



NRC-CNRC

*Institute for
Research in
Construction*

Water Quality in the Distribution System

Syed A. Imran



National Research
Council Canada

Conseil national
de recherches Canada

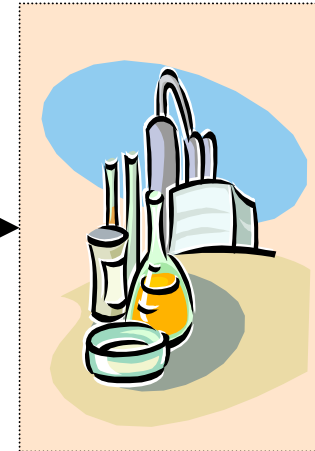
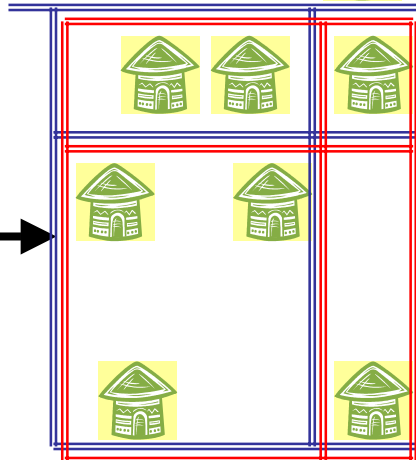
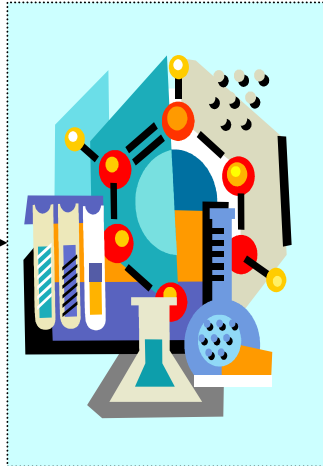
Canada

The Drinking Water Continuum

Drinking Water Treatment



Wastewater Treatment



Sources

- Groundwater
- Surface Water
- Sea Water

Distribution and Collection Infrastructure



What is a Distribution System?

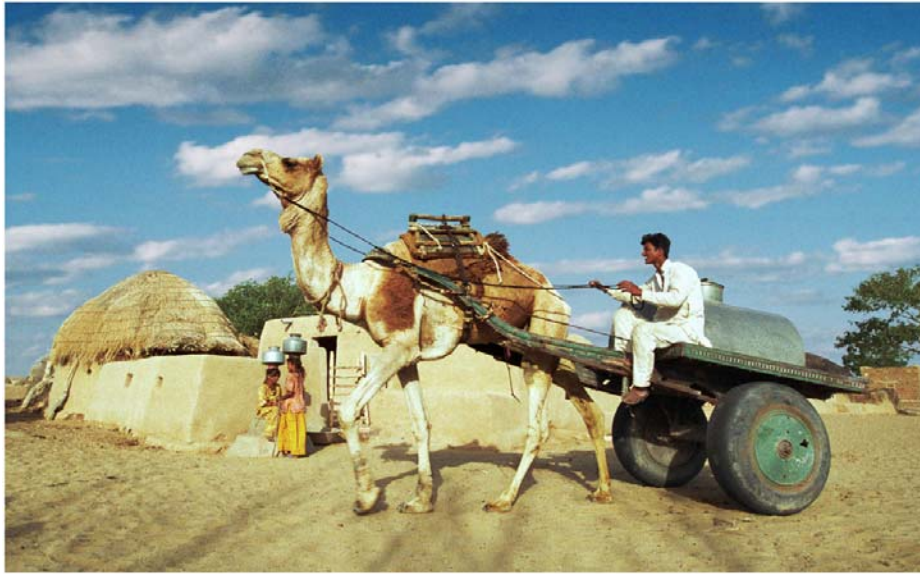


Photo Courtesy of Jorge Royan



Where is our Distribution System?



You won't see it ---- Till it's gone!

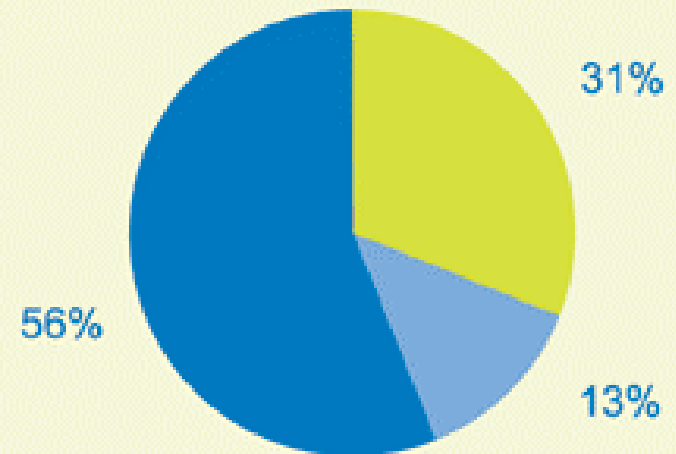
Need for Protection of Distribution System

“Every day [in the United States], six billion gallons of clean, treated drinking water disappears, mostly due to old, leaky pipes and water mains. That’s enough water to serve the population of a state the size of California.

William Henry, president of the
American Society of Civil Engineers

”

