USEPA Webinar Series

Best Practices for Simultaneous Compliance

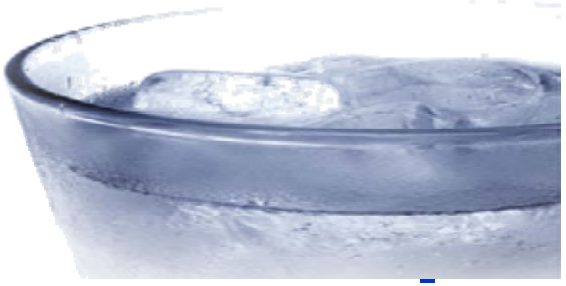
Office of Ground Water and Drinking Water

Simultaneous Compliance Planning

Best Management Practices for Distribution Systems

Add HW & Tt Logos??

OGWDW Contract No. EP-CI-08-018
Work Assignment 1-06



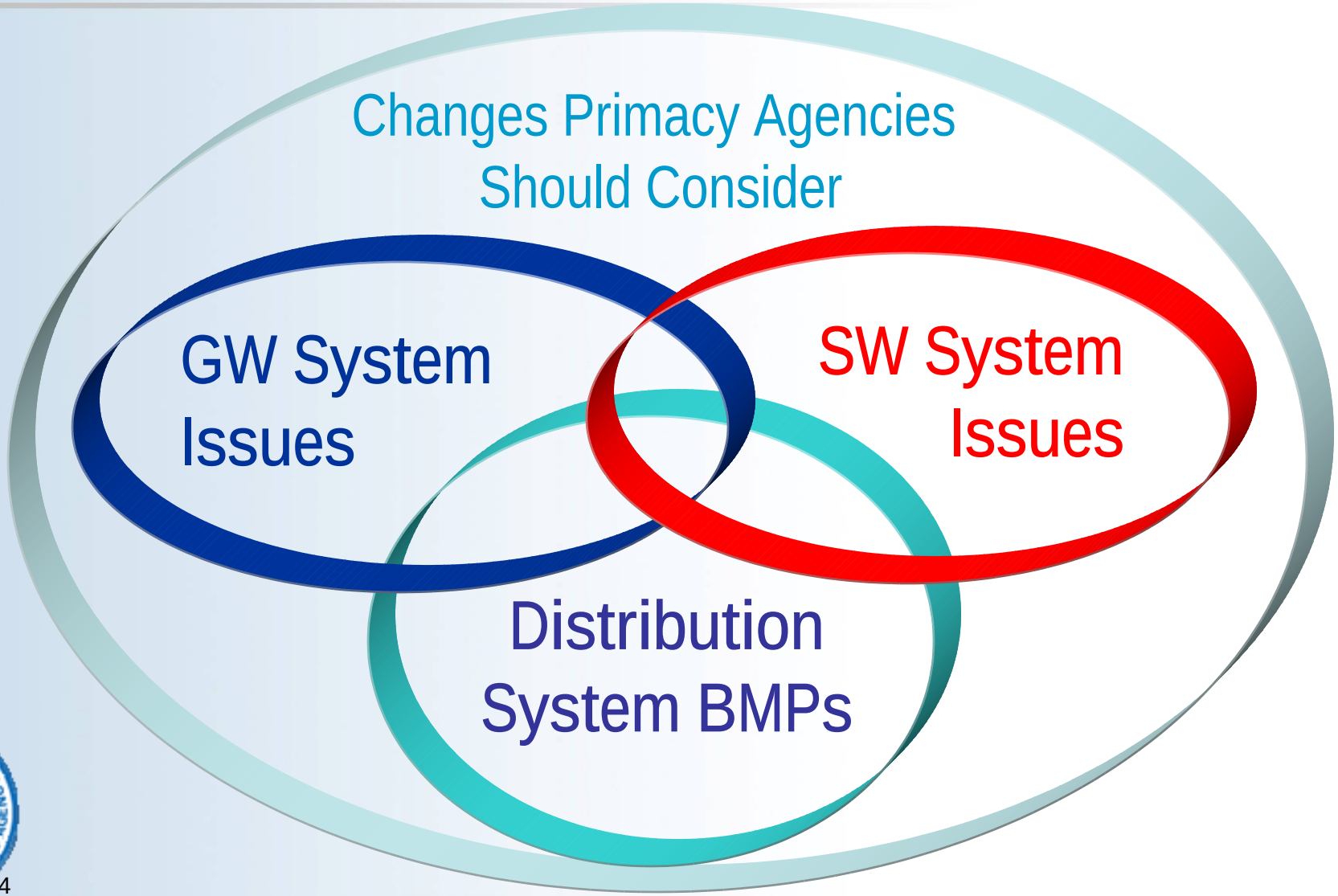
2009 Webinar Series:

- Source/Treatment Changes
  What Primacy Agencies Should Consider
- Simultaneous Compliance Planning Issues for Ground Water Systems
- Simultaneous Compliance Planning Issues for Surface Water Systems
- Simultaneous Compliance Planning – Best Management Practices for Distribution Systems

Defining Simultaneous Compliance

- Without careful planning and proper implementation, actions intended to improve one aspect of regulatory compliance can produce conflicts (or at least pose challenges) in other areas of water quality performance.
- Simultaneous Compliance is the comprehensive assessment and implementation of processes and practices which promote compliance with all SDWA regulations.

