

# **EVALUATION OF CHLORINE DIOXIDE IN POTABLE WATER SYSTEMS FOR LEGIONELLA CONTROL IN A ACUTE CARE HOSPITAL ENVIRONMENT**

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By

Gregory Bova, The Johns Hopkins Hospital, Baltimore, MD

Paul Sharpe, Water Chemical Service, Inc., Aberdeen, MD

Tim Keane, Legionella Risk Management, Chalfont, PA



**The Johns Hopkins Medical Institutions**

# Acute Care Hospital Environment

## Concerns:

- Health of patients, visitors and staff
- Water quality
- *Legionella* and bacteria (Potable Cold and Hot water)

## Response:

- Develop Prevention and Control Measures
- *Legionella* Task Force
- Water Treatment Team

# Water Treatment Goals

Select an potable water disinfection method:

- Safe for patients, visitors and staff
- Control and eliminate *Legionella* and bacteria
- Eliminate bio-film
- No impact on dialysis filtration equipment
- No impact on laboratory filtration equipment
- No increase on corrosion rates
- No impact on mechanical equipment and systems

# JHH Selection Criteria of Disinfection Method

- EPA approved for potable water disinfection
- Safe to use on potable cold and hot water
- Environmental and health effects
- *Legionella* and bacteria
- Residual effect
- Bio-film
- By-products
- Impact on dialysis filtration equipment
- Impact on laboratory filtration equipment
- Impact on equipment and systems

# Selected Disinfection Method

**Chlorine Dioxide**

# Site Selection

- The Johns Hopkins Hospital Weinberg Building
- Opened in 2000
- 600,000 sq. foot
- 154 bed facility with surgical and oncology patients, including bone marrow transplant and patients requiring hemodialysis
- Potable water supplied by local city municipality (treated with chlorine)

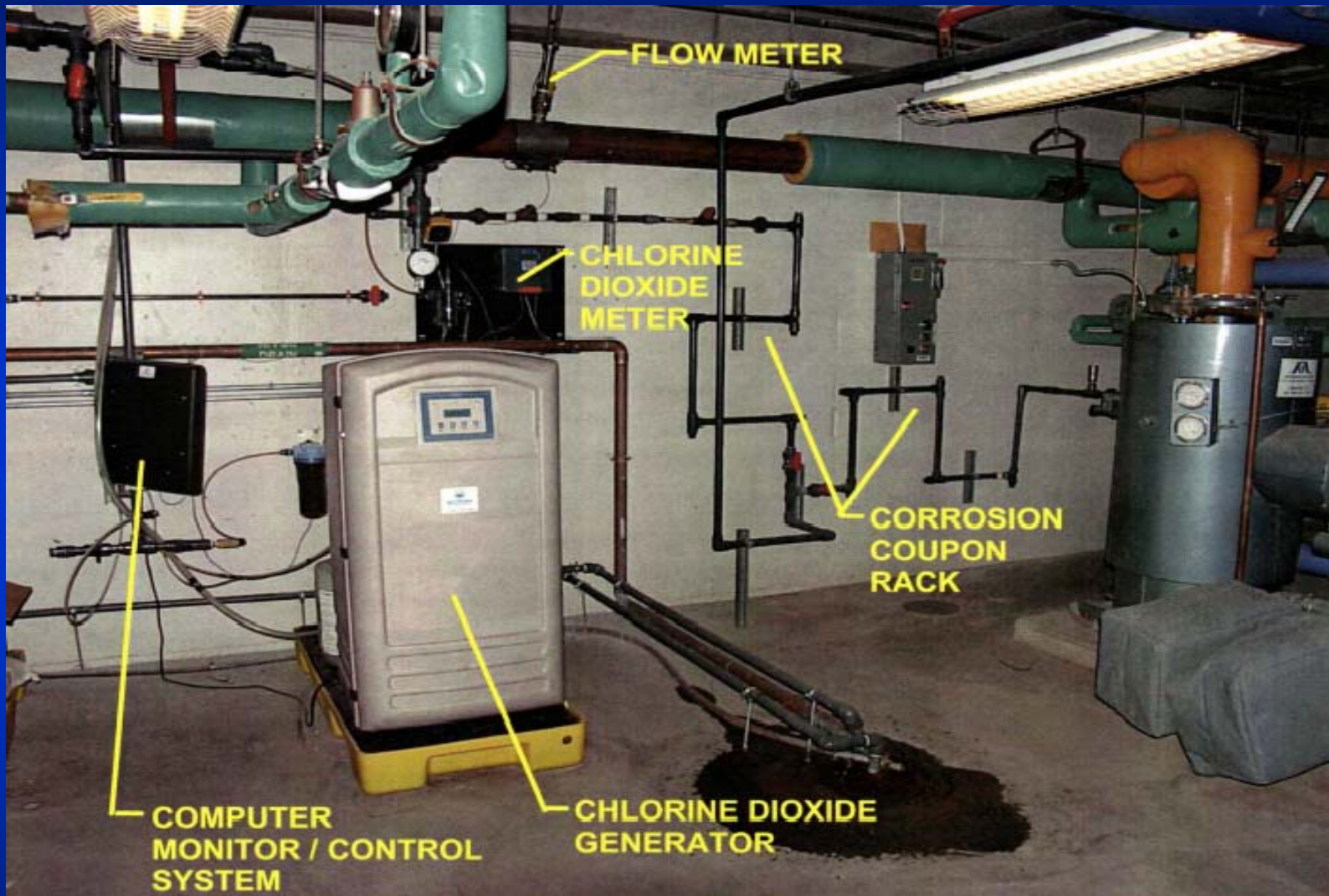
# Evaluation of Potable Water Distribution System