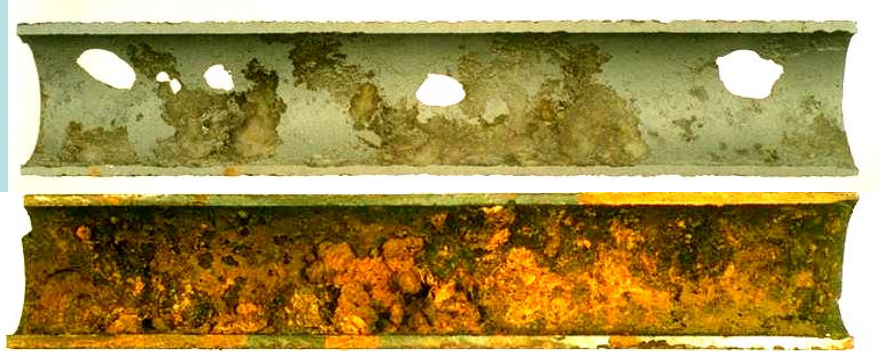
Chart 3: Municipal Water Use by Sector



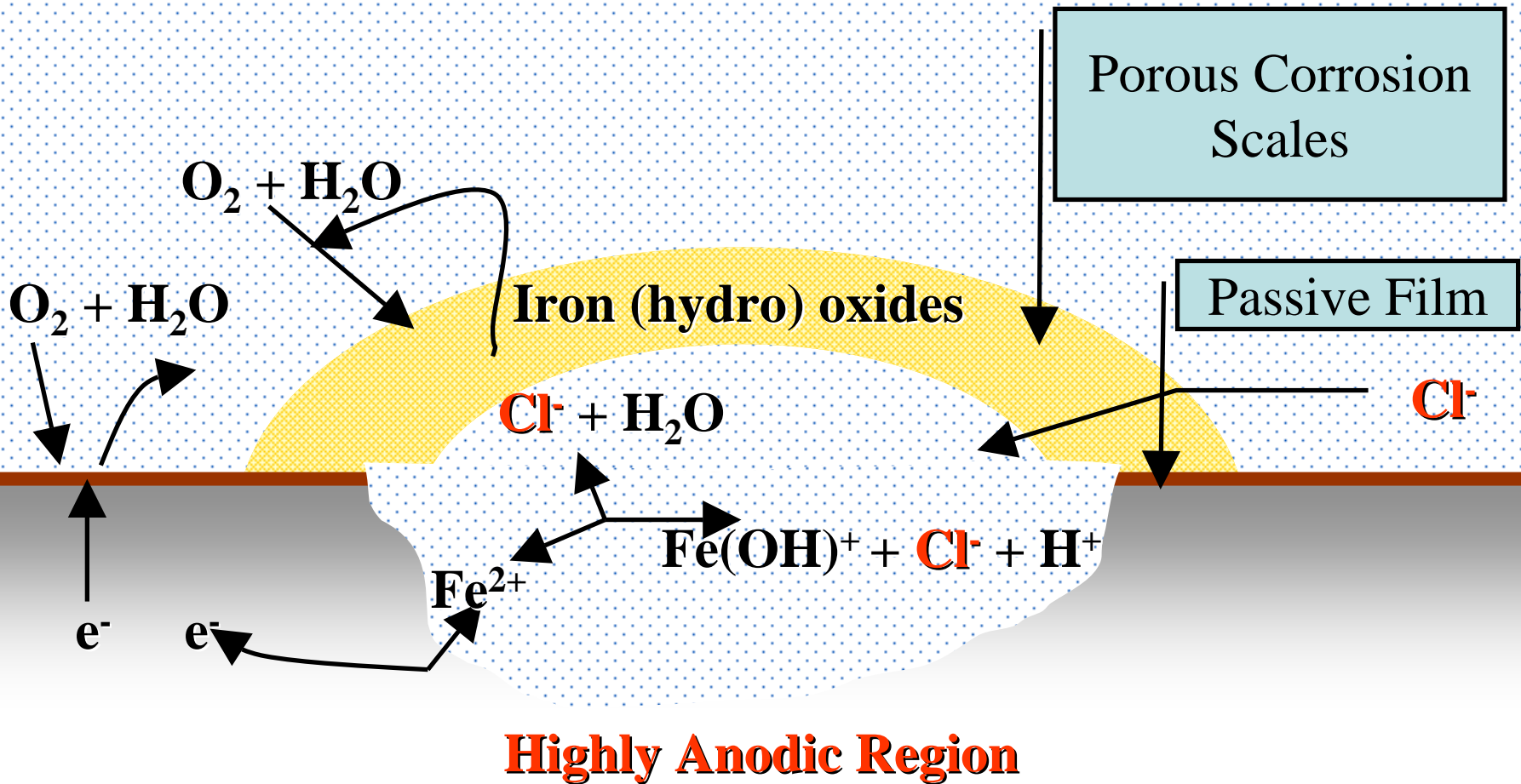
■ Industrial, Commercial, Institutional
■ System Losses
■ Residential (Single and Multi-family)

Source: Environment Canada

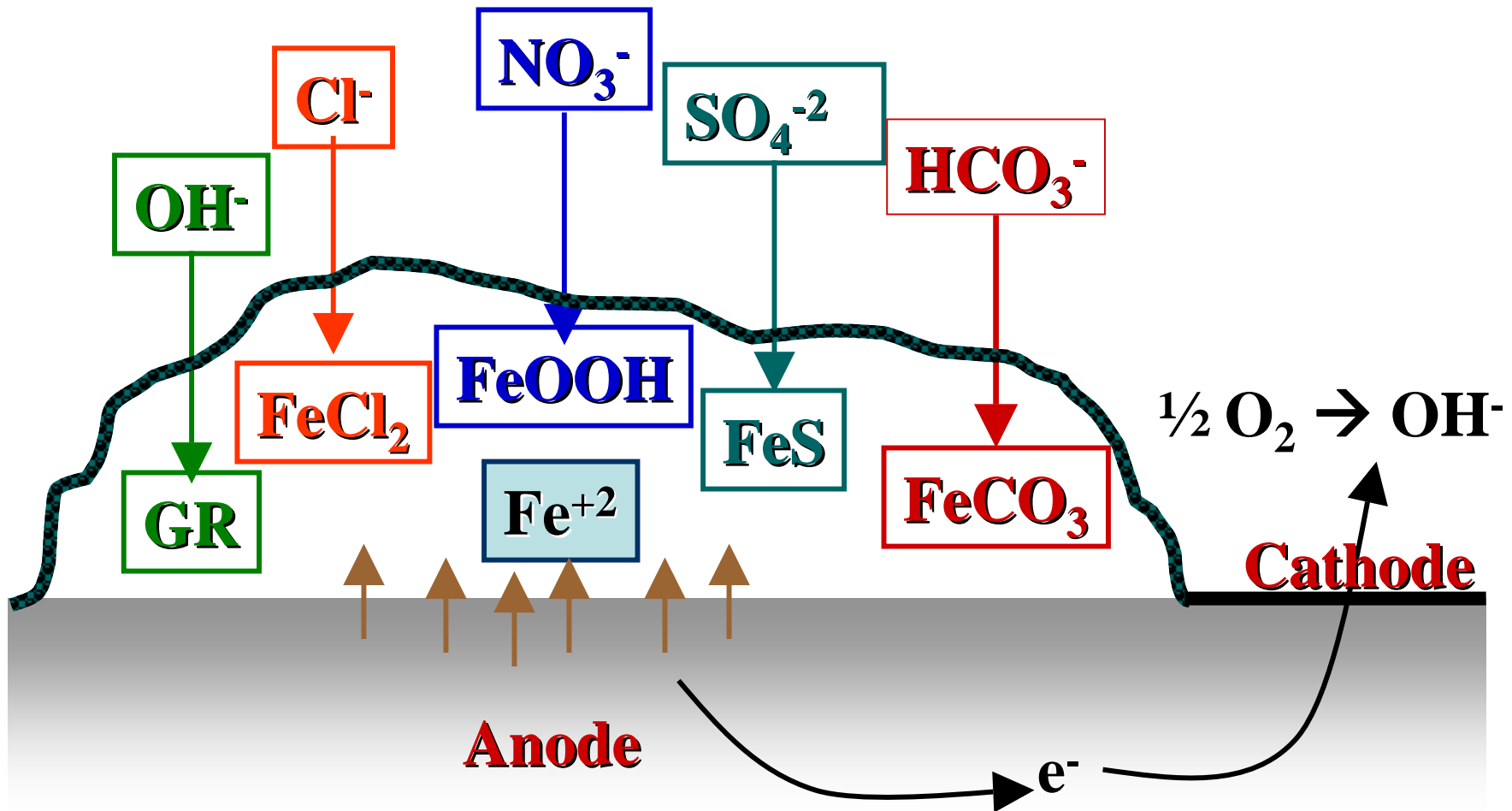
What Causes this?