Simultaneous Compliance Requires a "Source-to-Tap" Perspective



Outline of Today's Discussion

Simultaneous Compliance Planning – Best Management Practices for Distribution Systems

1. SDWA Rules Impacting Distribution System BMPs
2. Distribution System Public Health Issues of Greatest Concern
3. Distribution System BMPs
4. LCR Corrosion Control Treatment
5. Distribution System Water Quality Monitoring
6. Wrap-up/Discussion/Q&A

Key Acronyms – SDWA Regulations

SDWA – Safe Drinking Water Act

TCR – Total Coliform Rule

LCR – Lead & Copper Rule

SWTR – Surface Water Treatment Rule

IESWTR –"Interim" Enhanced Surface Water Treatment Rule

D/DBP Rule – Disinfectant/Disinfection Byproduct Rule

LT1-ESWTR – Long-Term 1 Enhanced Surface Water Treatment Rule

LT2-ESWTR – Long Term 2 Enhanced Surface Water Treatment Rule

FBR – Filter Backwash Rule

GWR – Groundwater Rule

Key Acronyms – Water Quality

AOC - biologically-assimilatible organic carbon
CCT – corrosion control treatment under LCR
DBP – disinfection by-product
Fe/Mn – iron/manganese
IOC – inorganic chemical
NOM – naturally-occurring organic material
ORP – oxidation reduction potential (redox)
SOC – synthetic organic chemical
TOC - total organic carbon
T&O – taste & odor
VOC - volatile organic chemical

NO_3 – nitrate
PO_4 – phosphate
SO_4 – sulfate

Misc Acronyms

DSOP - Distribution System WQ Optimization Plan
GAC – granular activated carbon
GW – groundwater
GWUDI – groundwater under direct influence of SW (SWTR)
IDSE – Initial Distribution System Evaluation
IX – ion exchange
MF/UF – microfiltration/ultrafiltration
NF – nanofiltration (loose RO)
PWS – public water system
RO – reverse osmosis
SW - surface water
WTP – water treatment plant
WWTP – wastewater treatment plant

SDWA Rules Impacting Distribution System Best Management Practices

Distribution System Components

- Pipelines & fittings
- Pumping Stations
- Valves
- Backflow Prevention Devices
- Storage tanks
- Hydrants
- Meters
- Premise Plumbing

Distribution System Water Quality Goal:

Pathogen Free Water

- Water entering the distribution system needs to be pathogen-free
  - Primary disinfection should be robust
  - Continuous disinfection – no lapses
  - Appropriate residual disinfectant at adequate concentration
- Need to prevent pathogens from seeding the distribution system
- Risk Reduction: SWTR; IESWTR; LT2ESWTR

Distribution System Water Quality Goal:

Biological Stability

- Secondary disinfectant residual
- Bacterial growth/re-growth in the distribution system can be reduced by removal of nutrients (TOC, AOC)
- Disinfectant decay rates can be reduced by removal of NOM and/or use of a weaker oxidant
- Risk Reduction: TCR; SWTR; Revised TCR

Distribution System Water Quality Goal:

Chemical Stability

- Oxidized forms of Fe, Mn, SO4, other IOCs should be removed by treatment
- DBP formation can be reduced by removal of NOM and/or use of a weaker oxidant
- Allows flexibility in secondary disinfectant selection
- Primary disinfection via free chlorine stabilizes chloramine reactions in distribution system
- Risk Reduction: SWTR; Stage 1 & 2 DBP Rules

Distribution System Water Quality Goal:

Non-Corrosive Water

- Minimize Pb/Cu exposure
- Slow corrosion of iron:
  - Fe corrosion consumes chlorine
  - Fe can be nutrient for bacterial growth
  - Tubercles and Fe-scales can provide habitat for biological activity
  - Contributes to particulates in system
- Better taste, odor, color, aesthetics
- Risk Reduction: LCR

SDWA Rules Impacting Distribution System Best Management Practices

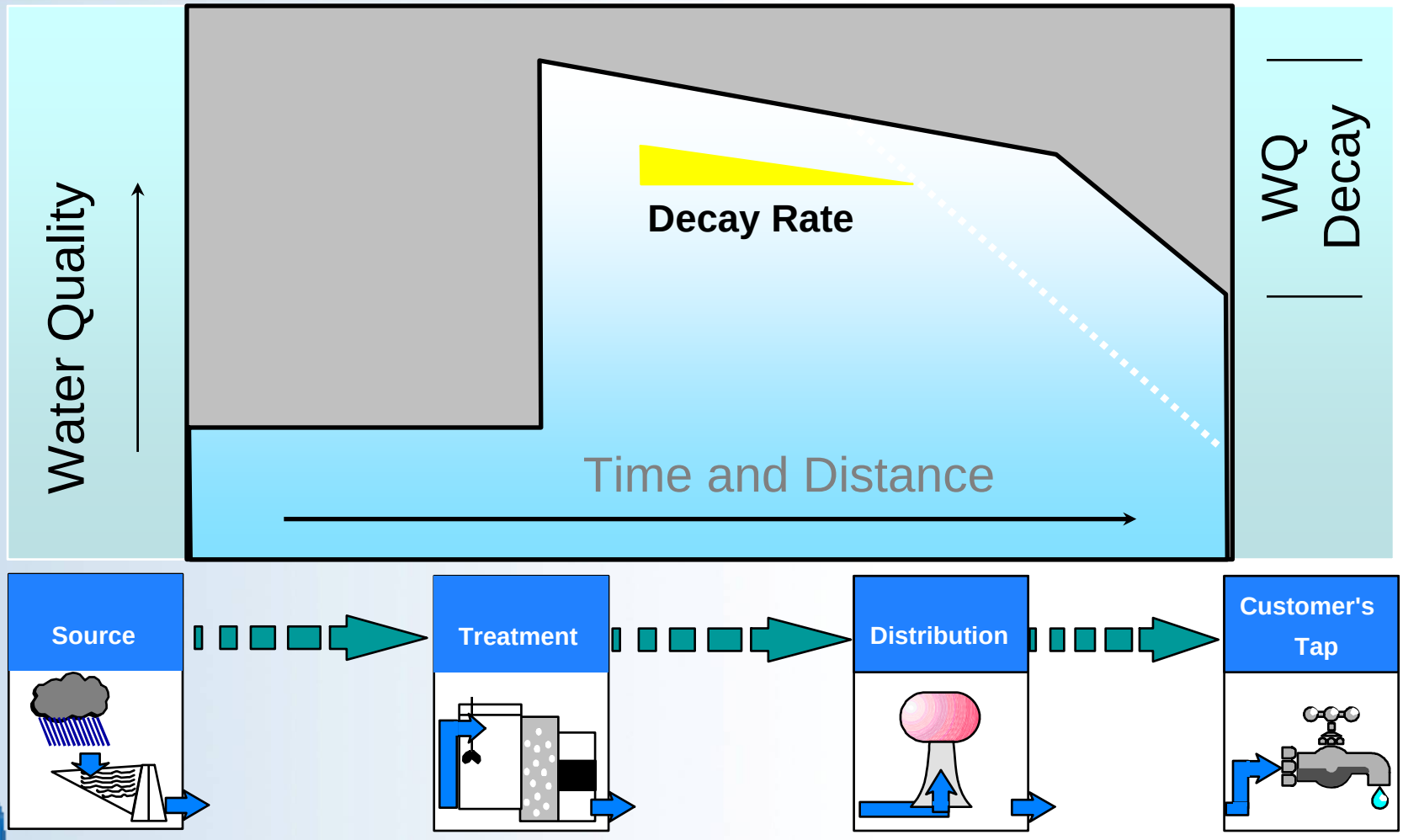
- MAJOR IMPACTS
  - TCR
  - LCR
  - Stage 2 D/DBP Rule
  - Revised TCR (2010?)
- INDIRECT IMPACTS
  - SWTR (primary/secondary disinfection)
  - LT2ESWTR (treatment, cover open reservoirs)
  - GWR (significant deficiencies)