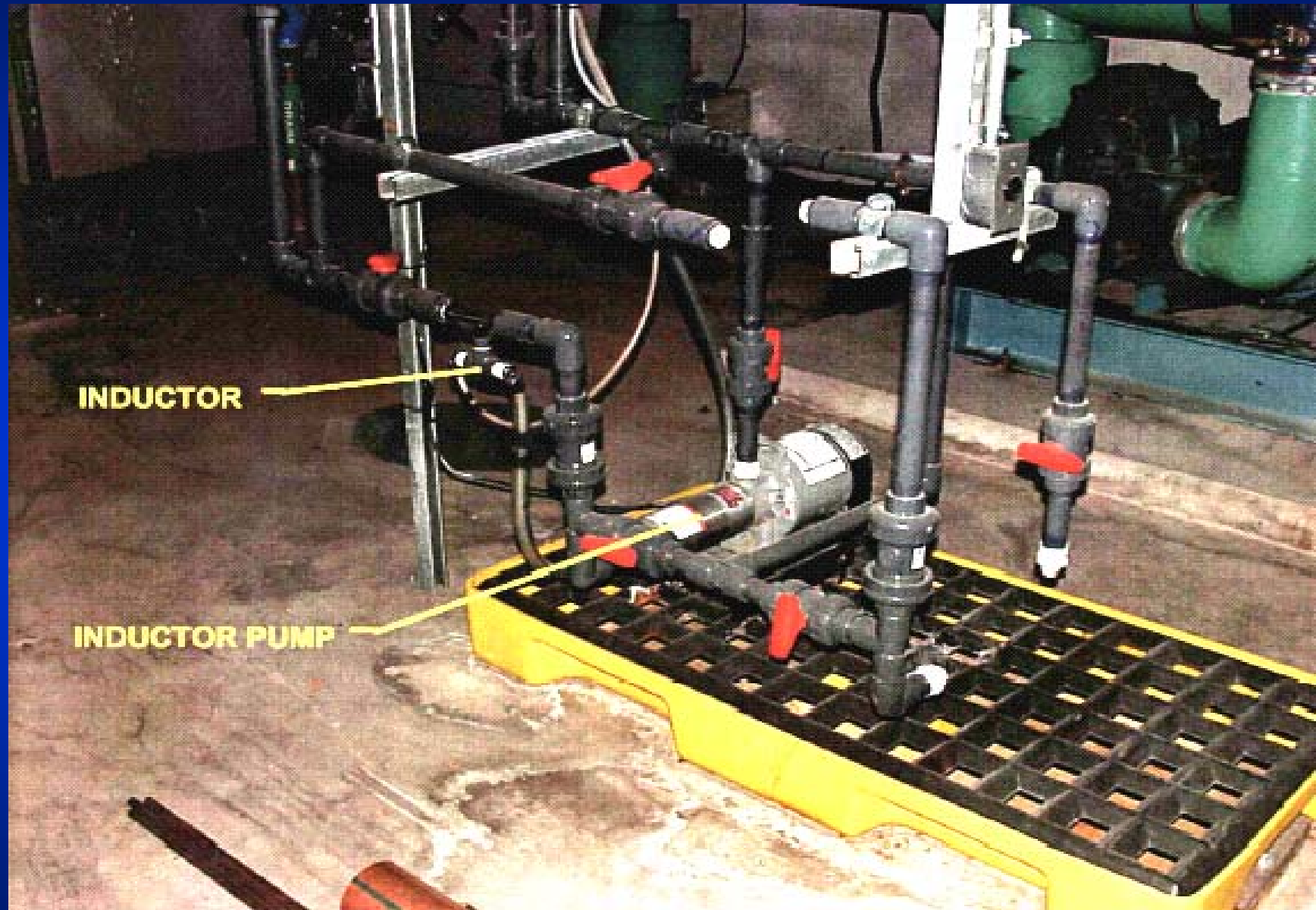
- Sizing
- Materials
- Flow rates
- Pressure
- Extent of service
- Connected equipment
- Demand profile

# Disinfection System Installation

- Selected the delivery system
- Designed system installation
- Developed protocols to operate and control the system
- Developed testing and monitoring protocols for chlorine dioxide and its by-products







**INDUCTOR**

**INDUCTOR PUMP**

## Assess Impact On:

- *Legionella* and bacteria
- Bio-film
- Dialysis filtration equipment
- Laboratory filtration equipment
- Chlorine dioxide and its by-products
- Corrosion
- Mechanical equipment and systems
- Safety of delivery system

# Phase 1

- Hyper-chlorination
- Super heating (hot water system)