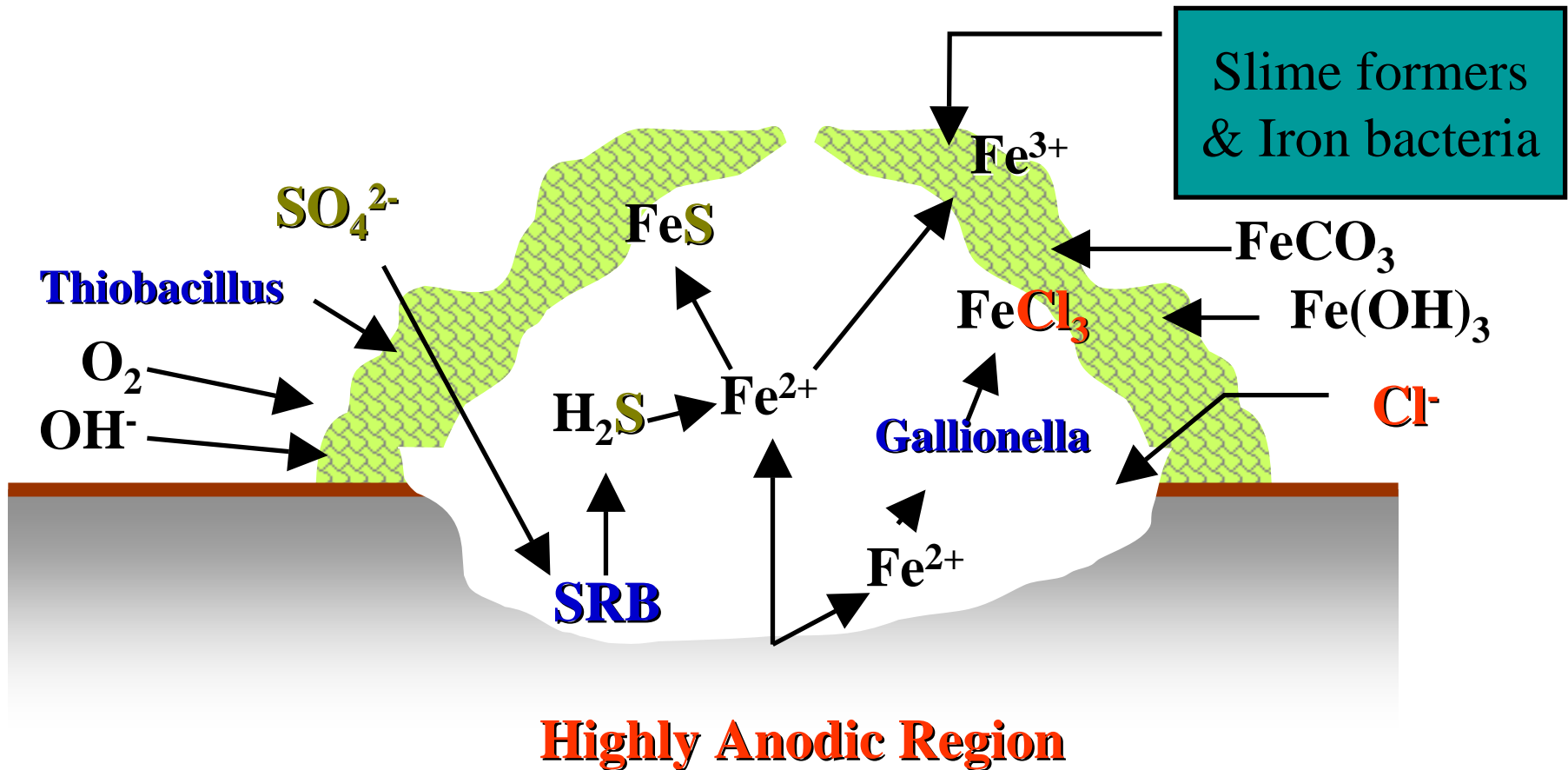
Internal Corrosion in Old Iron Pipes



Water Quality Interactions with Pipe Surfaces



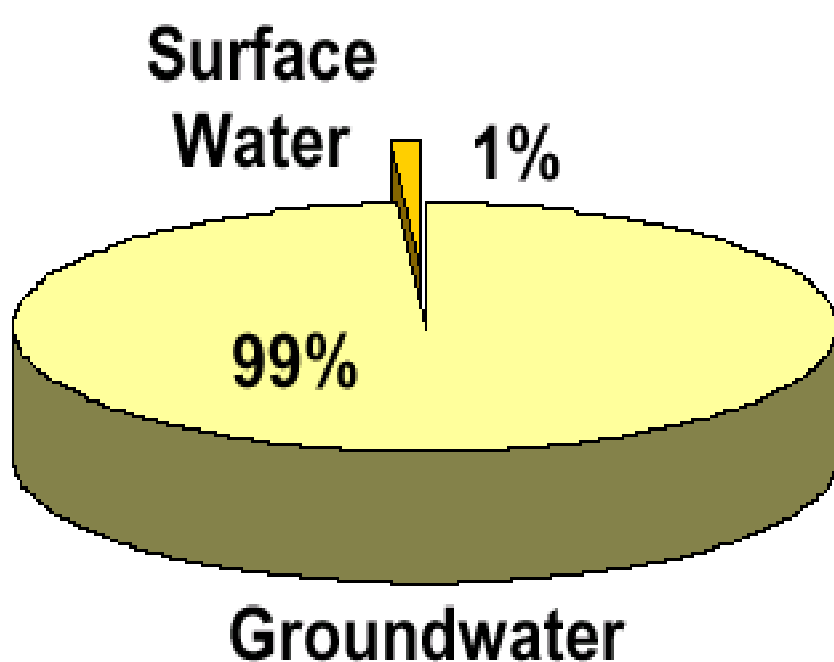
Microbiological (biofilm) Interactions with Pipe Surfaces



