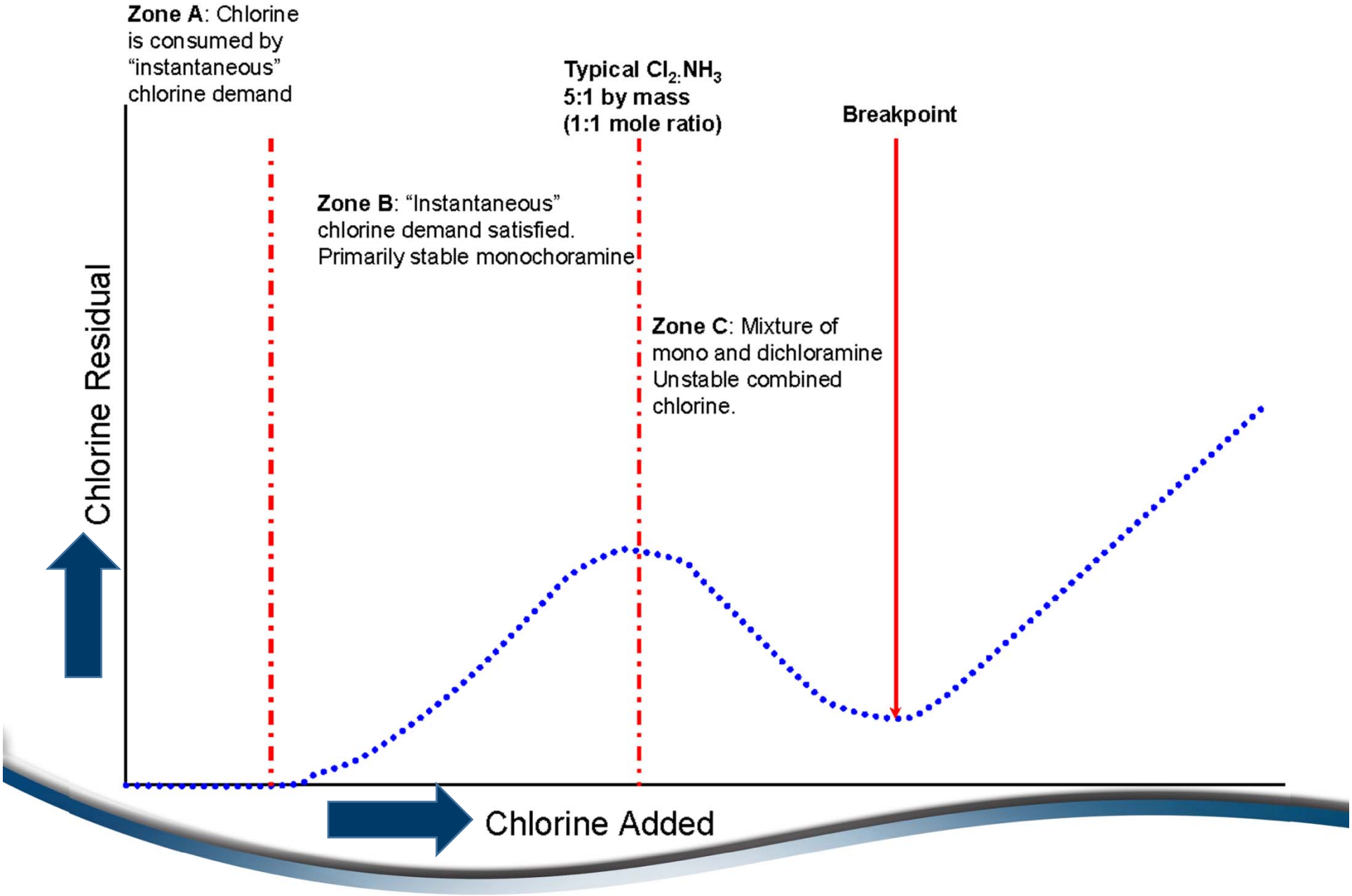
- Good
  - Lower disinfection by-products
  - Longer lasting residual in the distribution system
- Bad
  - Potential n-Nitrosodimethylamine (NDMA) formation
  - Nitrification
- Ugly
  - Severe consequences of uncontrolled nitrification