Distribution System Public Health Issues of Greatest Concern

Principal Causes of Distribution System Water Quality Deterioration

- Source/Treatment Deficiencies and/or Operational Problems
- Chemical/Biological Reactions:
  - water-to-water reactions
  - water-to-piping/system materials
- Contamination from External Sources
- Improperly Maintained Storage Facilities
- Premise Plumbing Issues

Water Quality Deterioration in Distribution Systems



Maintaining a Disinfectant Residual
(secondary disinfection)

- Free chlorine and monochloramine residual used for:
  - Secondary inactivation of organisms
  - Controlling biofilm growth
  - Potential indicator of distribution system integrity problems

Secondary Disinfection using Free Chlorine Residual

- Most common primary/secondary disinfection chemical
- Rapid initial decay rate
- Bulk fluid reactions and decay at pipe walls
- Free chlorine decay controlled by residual concentration and chemical/biological constituents

Secondary Disinfection using Monochloramine Residual

- Advantages
  - Weaker oxidant = less reactive, more stable and persistent residual disinfectant
  - Less DBP formation
  - Effective mitigating microbial growth/regrowth
- Disadvantages
  - Potential increase in nitrification
  - Negative impact on special uses (kidney dialysis centers, fish, other aquatic life)

Distribution System Issues of Greatest Concern

- National Research Council, 2006

- Cross Connection/Backflow
- Pipeline Repair and New Installation
- Finished Water Storage Facilities
- Premise/Household Plumbing

- Medium Priority Issues
  - Loss of Residual by Water Age & Nitrification
  - Biofilm Growth
  - Low Pressure Transients & Intrusion

Importance of Distribution System Maintenance

- Distribution systems must be properly maintained to ensure:
  - High quality water/public health
  - Public safety
  - Protection of public/private property
  - Reliability
  - Full service life of equipment – maximize return on public investment

Distribution System Best Management Practices

Cross-Connection/Backflow Prevention Programs

- Cross-connections are localized occurrences of back-pressure or back-siphonage
- Significant potential for waterborne disease!! Occurrence may be under-reported.
- Cross-connection control programs mandated in almost every state
  - Inspections, training, plumbing codes
- AWWA Guidelines
- Property/jurisdictional issues complicate consistent program adherence/enforcement

New/Repaired Water Mains
Pipeline Construction Activity

- Pipeline replacement/repair/installation is an opportunity for exposure of pipe interior to external contaminants
  - Main break or other failure; loss of pressure
  - Outside storage of piping prior to installation
  - Improper construction techniques
  - Improper disinfection prior to placing in service
- 40% of utility managers cited unsanitary construction practices as primary cause of microbial contamination (AwwaRF, 1998)

Water Main Repair/Construction
Cabool, Missouri

- 1989: E. coli outbreak caused 232 illnesses/4 deaths
- Linked (in part) to inadequate sanitary practices during water main repair
- 2 pipelines & 43 meters failed during record freeze
- Pipes replaced and flushed before release to service
- Sewage overflow had contaminated nearby surface soil
- Failure to isolate area during repairs
- Lack of proper post-construction disinfection

Development of Disinfection Guidelines for the Installation and Replacement of Water Mains. Denver CO. AwwaRF 1998.

Storage Facility Inspection, Operation and Maintenance

- Distribution system WQ issues often traced to storage tanks
  - Contamination by various ingress
  - Water age / mixing / loss of disinfectant residual
  - Materials corrosion / leaching
  - Lack of routine inspection and targeted WQ monitoring

Uncovered Finished Water Storage can Create Significant WQ Problems

- Contamination potential from birds, animals, wind, rain, algae
- Chlorine + Bromide + UV = Bromates
- LT2ESWTR requires cover or supplemental treatment
- Storage facility inspection & cleaning are essential!!

Storage Facility Case Study
Gideon, Missouri

- 1993: Town of Gideon MO experienced a *Salmonella* outbreak leading to 500 illnesses and 5 deaths
  - Outbreak apparently caused by bird droppings in elevated storage
  - Birds entered tank via screens, vents, hatch and holes

Missouri DNR. 2006. Fact Sheet: Microbial Contamination of Water Storage Tanks. PUB000172.