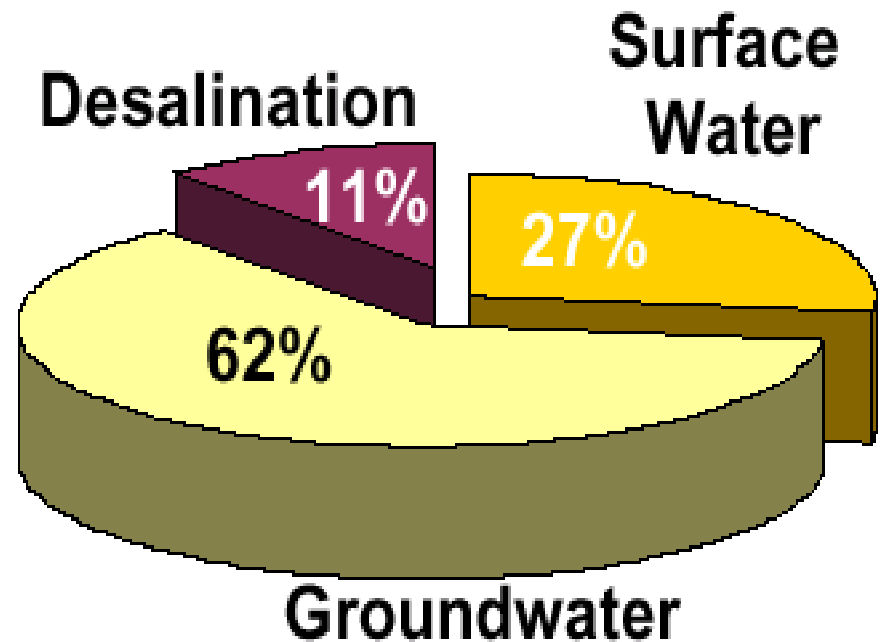
A picture is worth ...



TBW groundwater protection targets - How to reconcile new sources with old pipes?



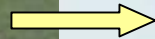
Before 2002



2007

Construction of Pilot Site

\$ **3,000,000** Tailored Collaboration Project
Tampa Bay Water
AwwaRF
University of Central Florida



Pilot Distribution System (PDS) Setup



- **N**ominal length of PDS - 100 feet
- **O**ld pipes excavated and transported from actual distribution system
- **18** PDS constructed - 14 of which were identical