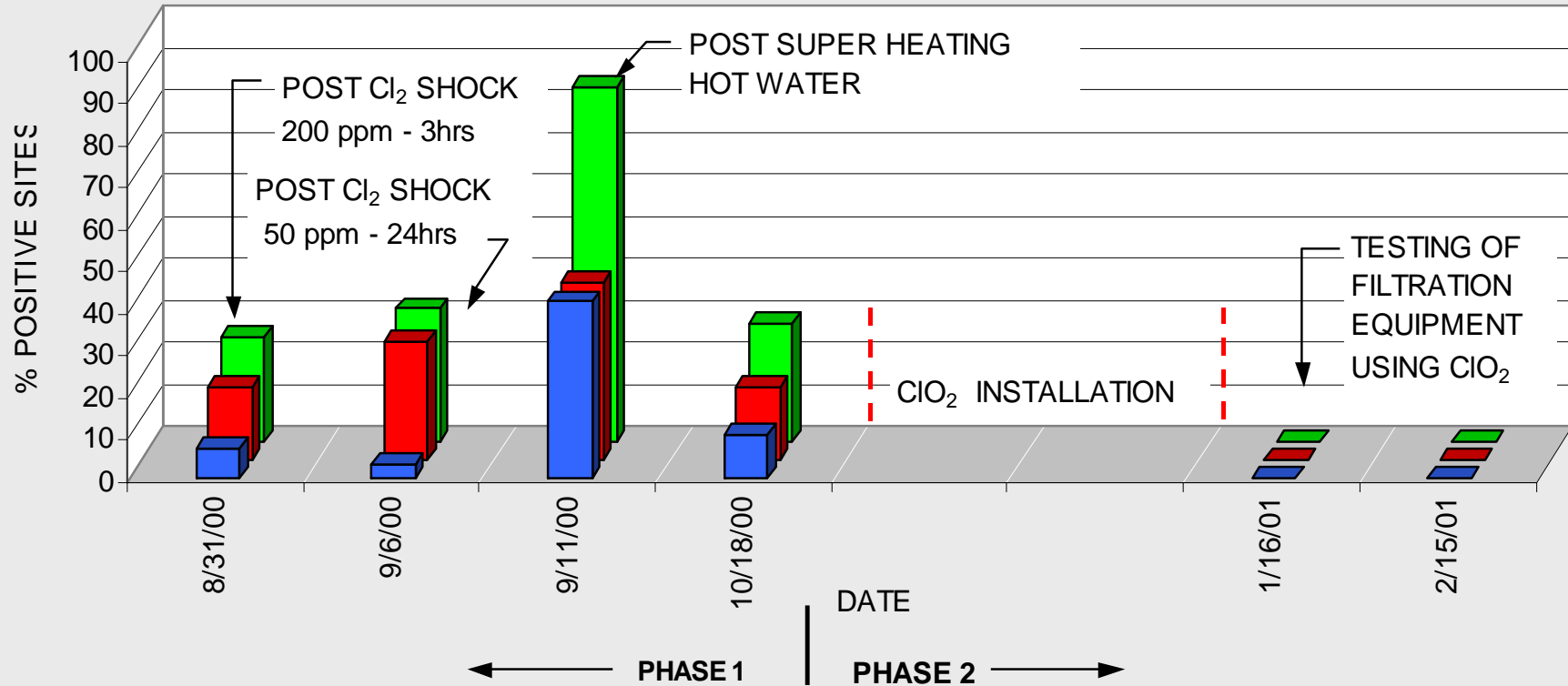
## Phase 2

- Installation and startup of delivery system
- Dialysis filtration equipment testing
- Laboratory filtration equipment testing