Chloramination

- React free chlorine with ammonia to form chloramines
  - **$HOCl + NH_3 \rightarrow NH_2Cl + H_2O$ (monochloramine) GOAL**
  - $NH_2Cl + HOCl \rightarrow NHCl_2 + H_2O$ (dichloramine)
  - $NHCl_2 + HOCl \rightarrow NCl_3 + H_2O$ (trichloramine)
- Usually monochloramine


When you add more chlorine…
…you expect more chlorine residual
Chlorine Residual
Chlorine Added

...*but not necessarily so when ammonia is present!!!*

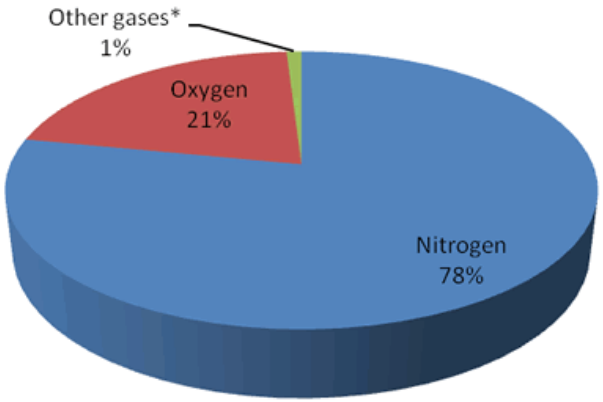


What happens to the chlorine and ammonia during breakpoint?

- Chlorine becomes chloride

http://www.saltopiasalts.com/health-benefits.html

- Ammonia becomes nitrogen gas



http://www.epa.vic.gov.au/agc/r_cc_understanding.html#page-3/!

Breakpoint chemistry

$$2NH_2Cl + HOCl \rightarrow N_2 + H_2O + 3H^+ + 3Cl^-$$

- Chlorine becomes chloride
- Ammonia becomes nitrogen gas
- Note that the reaction goes to completion