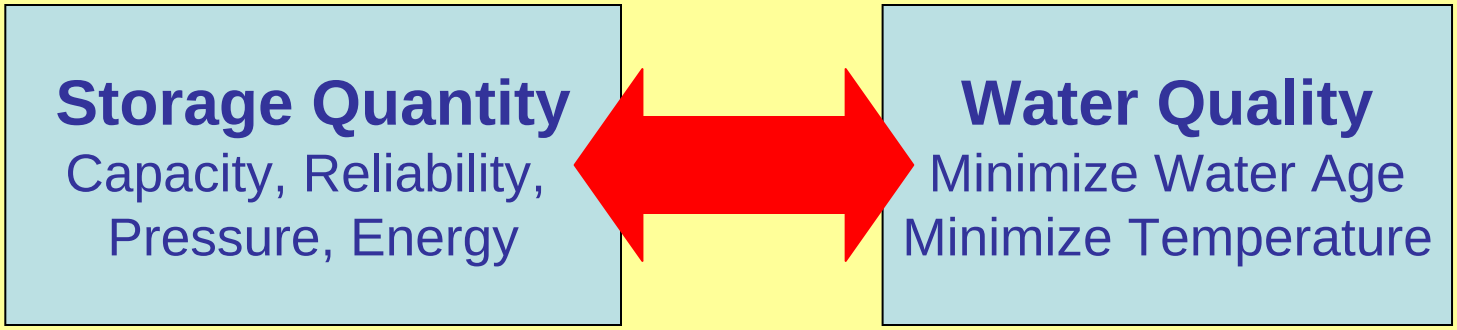
Storage Facility Case Study
Gideon, Missouri

- Old tanks had sanitary defects in hatch, vent, overflow and roof/wall joints
- Tank painting contractor had drilled holes, then left open or duct taped
- Tank inspections infrequent
- Inadequate inspection standards (since been updated by state)

Missouri DNR. 2006. Fact Sheet: Microbial Contamination of Water Storage Tanks. PUB000172.

Finished Water Storage Objectives Pose Inherent Trade-offs

- Hydraulic integrity/reliability
- Reduce water production requirements by dampening diurnal demands
- Fire protection
- Equalize system pressure



Importance of Water Age

- Water age management is critical to distribution system WQ
- As Water Age increases:
  - ↑ Temperature increases
  - ↓ Disinfectant residual decays
  - ↑ Regrowth/nitrification potential goes up
  - ↑ DBP formation increases

Water Age Management Strategy

- Storage design & operation
  - More frequent “tank turnover”
  - Improved mixing/eliminate dead zones
  - Avoid short-circuiting
- Pipeline design & operation
- Eliminate/loop dead-end pipelines
- Pressure zone control

Distribution System Flushing Program

- A well-crafted written procedure for preventative, systematic flushing
- Spot flushing in response to customer concerns
- System Flushing:


Improves disinfectant residual

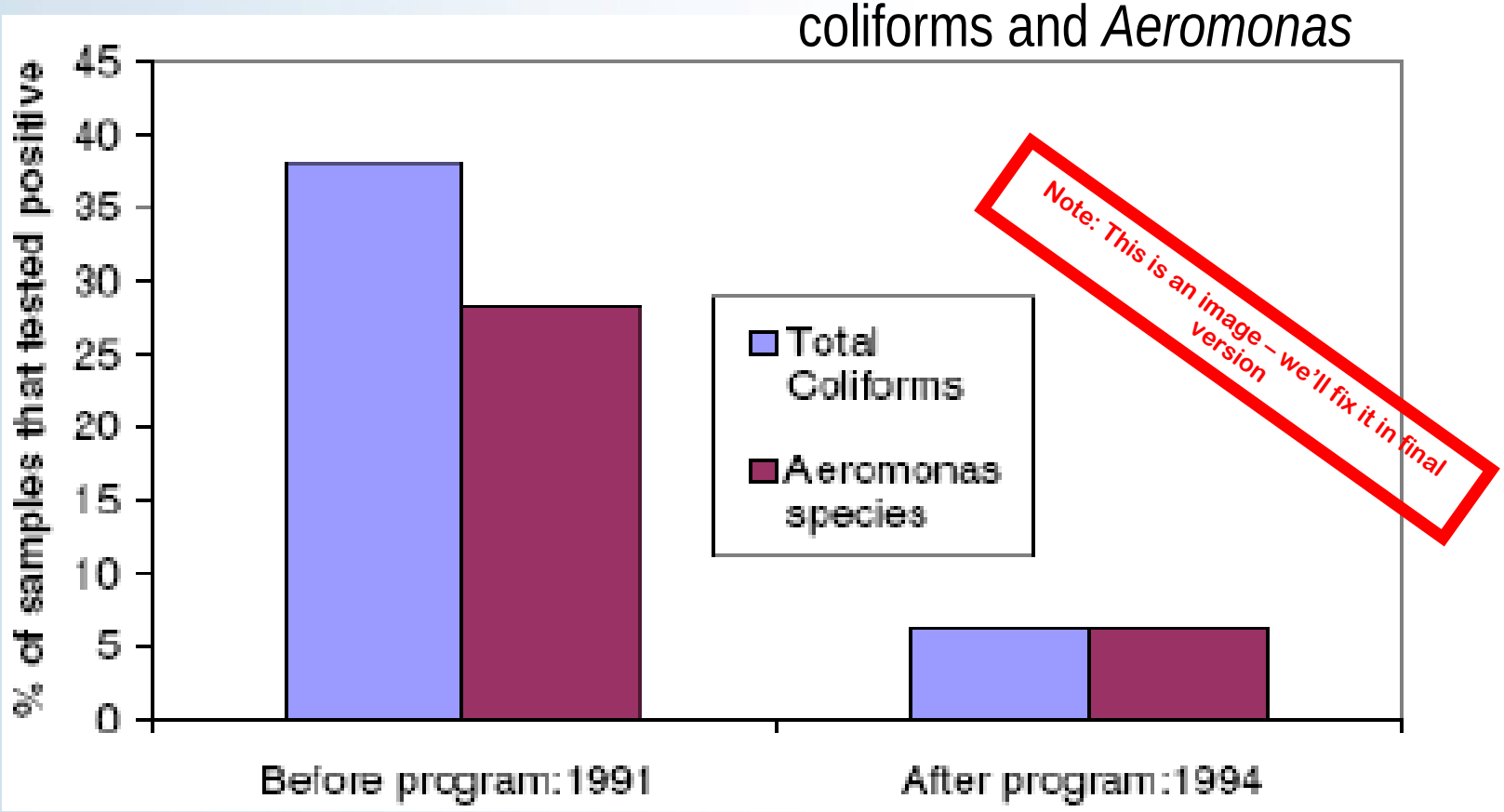

Decreases water age


Mitigates stagnant water effects


Re-suspend sediments/dirty water

Flushing Program Case Study
Seattle Public Utilities

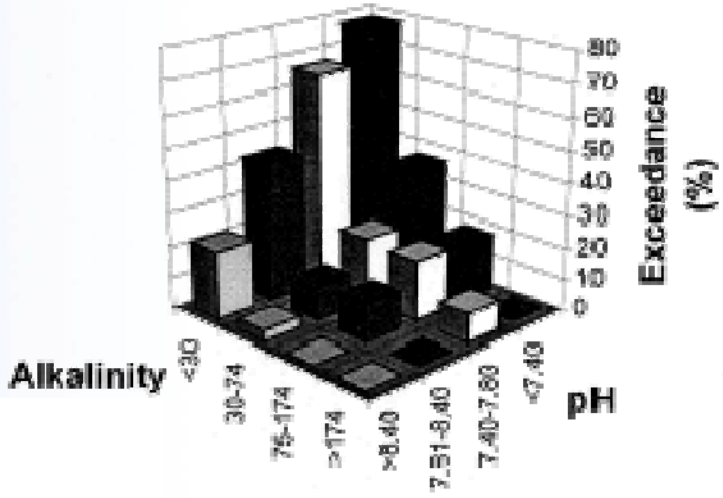
SPU concluded that system-wide flushing program, and other distribution system BMPs enabled significant reduction in coliforms and *Aeromonas*



LCR Corrosion Control Treatment

LCR Corrosion Control Treatment

- Carbonate Passivation (adjust pH, alk)
- Carbonate Precipitation (adjust pH, Ca)
- Passivation using corrosion inhibitor chemical (PO_4)

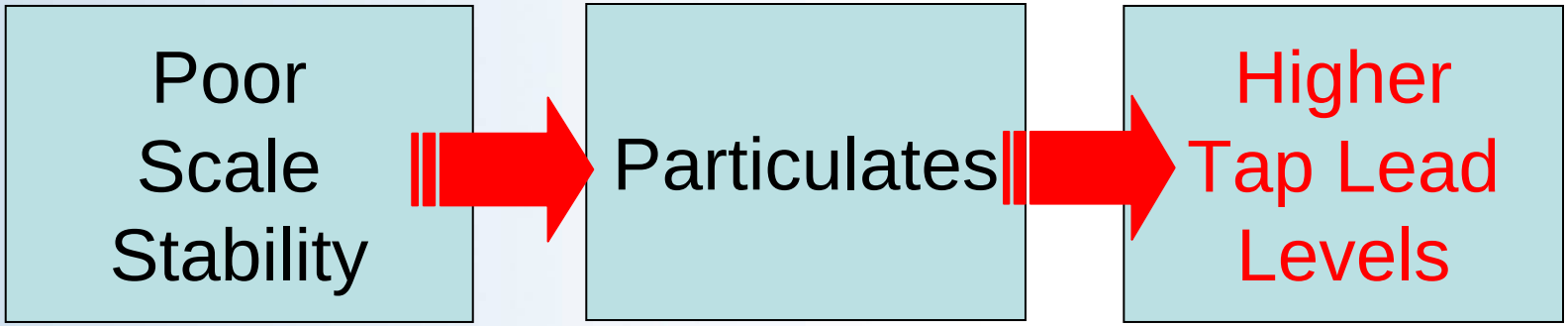


Why Optimize/Re-Optimize CCT?

