Understanding Lead in Tap Water: Chemistry, Control, and Challenges

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Rationale

Understanding the sources and forms of lead in drinking water, factors influencing lead release, and the challenges involved can help water utility and public health personnel:

- Diagnose problems
- Identify and evaluate solutions
- Communicate with the public and others
- Avoid unintended consequences
- Avoid future problems

Learning Objectives

- Identify sources and forms of lead in tap water, and methods for its control.
- Appreciate various challenges involved in controlling lead levels.
- Communicate more effectively with others regarding lead in tap water.

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Overview

- Sources & Forms of Lead in Tap Water
- The Role of Water Quality
- Control Options
- Challenges
- Summary & Closing Thoughts

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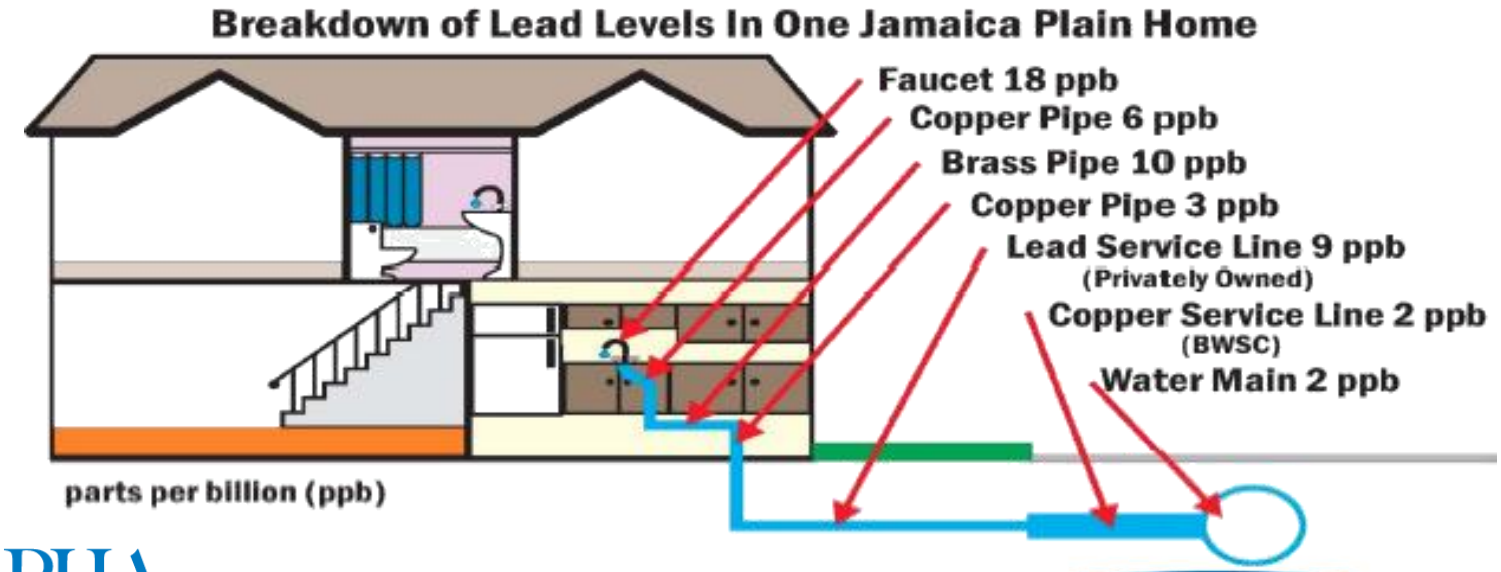
Sources of Lead in Tap Water

- Lead service lines (LSLs)
- Lead solder
- Plumbing components, esp. if brass
- Lead incorporated into scale deposits



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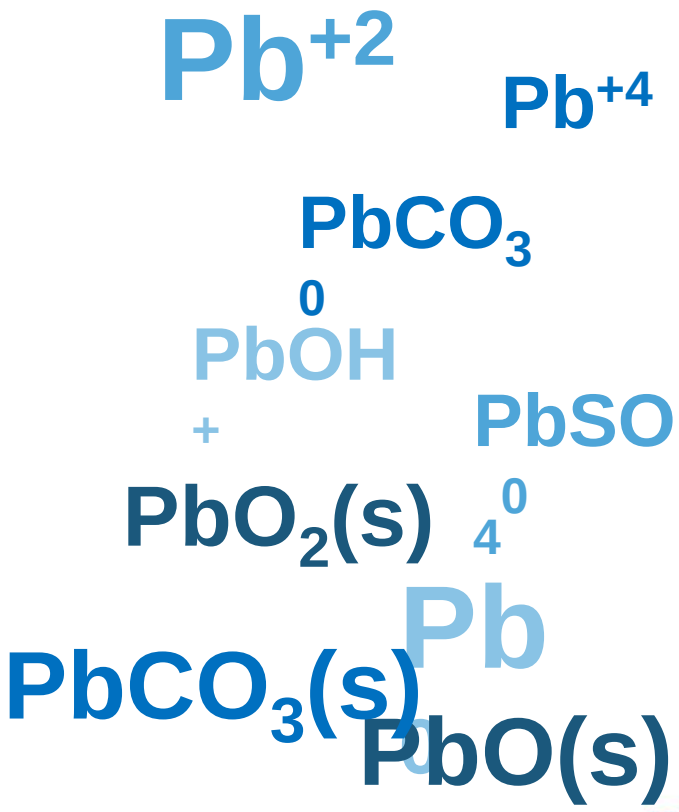
Source: Sandvig (2008) Example illustrating the influence of plumbing materials and sampling protocol on observed lead value
http://www.mwra.com/04water/html/1206leadtestimonytranscript.htm