## Phase 3

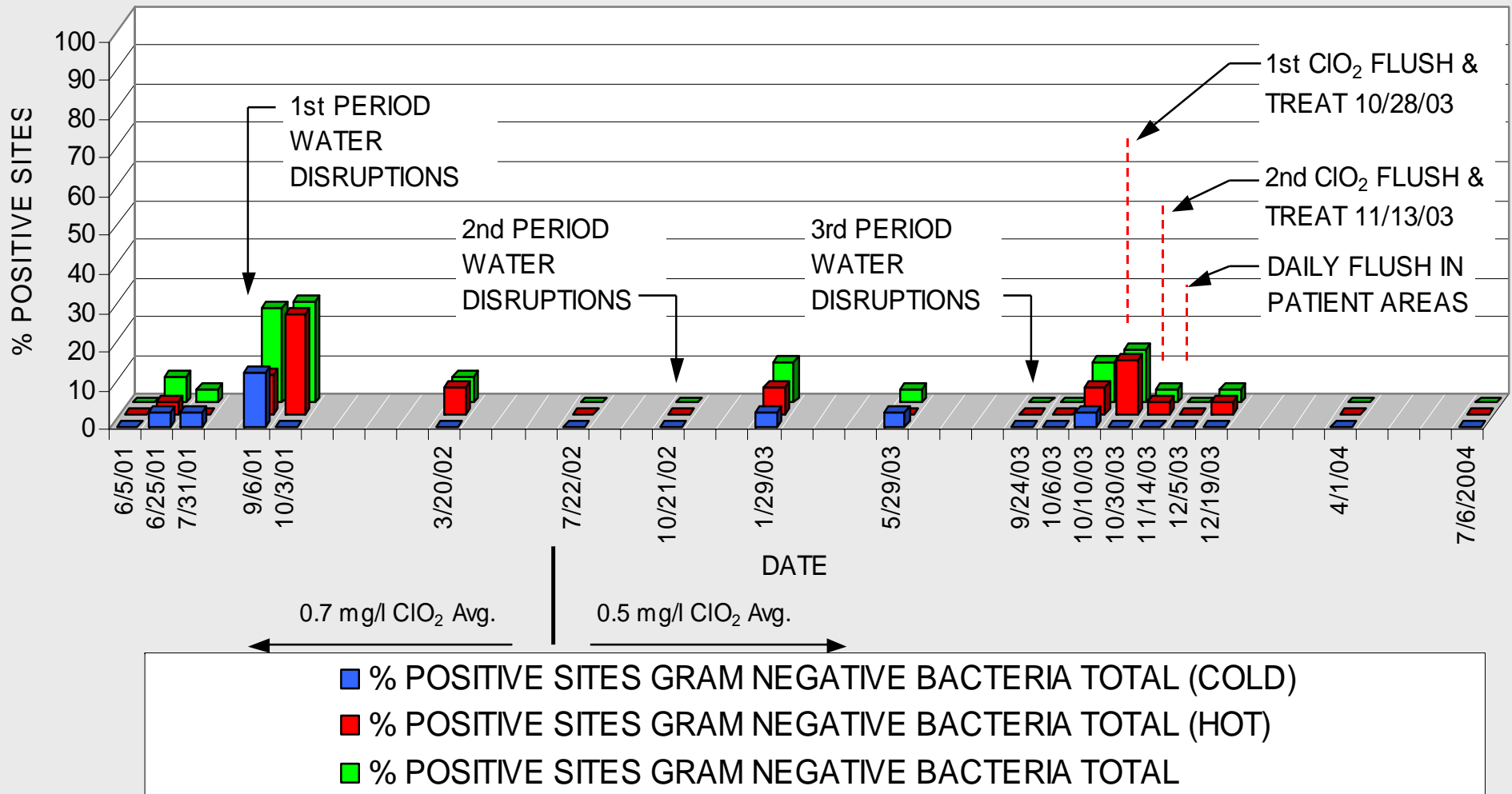
- Delivery system operation
- Chlorine dioxide and its residual by-products
- Corrosion rates
- *Legionella* and bacteria cultures

CHART 1 - % POSITIVE GRAM NEGATIVE BACTERIA SITES  