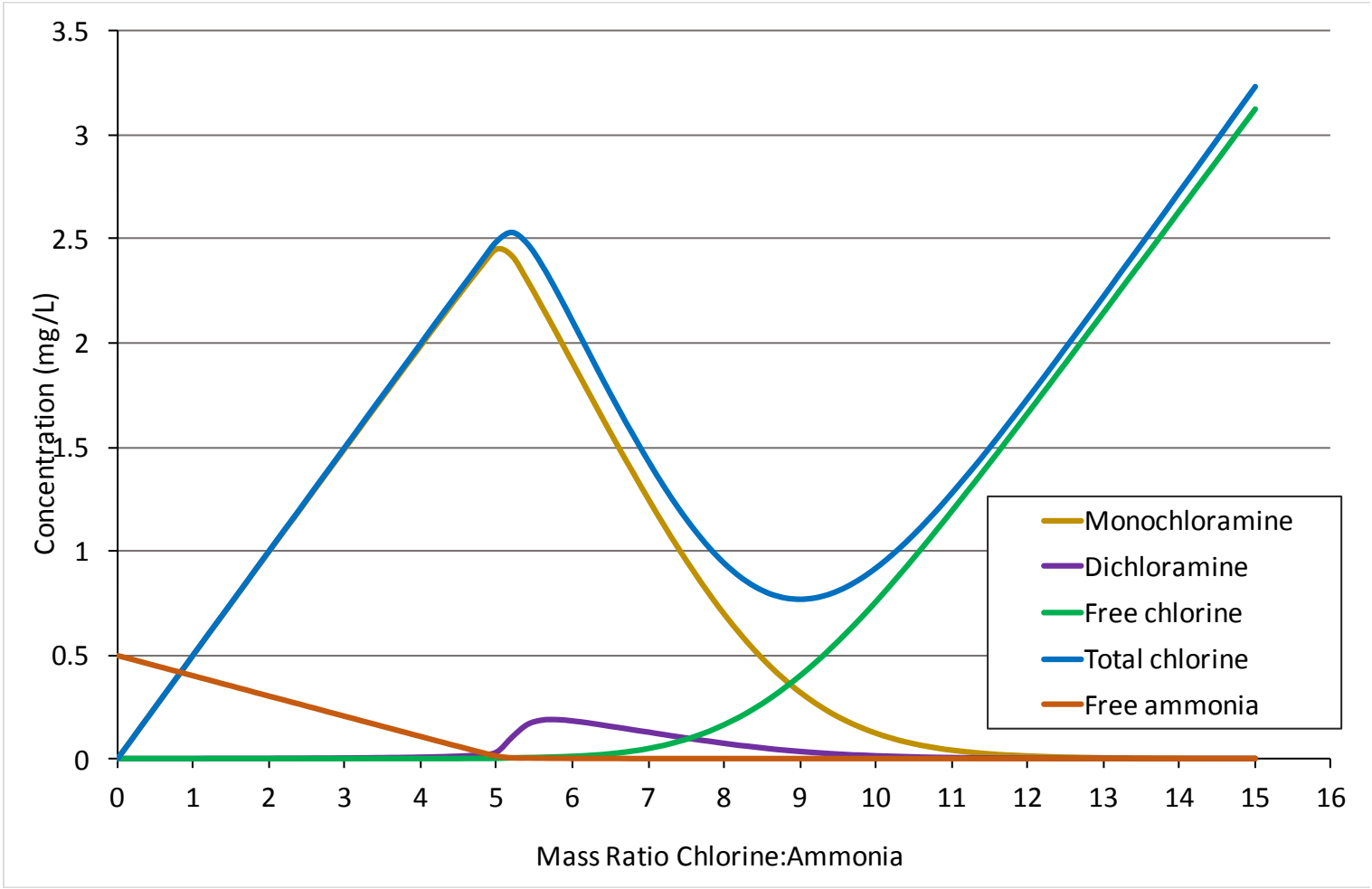
How do you manage your chlorine to ammonia ratio?

Do you make changes seasonally to the residual or ratio?

Minimize free ammonia

- Excess free ammonia = food for microbes
- 4.5:1 chlorine to ammonia (as N) on a weight basis