Headworks

Lead and Copper Loops



Pilot Water Treatment Processes



Reverse Osmosis Unit



Nanofiltration Unit



Coagulation and Settling Unit



Softening and Filtration Units

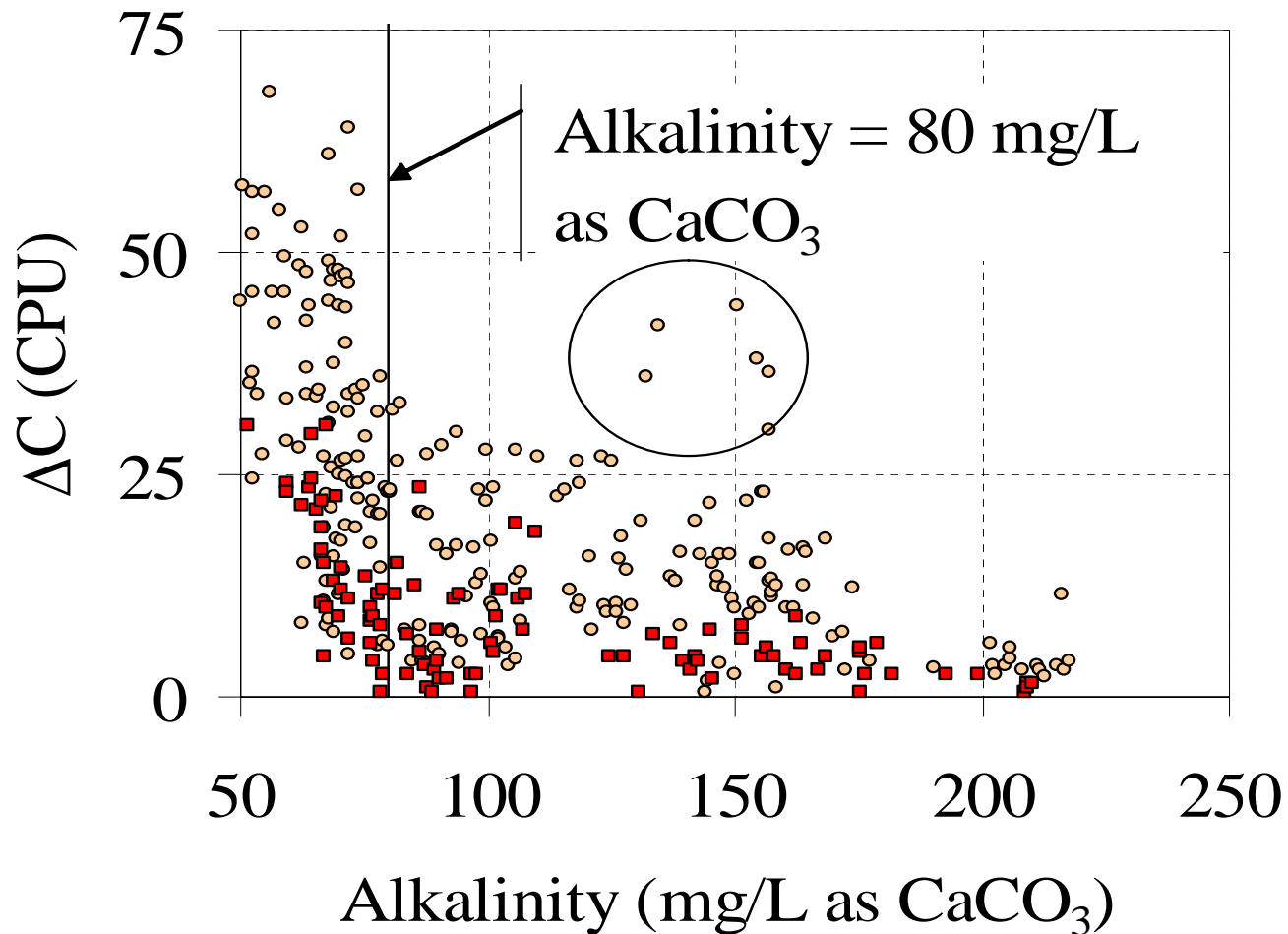


Sludge Drying Bed



Field Laboratory

Mitigation measures for red water release control



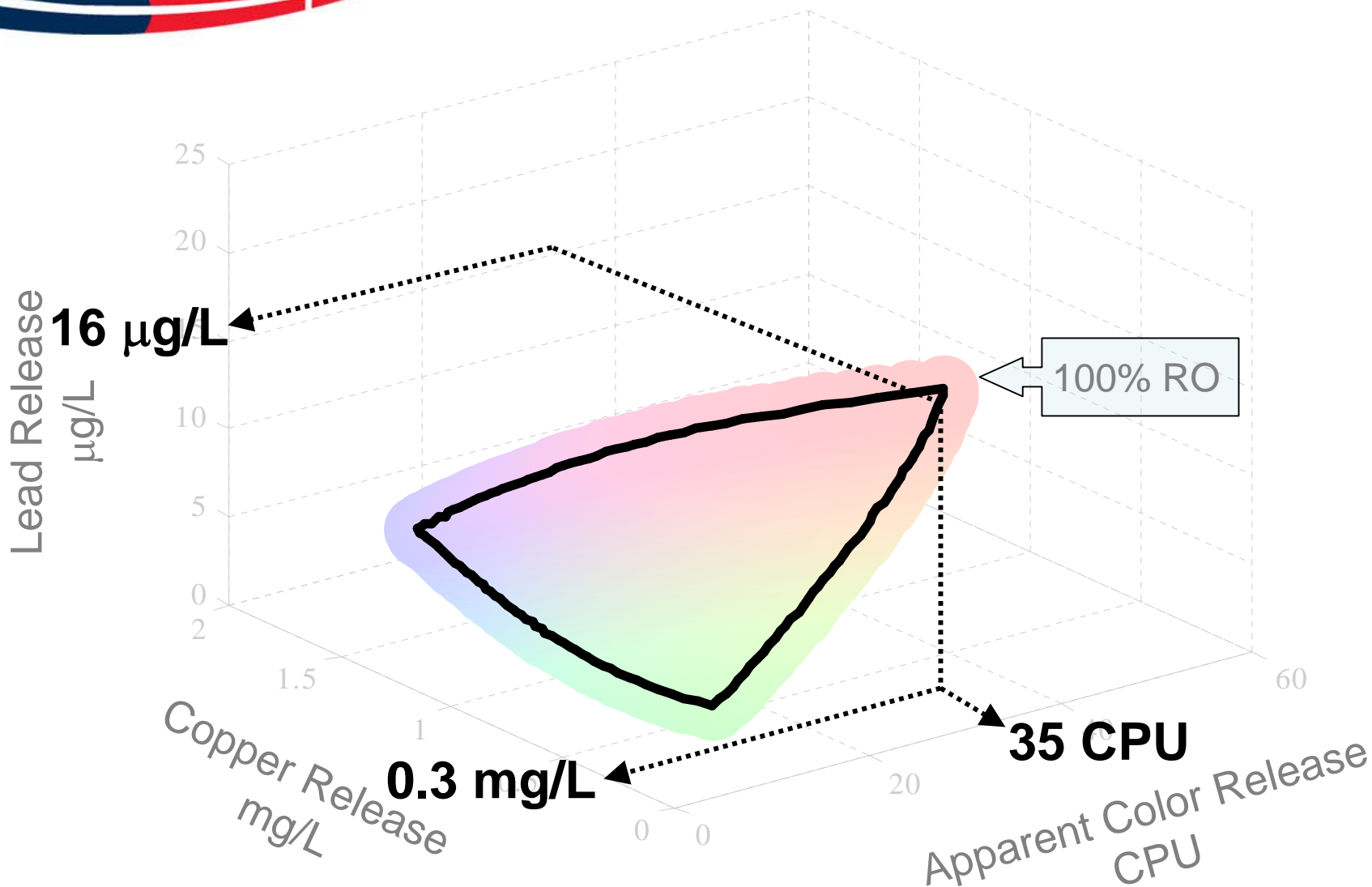