PHASE 1 & 2



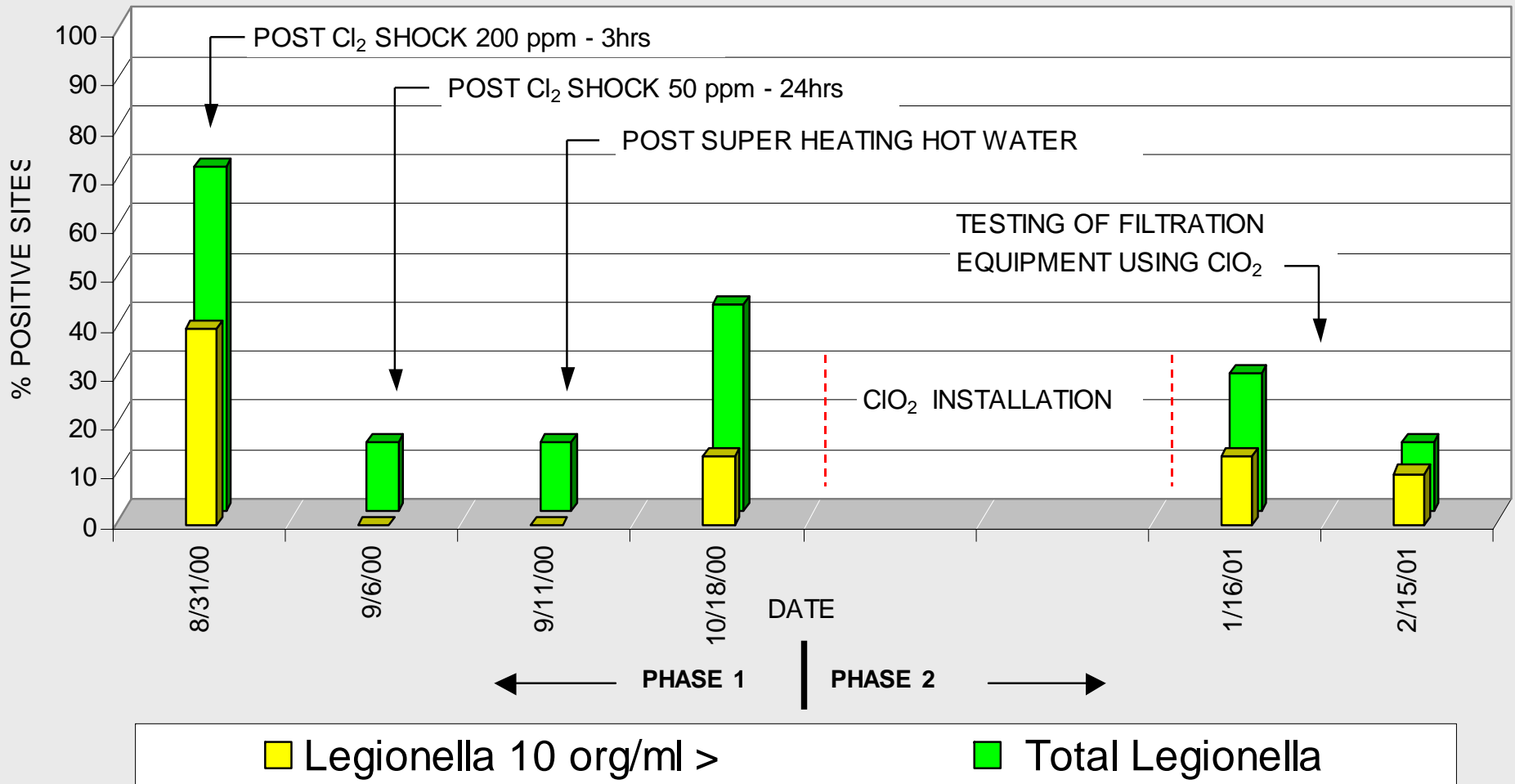
- % POSITIVE SITES GRAM NEGATIVE BACTERIA TOTAL (COLD)
- % POSITIVE SITES GRAM NEGATIVE BACTERIA TOTAL (HOT)
- % POSITIVE SITES GRAM NEGATIVE BACTERIA TOTAL