How free ammonia varies

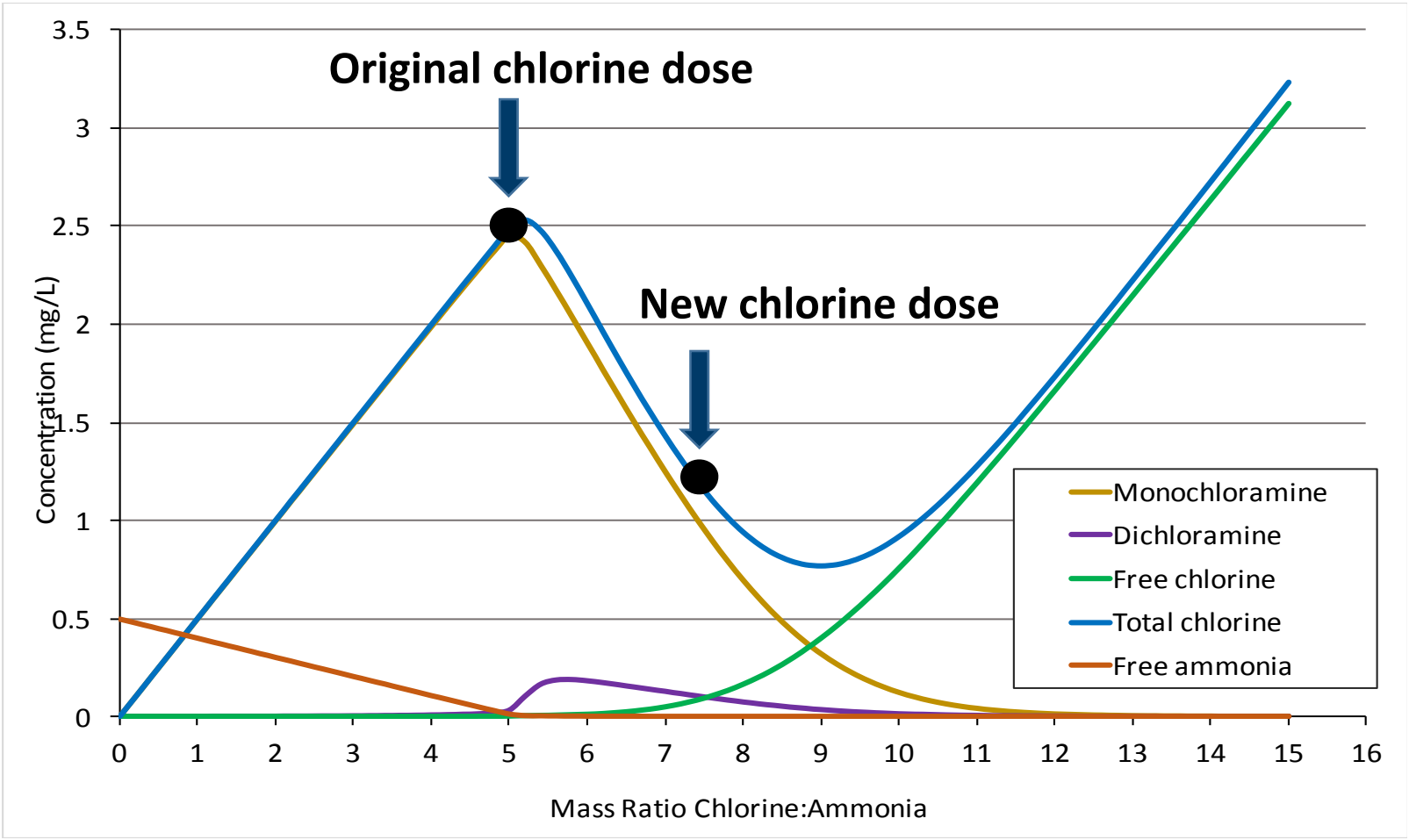


https://usepaord.shinyapps.io/Breakpoint-Curve/

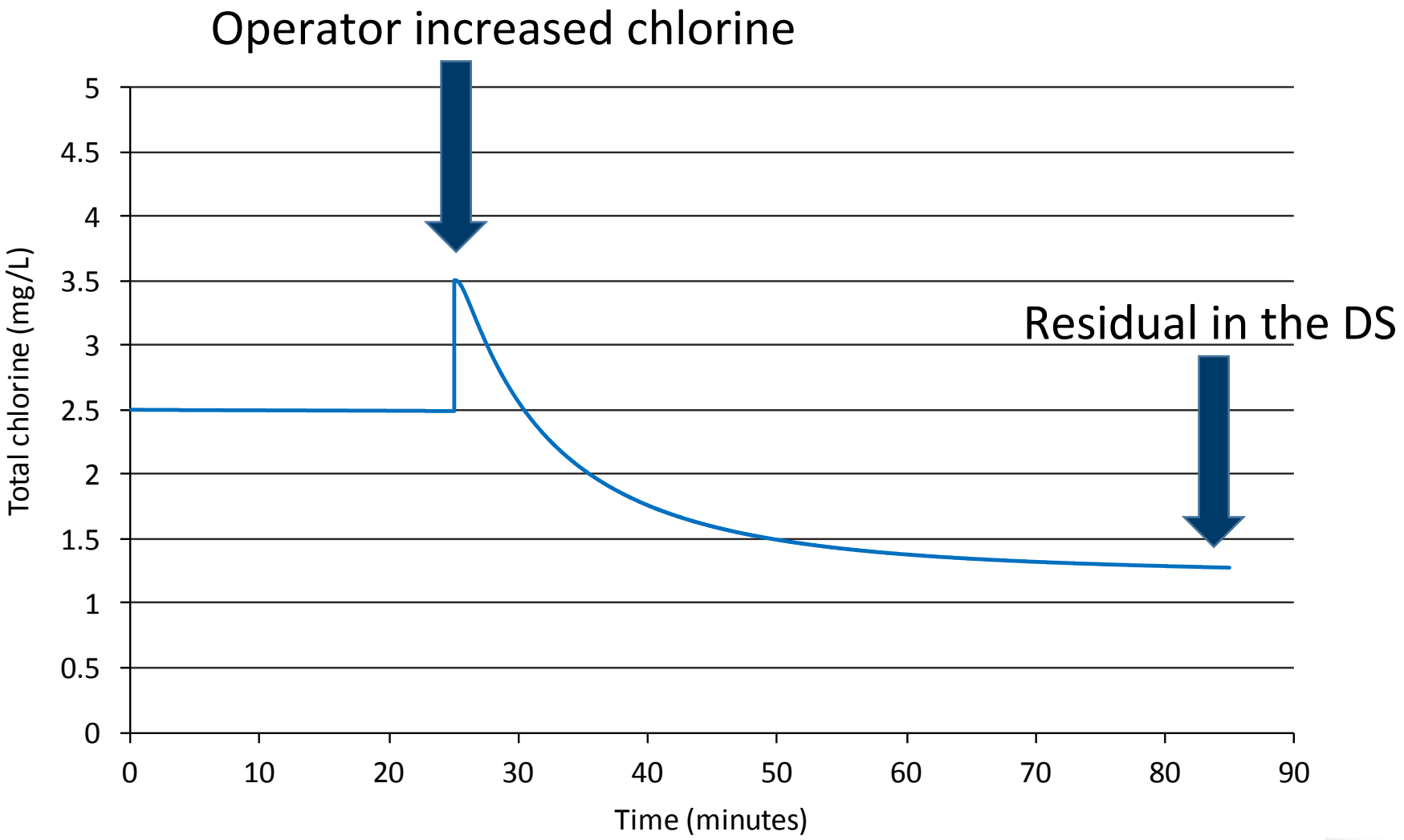
Question

- A water system is having trouble maintaining a residual at the end of the distribution system.
- The residual leaving the plant is 2.5 mg/L
  - The ratio of chlorine to ammonia is 5:1
- The operator is directed to increase the chlorine
- After turning up the chlorine the residual is 1.3 mg/L
- What would explain this?

New dose on the breakpoint curve



Chlorine residual goes down



Ratio between 5:1 and 8:1

- The other side of the breakpoint curve
- Residual will go down as more chlorine is added
- 0.1 mg/L ammonia needs 0.76 mg/l chlorine to get past breakpoint
- Sometimes to raise the residual you need to turn the chlorine pump DOWN

Total ammonia vs free ammonia

- Free ammonia is NH_3 or NH_4^+
- Total ammonia is free ammonia and mono, di and trichloramine

Organic Carbon

- Chlorine demand can lead to free ammonia
- Meet chlorine demand at the plant
- Address carbon sources in the system
  - Main flushing
  - Tank cleaning

Phosphate

- Can be added as a corrosion control measure
- Carbon, phosphate and ammonia is a microbe feast

What to measure

- Total chlorine and/or monochloramine
- Total ammonia
- Free ammonia
- Nitrite