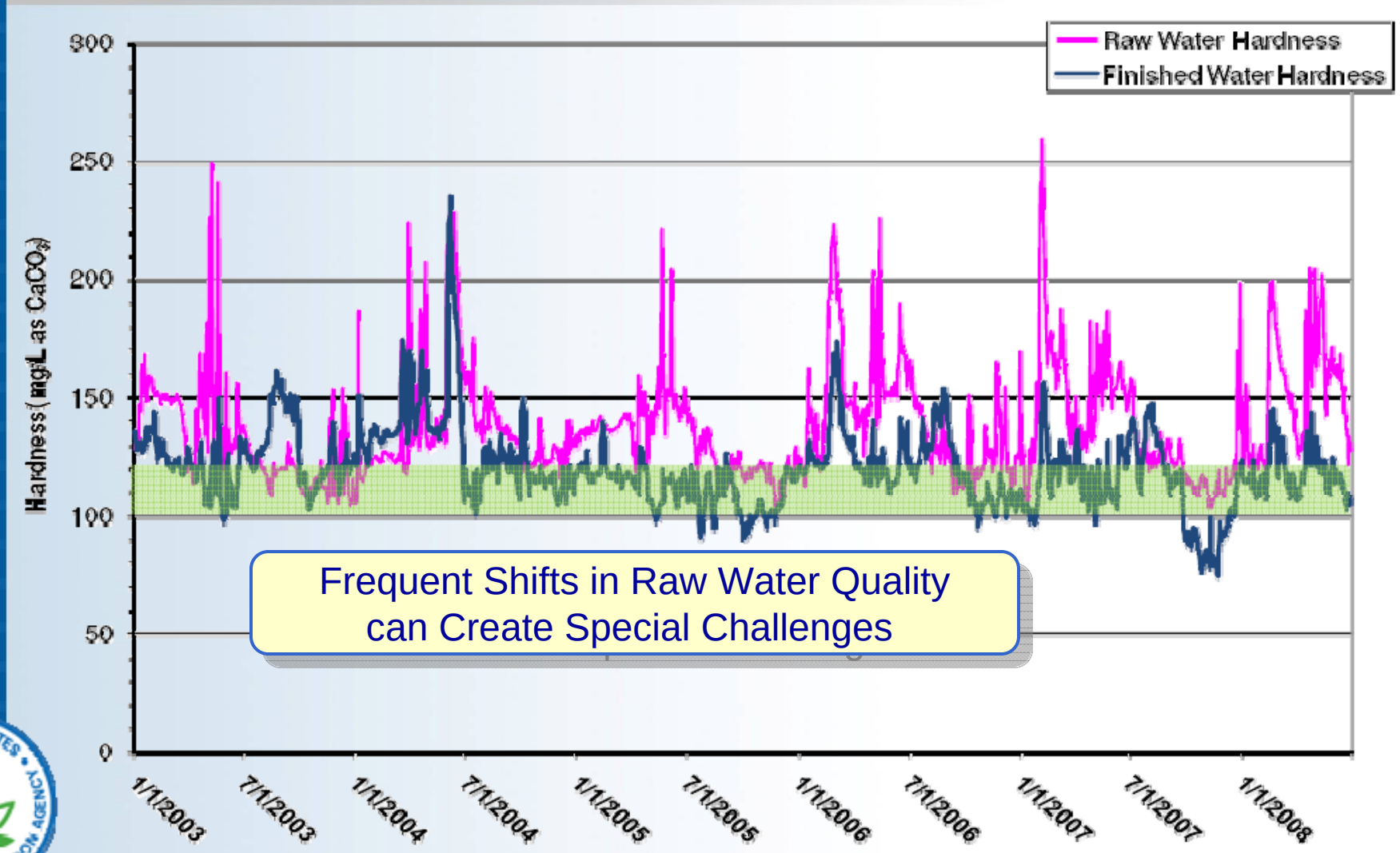
- CCT required by LCR, to avoid:
  - Exposure to Pb/Cu
  - AL exceedance/Public Education
  - LSL Replacement
- Update CCT in conjunction with process modifications
- Address Fe/Mn/dirty water/aesthetics
- Mitigate/manage WWTP Issues
  - Zinc
  - Phosphorus

Managing CCT is Frequently about Consistency

- Primary: pH, alkalinity, orthophosphate, ORP
- Secondary: NOM, TDS, nitrifying bacteria, etc.
- Metals/mineral solubility (Pb, Cu, Ca, Cd, ?)
- Scale "Stability"
  - Deposition, permeability and scale hardness