○ **HRT = 5 days**

■ **HRT = 2 days**

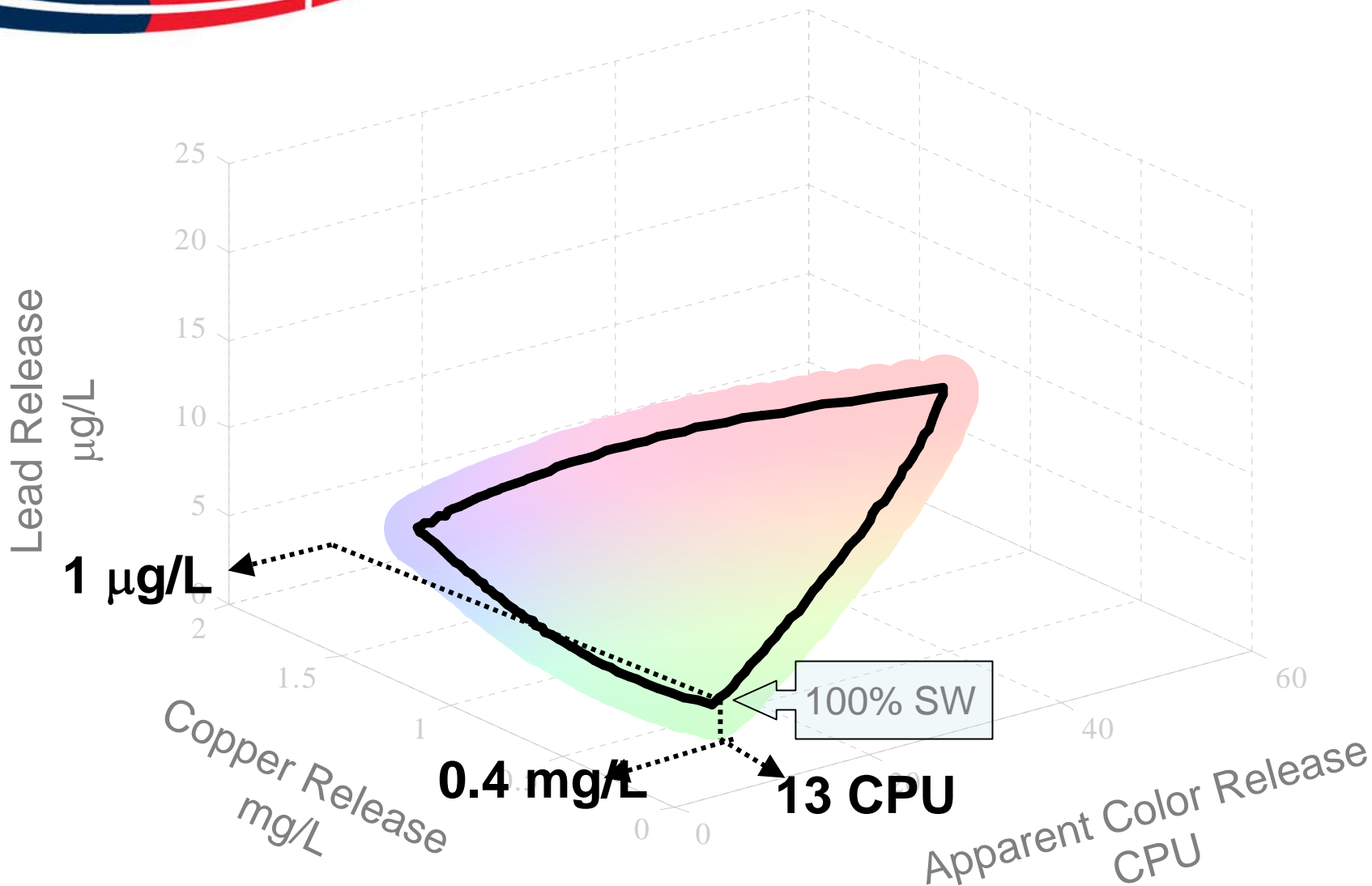
Conflicting Water Quality Impacts on Different Pipe Materials

		Copper	Lead	Color
Alkalinity	↑	↑	↓	↓
Chlorides	↑	↑	↑	↑
Sulfates	↑	↑	↓	↑
pH	↑	↓	↓	↓
Temperature	↑	↑	↑	↑
HRT	↑			↑

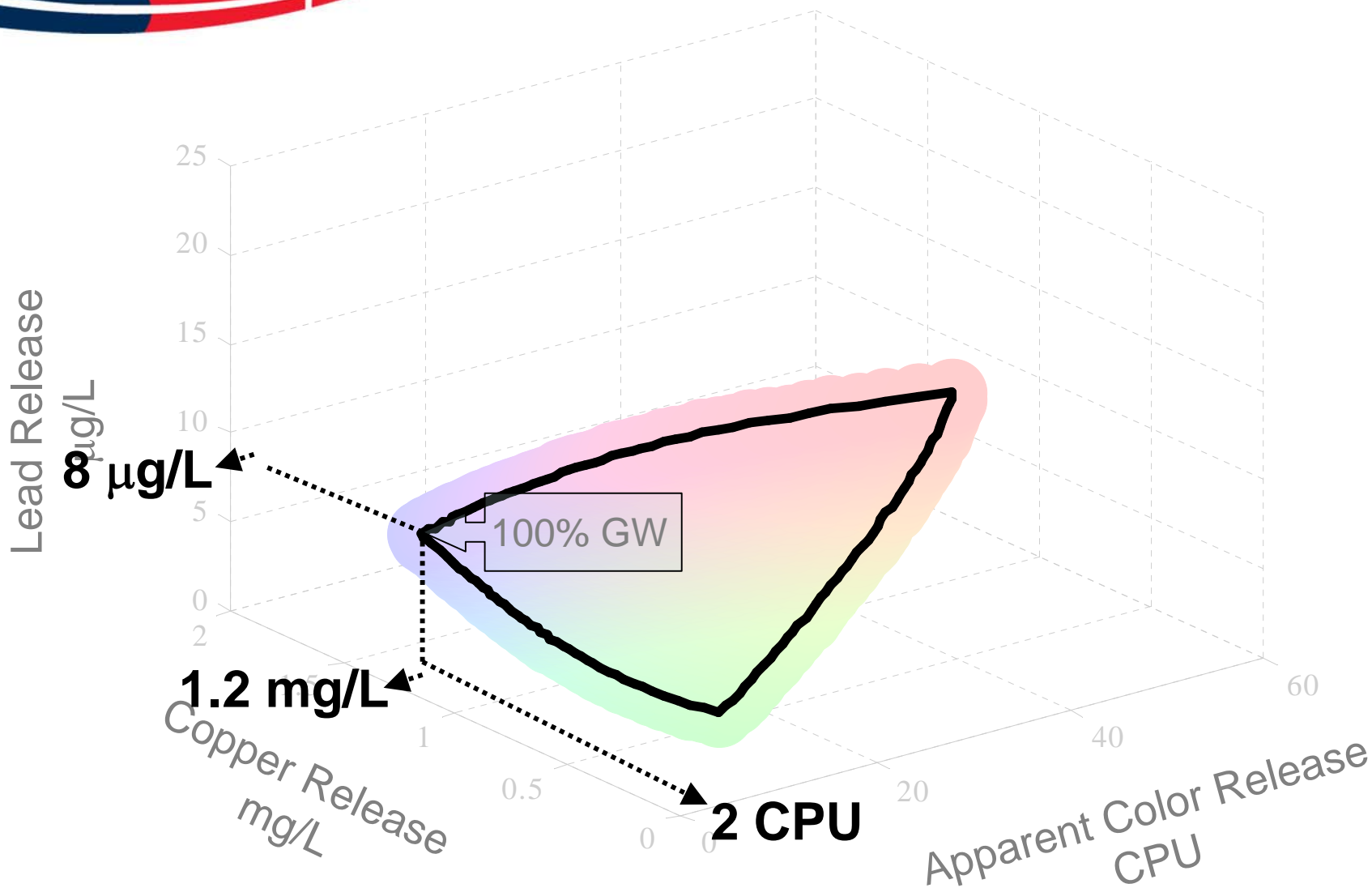
Definition of blend response [100% RO]