# CHART 2 - % POSITIVE GRAM NEGATIVE SITES PHASE 3

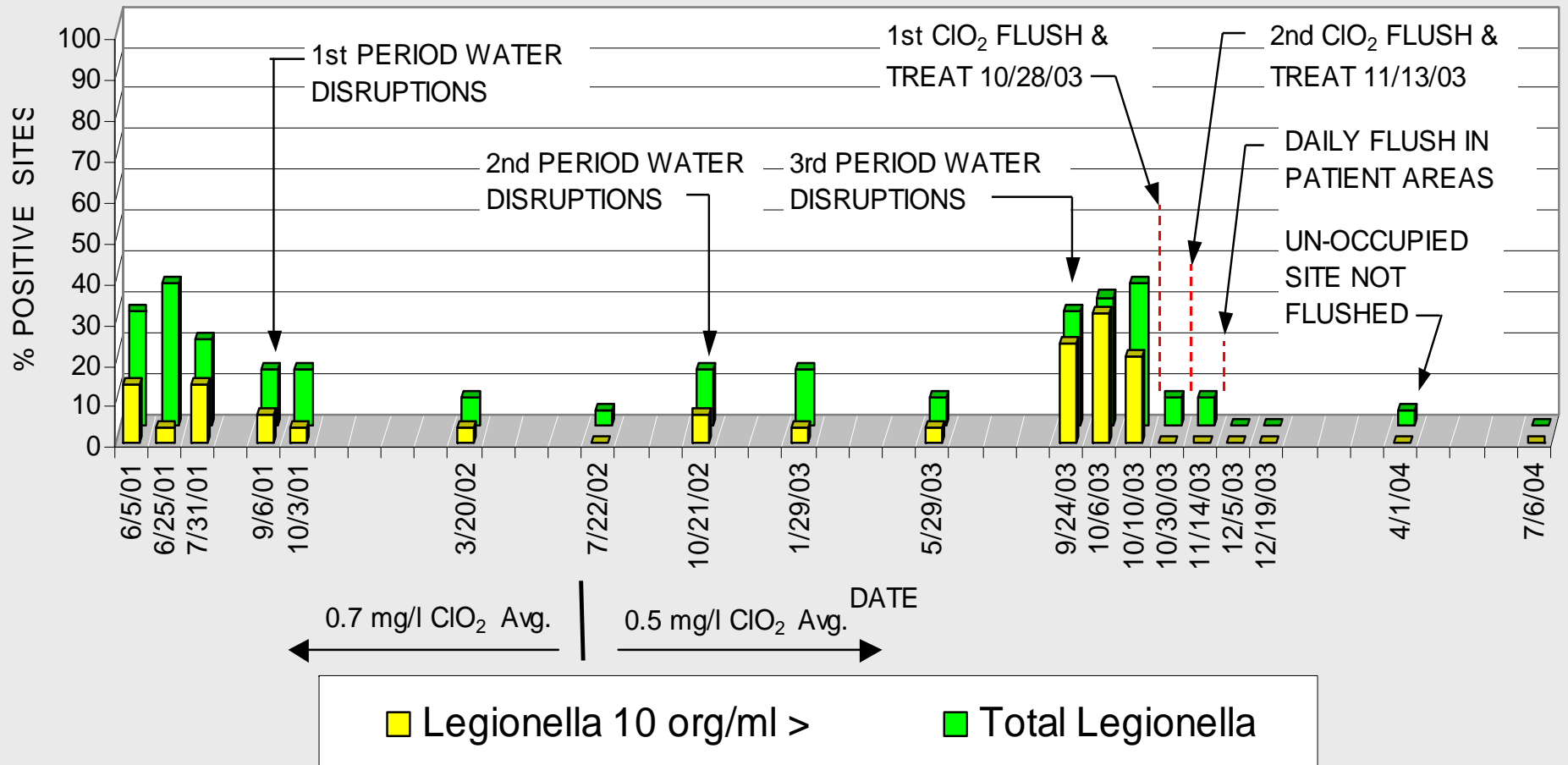




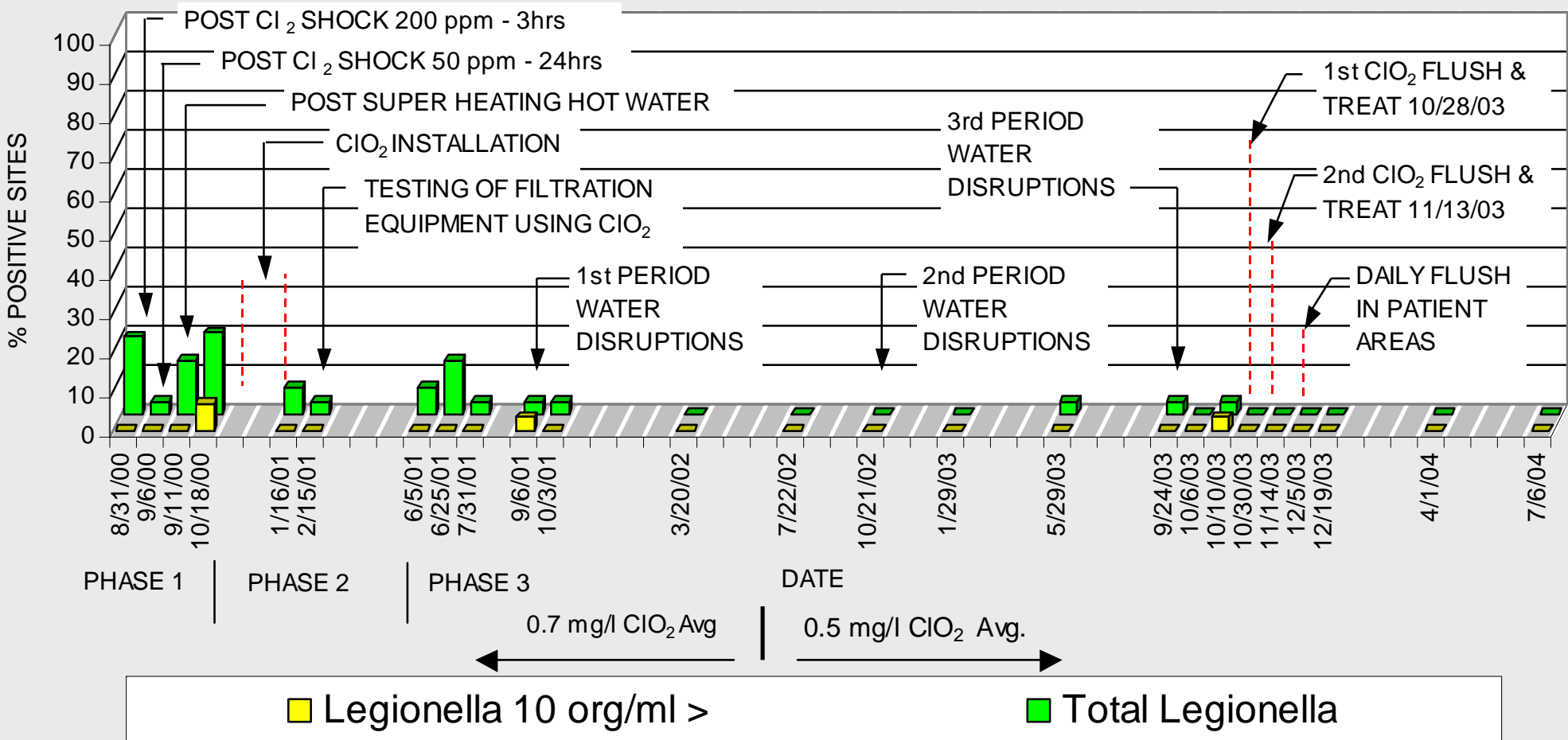