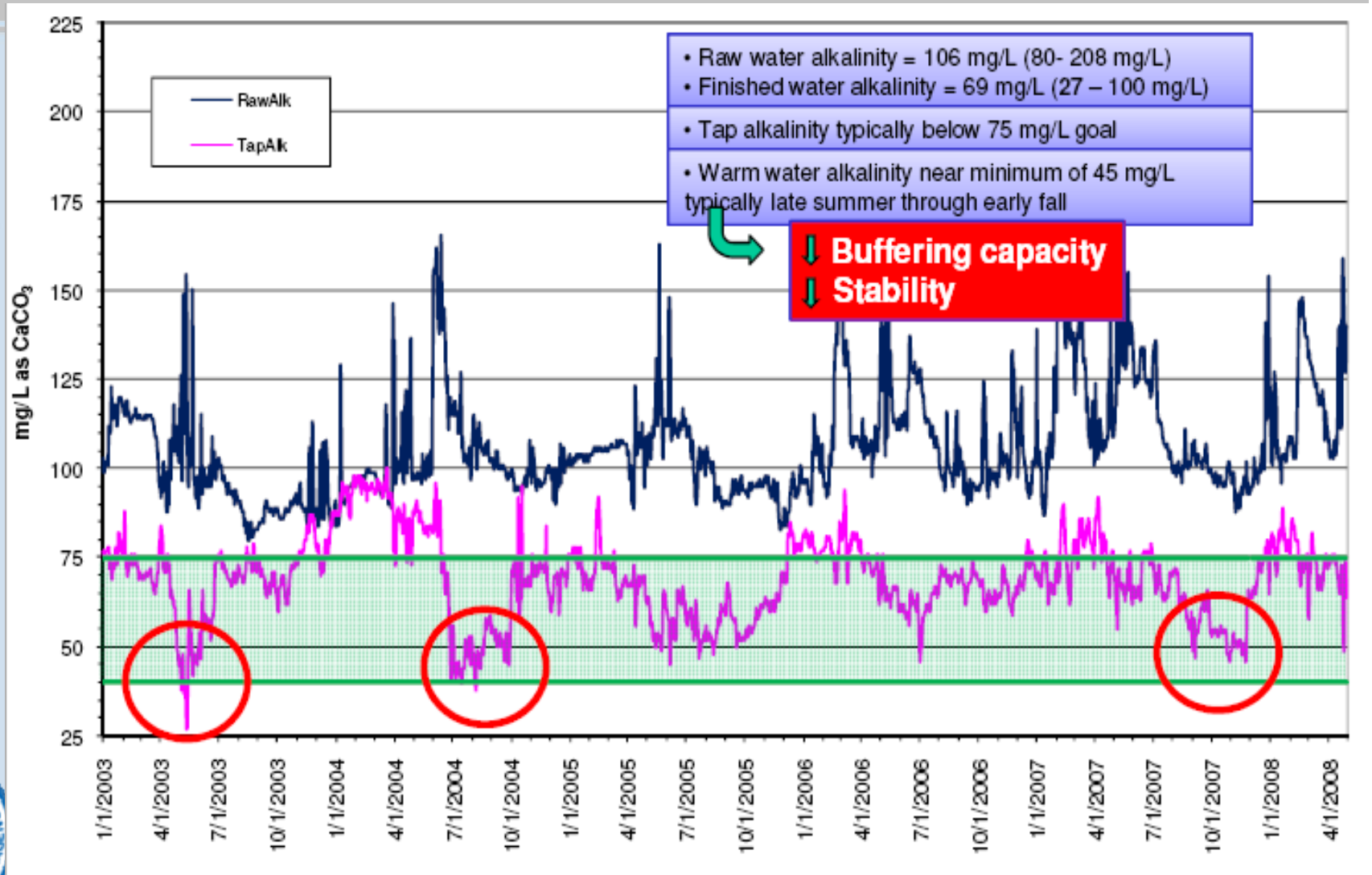


Managing CCT Challenges
Bay City, MI



Managing CCT Challenges

Bay City, MI



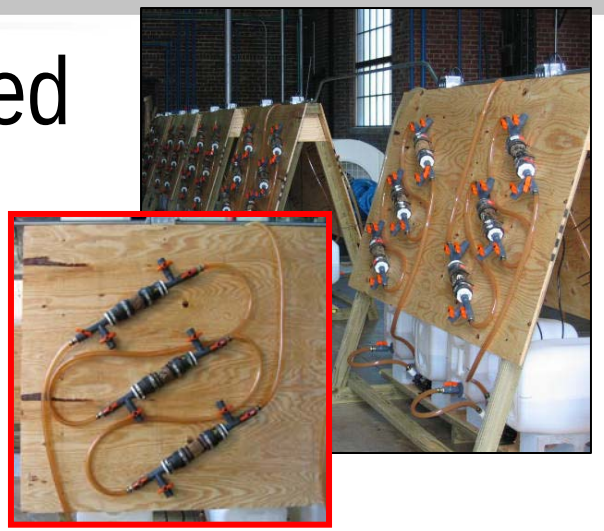
LCR Corrosion Control Treatment Possible Conflicts/Challenges

- Optimum CCT pH not always best for secondary disinfection efficacy
- Frequent variations in raw/finished water pH/alkalinity may have negative impacts on scale stability
- ORP shifts related to disinfectant chemical changes may impact lead solids in home plumbing
- Shift in Cl:SO_4 ratio may increase lead solubility/release
- Bio-regrowth potential
- Red water / “dirty water” / aesthetics
- WWTP Impacts (phosphorus, zinc)

LCR CCT Optimization
Overcoming Compliance Challenges

- Maintain consistent target pH/alkalinity to minimize Pb/Cu and promote scale stability
- Critically examine any changes with potential to impact CCT
- Carefully re-optimize CCT if needed
  - *"Final Revised Guidance Manual for Selecting Lead and Copper Control Strategies'" EPA 816-R-03-001, March 2003.*
  - *"Managing Lead and Copper Rule Corrosion Control Practices to Avoid Unintended Consequences," AWWA, 2005.*

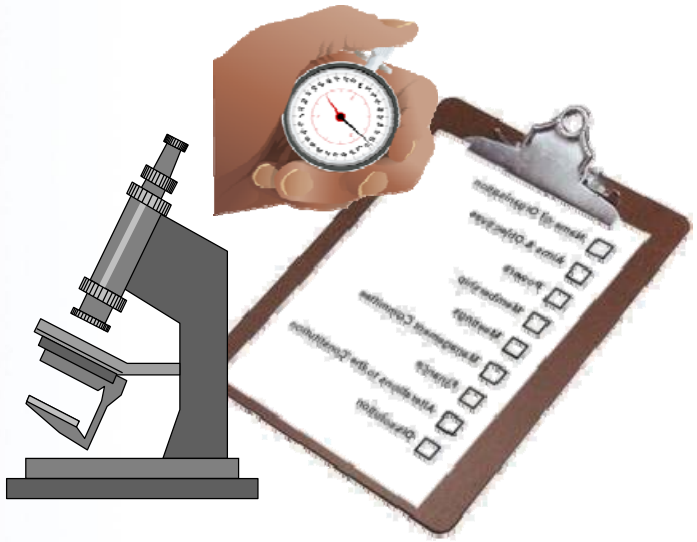
LCR CCT Optimization
Overcoming Compliance Challenges



- Update CCT studies if needed
  - Desktop
  - Bench scale CCT study
  - Pipe loop CCT study (1-2 years)
- Maintain Cl:SO4 ratio <0.6
- Consider secondary constraints:
  - red water / “dirty water” / aesthetics
- Recognize potential WWTP impacts
  - phosphorus, zinc

Distribution System Water Quality Monitoring

Distribution System Water Quality Monitoring



- Residual Disinfectant
- Flows & Pressure
- Water Age
- Microbial Quality
  - Coliform, E. coli, HPC, AOC
- CCT & LCR water quality parameters
- DBPs

On-line Water Quality Sensors and Monitoring Devices

- Real-time feedback improves:
  - Control/consistency of distribution WQ
  - Response to unusual events/conditions
  - Recordkeeping and diagnostics
- On-line devices commonly used for pH, residual chlorine, turbidity, temperature
- Hand-held data loggers also used at TCR, DBP, other sample points

On-line Chlorine Residual Monitoring Devices

- Helps ensure adequate secondary disinfection
- Potential trigger for operational responses
- Can provide indirect feedback about:
  - Ingress/microbial contamination
  - Water age
  - Nitrification
  - Mixing/flushing

Chlorine Residual Monitoring Examples

- **Cincinnati OH** uses on-line chlorine analyzers to help control operation of distribution system, tanks and re-chlorination systems
- **Bellevue, WA** purchases water from Seattle, uses on-line chlorine analyzers to monitor consistency, reduce water age and increase turnover in storage tanks

"Case Studies of On-line Monitoring Systems, Ch 12." AwwaRF. 2002
"Guidance Manual for maintaining Distribution System Water Quality." AwwaRF 90798. 2000.