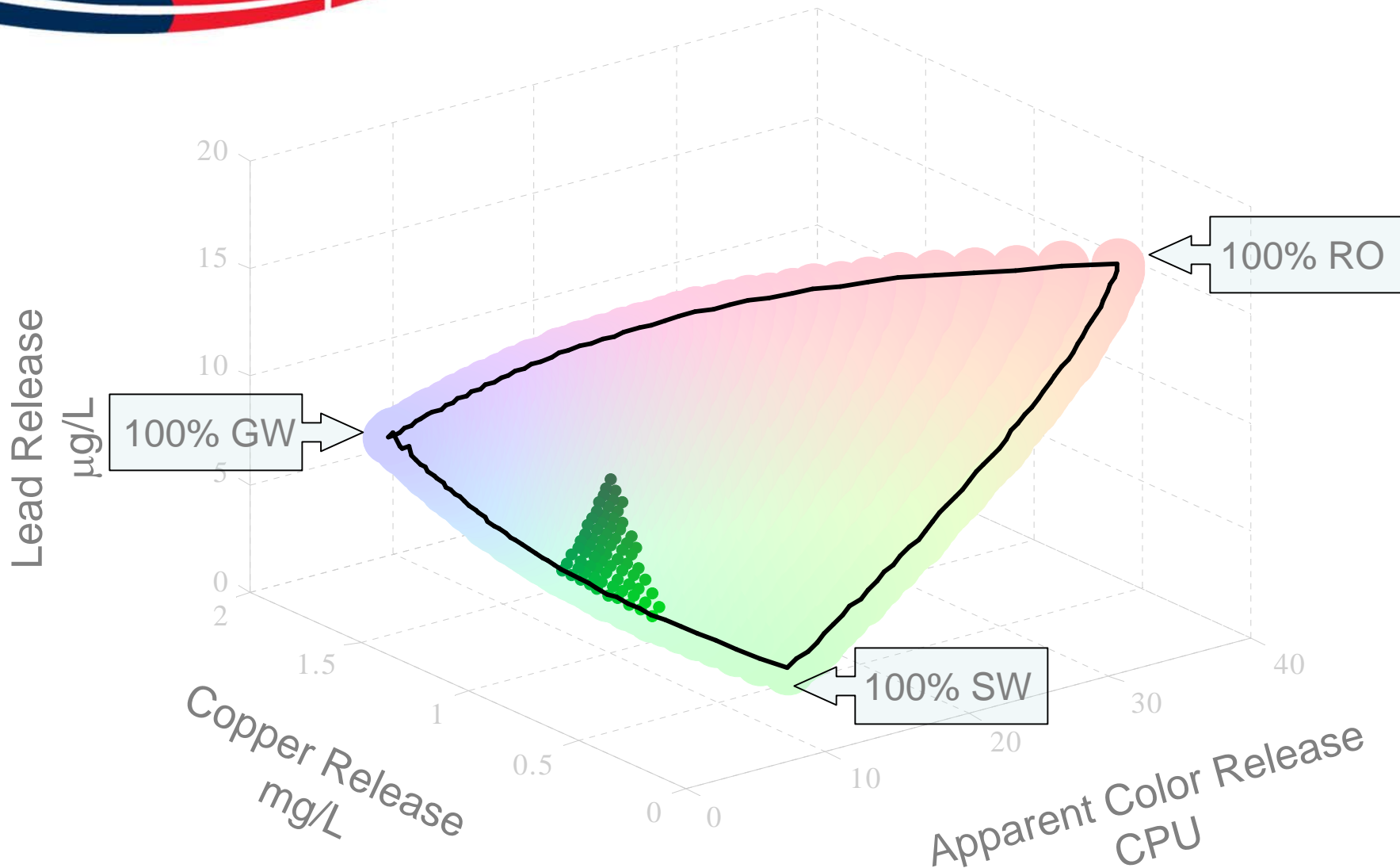
Definition of blend response [100% SW]



Definition of blend response [100% GW]



Feasible blends



Impact of Distribution Pipes on Disinfectant Decay: Bulk Water and Pipe Wall Reactions