### CHART 3 - % POSITIVE LEGIONELLA SITES PHASE 1 & PHASE 2



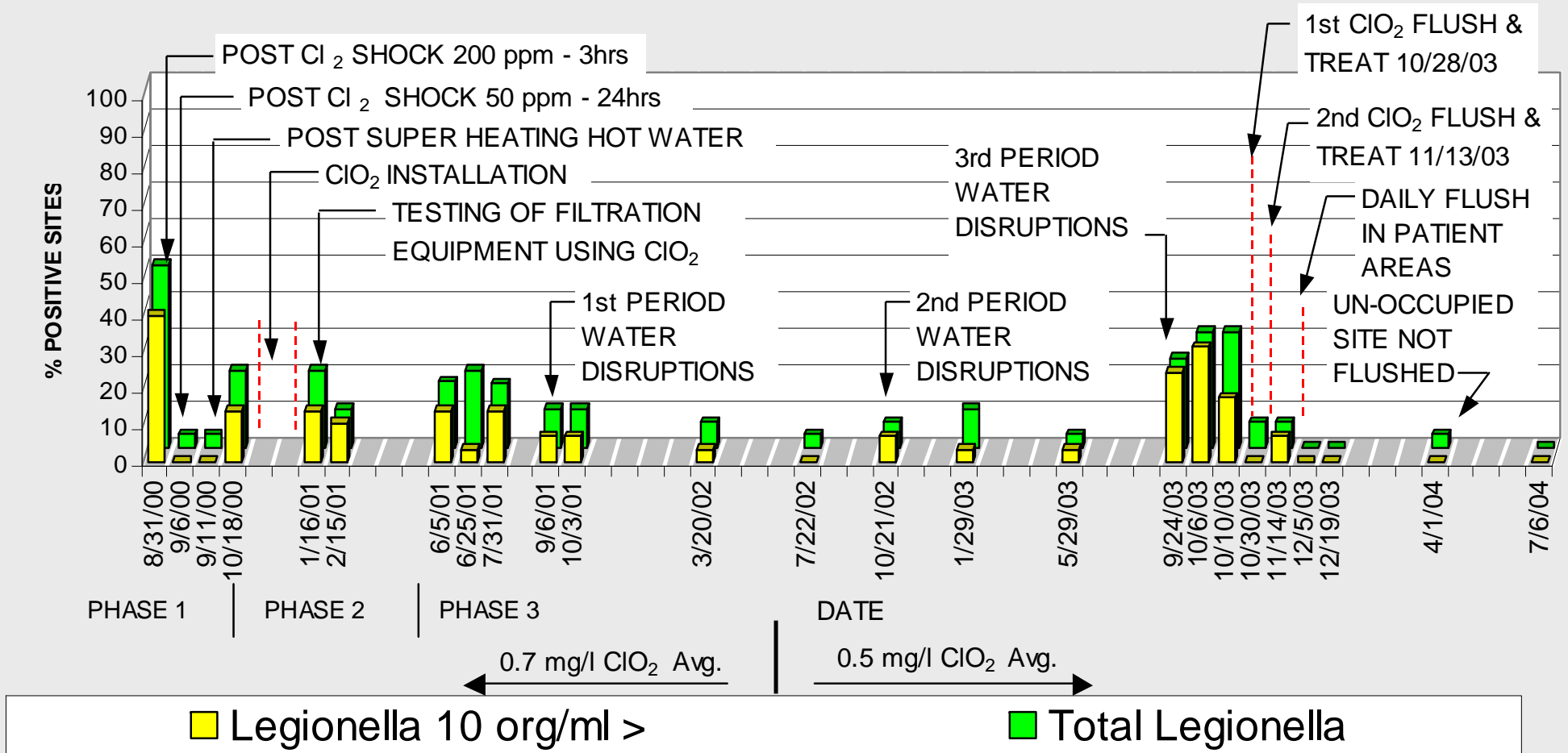
### CHART 4 - % POSITIVE LEGIONELLA SITES PHASE 3