Corrosion Monitoring

- "Corrosion" is not just Pb/Cu, also influences microbial growth and aesthetics!
- Several monitoring methods:
  - Metals uptake – by water
  - Metals loss by pipe – weight loss
  - Pit depth measurement
- On-line electrochemical methods

Wrap-Up

Utilities & Primacy Agencies Need to Anticipate Interactions/Conflicts/Challenges

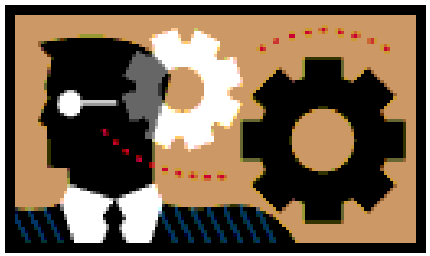
- Direct SDWA-driven Rule conflicts
- Treatment process interactions/impacts
  - Disinfection
  - Oxidation/aeration
  - Softening
  - GAC Adsorption
  - Residuals production
- Distribution system impacts
  - Microbial/regrowth
  - Chemistry/Corrosion/Pipe-scale
  - Secondary/Aesthetics/O&M practices

ID possible solutions

Recognize Potential Issues

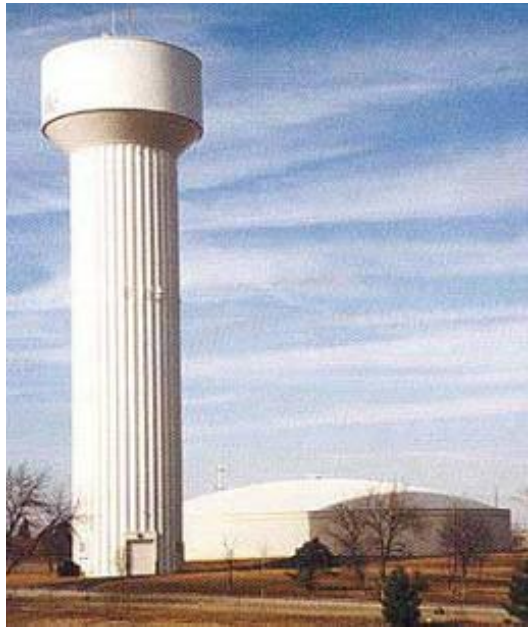
Screen Alternatives

Collect Site-specific Data



Distribution System O&M Changes
Possible Conflicts/Challenges

- Negative impact on CCT effectiveness
- Nitrification/regrowth spikes
- Release/re-suspension of sediments
- Dirty water complaints
- Reduced storage for emergencies (e.g., fire protection)



Key Distribution System BMPs

- Effective primary/secondary disinfection
- Cross-connection control program
- Sanitary pipeline construction practices including post-construction disinfection
- Storage facility inspection/cleaning
- Water age management strategy
- Distribution system flushing program
- Optimum CCT
- Water quality monitoring program

Distribution System BMPs Will Address Multiple WQ Issues

- Improve secondary disinfection
- Maintain disinfectant residual all the way to system periphery
- Reduce water age to lower DBPs
- Reduce nitrification / regrowth
- Improve bio-stability of water
- Consistent management of Optimum CCT

Distribution System WQ Optimization Plan (DSOP)

- Integrated plan for maintaining distribution system water quality
- Identifies needs and potential vulnerabilities
- Develops BMPs
- Organizes and integrates utility policies and programs impacting distribution system water quality
- Road map of short-term/long-term goals
- Repository for BMPs and implementation status
- AWWA Standard G-200.04

Distribution System BMPs can Address Numerous and Subtle *Secondary Impacts*

Blending of source/finished waters
Hardness
Taste & Odor
Iron/manganese
“Dirty Water”
Residuals Issues (As, Rads)
Degradation of Filter Performance
Changes in flow, direction and pressure
WWTP conflicts

Take Away

- Utilities and primacy agencies need to recognize and assess the potential for actions that may impact:
  - *Cross-connections*
  - *Disinfectant residual*
  - *Distribution system pH, alkalinity*
  - *Water age management*
  - *Storage tank integrity*
  - *Corrosion control treatment*
- Significant water quality monitoring, treatability, or process evaluation may be necessary to assessment efforts
- Technical resources are available.

Resources

- USEPA. January 2009. Ground Water Rule (GWR) Implementation Guidance
- USEPA. November 2008. Ground Water Rule Corrective Actions Guidance Manual. EPA 815-R-08-011
- USEPA. October 2008. Sanitary Survey Guidance Manual for Ground Water Systems
- USEPA. March 2007. Simultaneous Compliance Guide for the Long Term 2 and Stage 2 DBP Rules. EPA 815-R-07-017
- AWWA 2005. "*Managing Lead and Copper Rule Corrosion Control Practices to Avoid Unintended Consequences*"
- WRF 3115 "Simultaneous Compliance Tool" 2009.
- EPA 1999. Microbial and Disinfection Byproduct Rules Simultaneous Compliance Manual. EPA 815-R-99-015
- WRF "Balancing Multiple Water Quality Objectives," 1998.

Discussion

Q&A