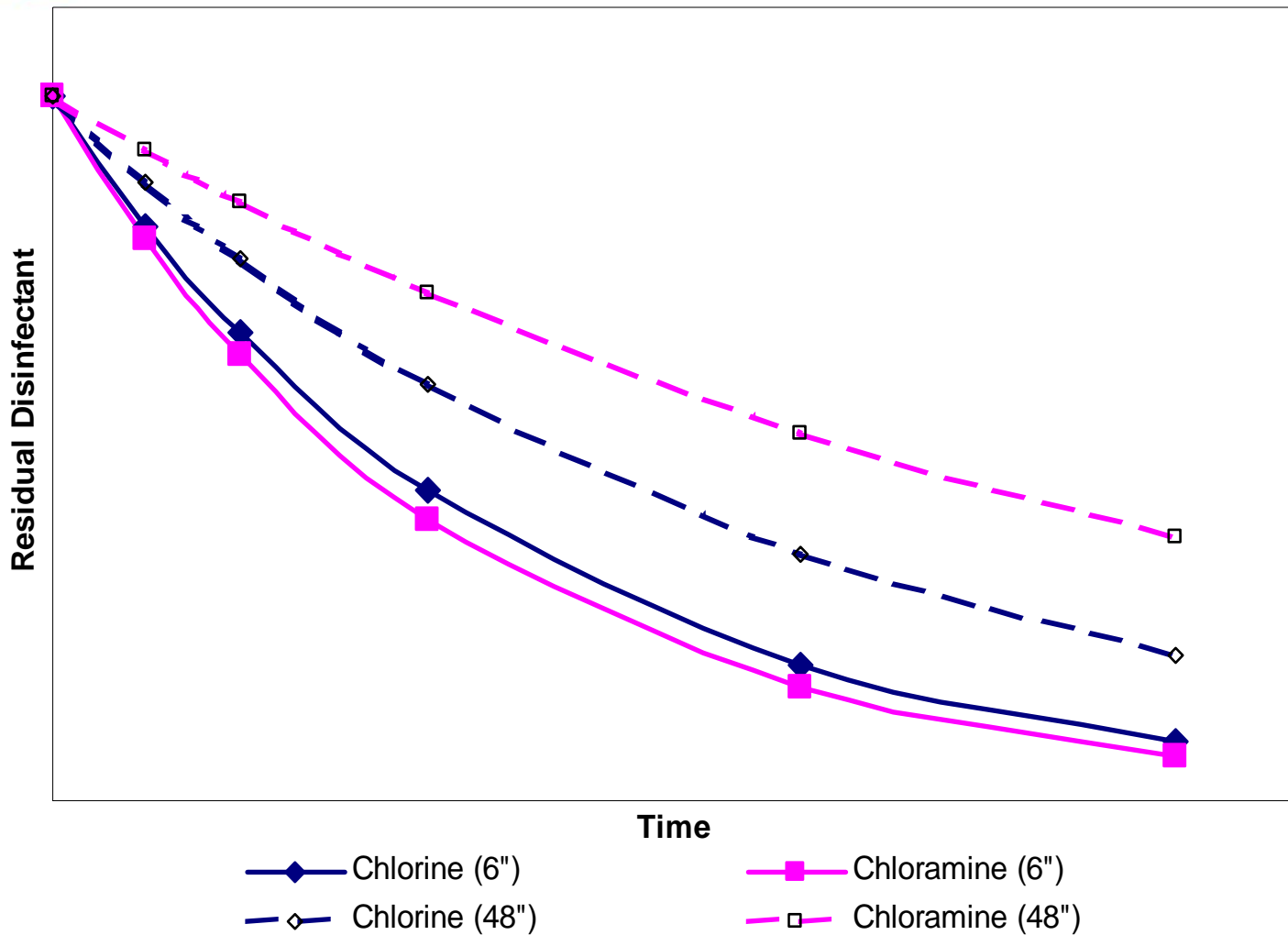
$$C_t = C_0 \cdot e^{(K_b + K_w)t}$$

$K_b = f(\text{Residual, Water Quality, Temperature})$

$K_w = f(\text{Residual, Water Quality, Pipe Material, Condition of Interface})$

- K_b is the bulk reaction coefficient
- K_w is the wall reaction coefficient

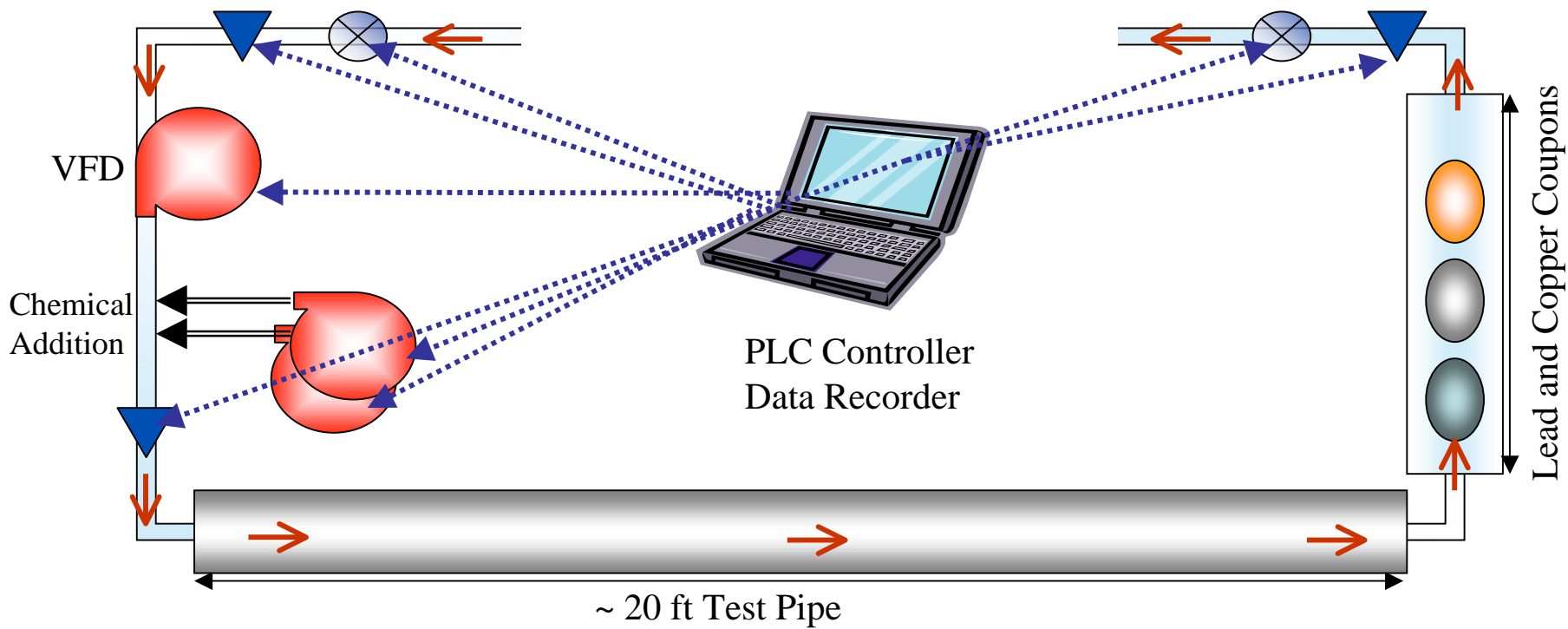
Chlorine vs. Chloramines







Examining the Effect of Water Quality on Integrity of Distribution Infrastructure

- NRC – AWWARF Collaborative Project
 - Linking water quality changes to integrity of distribution systems
 - “Talking Heads” – Getting experts together for a 1 Day workshop at NRC Ottawa in March 2005
- Development of a Drinking Water Distribution Laboratory at the Center for Sustainable Infrastructure Research (CSIR), Regina

Distribution System Water Quality Laboratory



-  Water Quality Sensors & Sampling Ports
-  Variable Flow Device
-  Flow Control Valves
-  Direction of Flow

Distribution System Water Quality Laboratory

- Hydraulic parameters can be controlled using VFD's
- Online measurement and data-logging
- Laboratory scale simulation of actual distribution systems
- Test pipes can be changed for different material, age, degree of corrosion and locations
- Additional ports for Lead and Copper, biofilms or surface characterization coupons
- Biological control, disinfectant dynamics and persistence of pathogens can be studied

Enabling Drinking Water Sustainability in Small Communities

NRC 2006 Vision: Science at work for Canada

- ⊕ Support and enable drinking water systems towards self-sufficiency
- ⊕ Conduct demonstration and verification of emerging technologies
- ⊕ Develop and sustain innovative methods of maintaining safe drinking water in the distribution systems
- ⊕ Partner with federal, provincial and local governing bodies to identify and investigate research needs

**What is the difference
between this picture...**



And this?



NRC-CNRC

*Institute for
Research in
Construction*

24 Hours

NRC CNRC

*Institute for
Research in
Construction*



Science
— at work for —
Canada



National Research
Council Canada

Conseil national
de recherches Canada

Canada