# CHART 5 - % POSITIVE LEGIONELLA SITES IN COLD WATER



# CHART 6 - % LEGIONELLA POSITIVE SITES IN HOT WATER

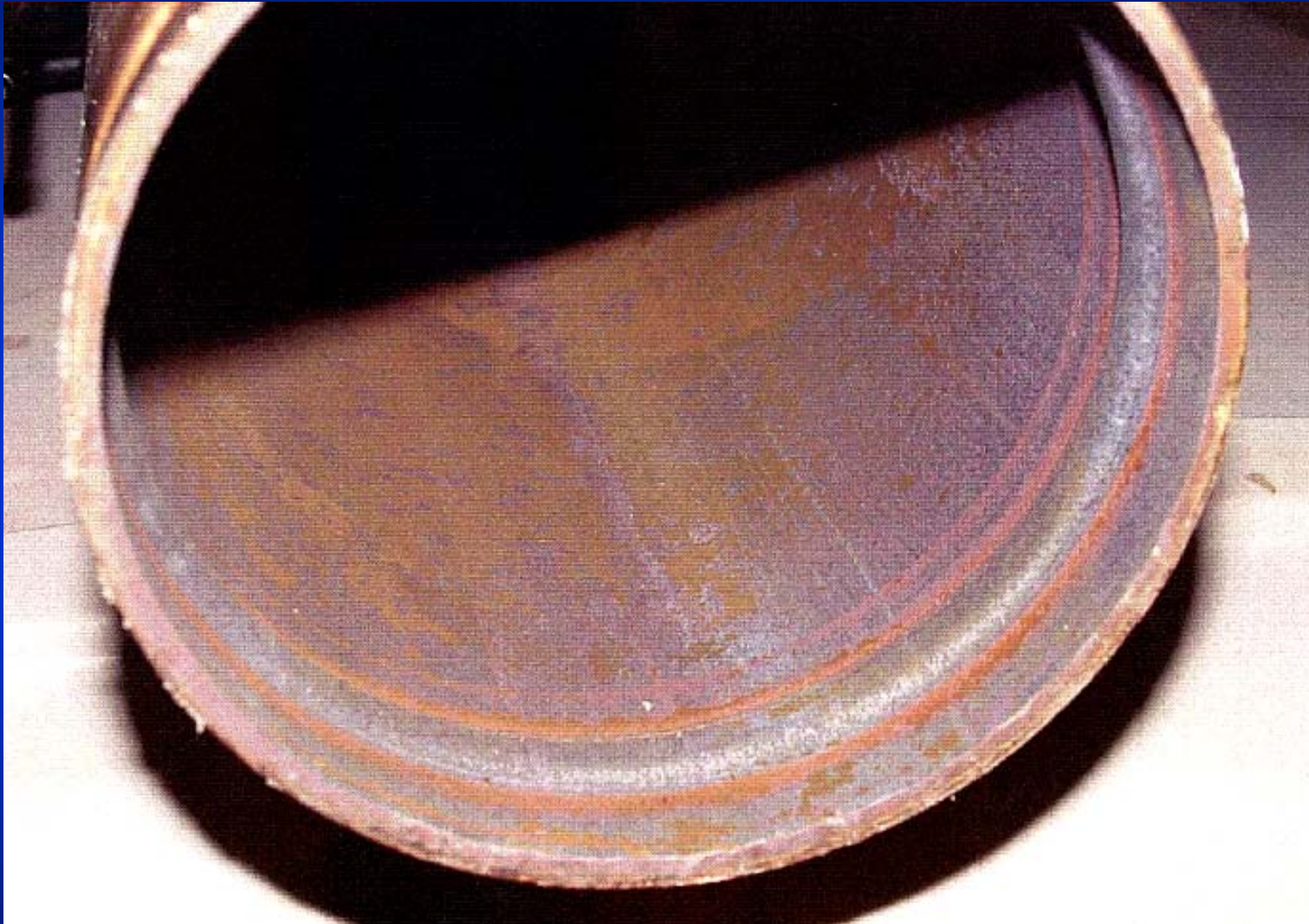




# Remediation using Chlorine Dioxide

- Chlorine Dioxide Shock and Flush remediation method (potable cold and hot water)
- Introduced Chlorine Dioxide  $>4.0$  mg/l for 6 hours
- Distal sites were flushed at low flow rates during remediation
- Minimal water restriction (no drinking)







# Phase 1 - Results of Typical Remediation Methods

- Hyper-chlorination ineffective
- Super heating ineffective
- *Legionella* and bacteria rebound

## Phase 2 – Results of Testing Filtration Equipment

- Dialysis filtration equipment effectively removes Chlorine Dioxide and its by-products
- Laboratory filtration equipment effectively removes Chlorine Dioxide and its by-products

# Phase 3 - Chlorine Dioxide Evaluation

## Summary

- Controls and eliminates: *Legionella*, bacteria and bio-film when maintained below 0.8 mg/l MCL
- Chlorite residuals maintained below 1.0 mg/l MRDL
- Delivery system operated as designed
- No impact on mechanical equipment and systems
- Corrosion rates within acceptable limits
- No safety problems identified

# Hopkins Legionella Monitoring Program

Developed monitoring protocols that exceed current practices:

- Cultures obtained from four distal sites per patient floor (first draw sample at sinks and showers)
- Cultures obtained from potable cold water distribution system (pre-treatment, post treatment and end of distribution system, 30 second draw)
- Cultures obtained from hot water distribution system (supply main and return main, 30 second draw)

# Maryland Department of Environment (MDE) Permit Issues

- Potable water from local city municipality
- Point of entry potable water treatment system
- Public water system
- Non-transient non-community consecutive public water system
- PE stamped construction documents
- Construction permits required (Water Quality Infrastructure Program, state and local)
- Certification or application of delivery system by National Sanitation Foundation (NSF) required

# MDE - Operating Requirements

- System supervised by an operator certified by the State of Maryland Board of Waterworks and Waste Systems Operators
- EPA allows the state flexibility to set monitoring requirements to consecutive water systems
- Pre-operation test of  $\text{ClO}_2$ , chlorite and coliform bacteria by an independent state certified laboratory
- Daily testing of  $\text{ClO}_2$  and chlorite at the point of treatment
- Monthly testing of chlorite in the distribution system (three set sample beginning, middle and end of system)
- All test data must be submitted to MDE monthly

# Maximizing Efficacy of Disinfectant

- Identify and correct piping deficiencies
- Obtain water use demand profile
- Proper application of delivery system
- Proper delivery system operation and control
- Monitor disinfectant residuals
- Monitor of *Legionella* and pathogenic bacteria
- Daily flushing protocols
- Prompt remediation after disruptions to the potable water system

## Summary

Chlorine dioxide has proven safe and effective as a disinfectant for controlling and eliminating Legionella, pathogenic bacteria and bio-film.

While all stated water treatment goals were achieved, the knowledge and data obtained during this study identified the complexity of implementing an effective water treatment program. Hopkins will continue to study the efficacy of chlorine dioxide as its application is expanded throughout the medical institution.