Forms of Lead in Tap Water

- Lead may be
  - Dissolved
  - Complexed with carbonate, hydroxide, sulfide, organic material, etc.
  - Composed of, or adsorbed on, corrosion products
  - Lead particles



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The Role of Water Quality

Impacts

- Lead solubility
- Lead speciation
- Behavior of pipe scales containing lead

Lead pipe with scale (Del Toral et al., 2014)

Parameters of interest

- pH, alkalinity, hardness
- Temperature
- Chloride and total dissolved solids (TDS)
- Residual chlorine
- Iron and manganese
- Organic matter
- Stability (chemical and biological)

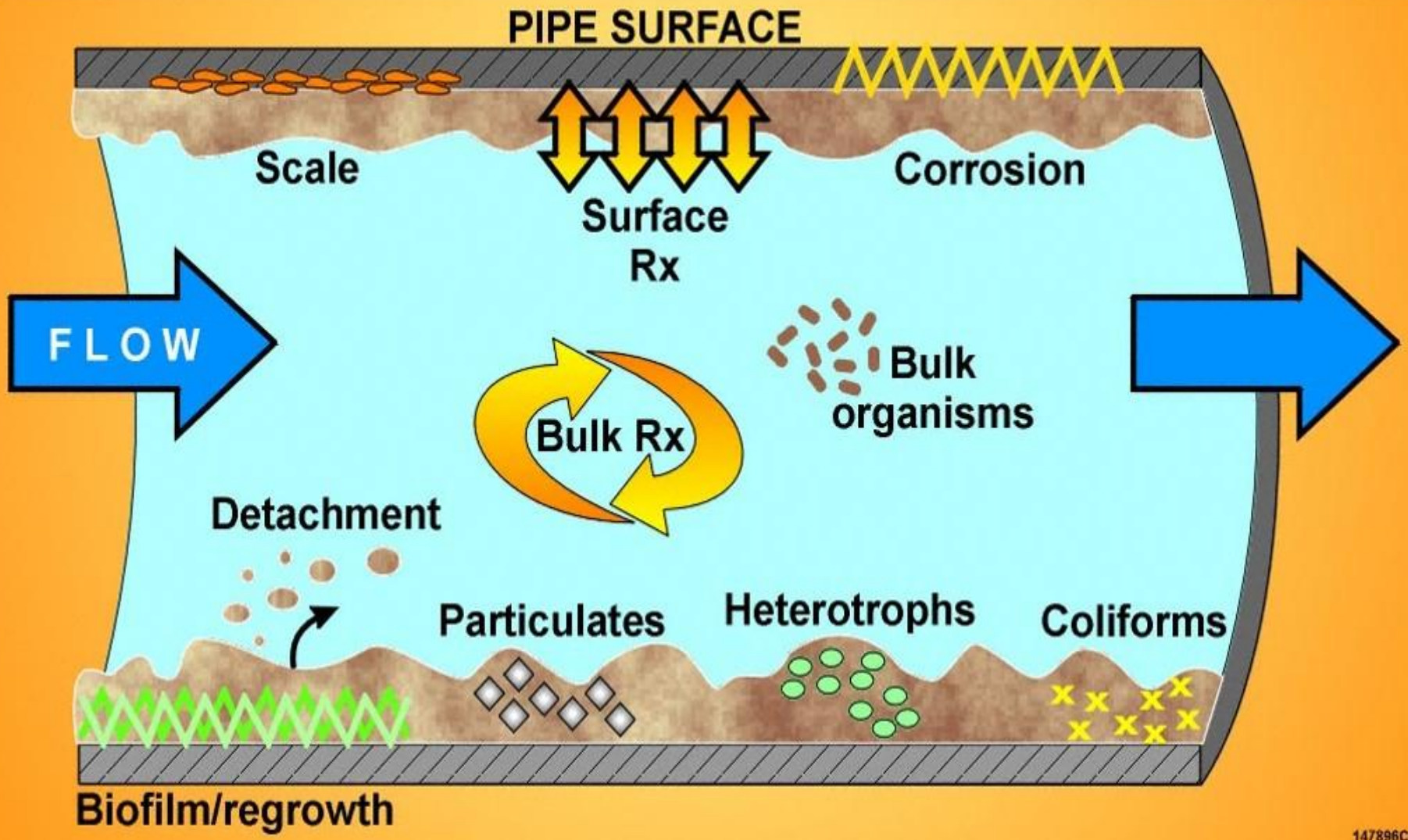
Influences on Water Quality

- Changes in source water quality
- Changes in treatment
- Design and operation of the distribution system:
  - Pipe materials and condition
  - Water age
  - Water disinfection practices
  - Maintenance, e.g., flushing & pigging

Water Main Maintenance

Source: Journal AWWA, cover photos in Feb. 1983 and May 1980, resp.

The Distribution System as Reactor



Control Options

- Corrosion control treatment (CCT)
  - Required for all systems subject to the Lead & Copper Rule (LCR)
  - The two most common methods are:
    - Adjusting pH and alkalinity
    - Orthophosphate addition

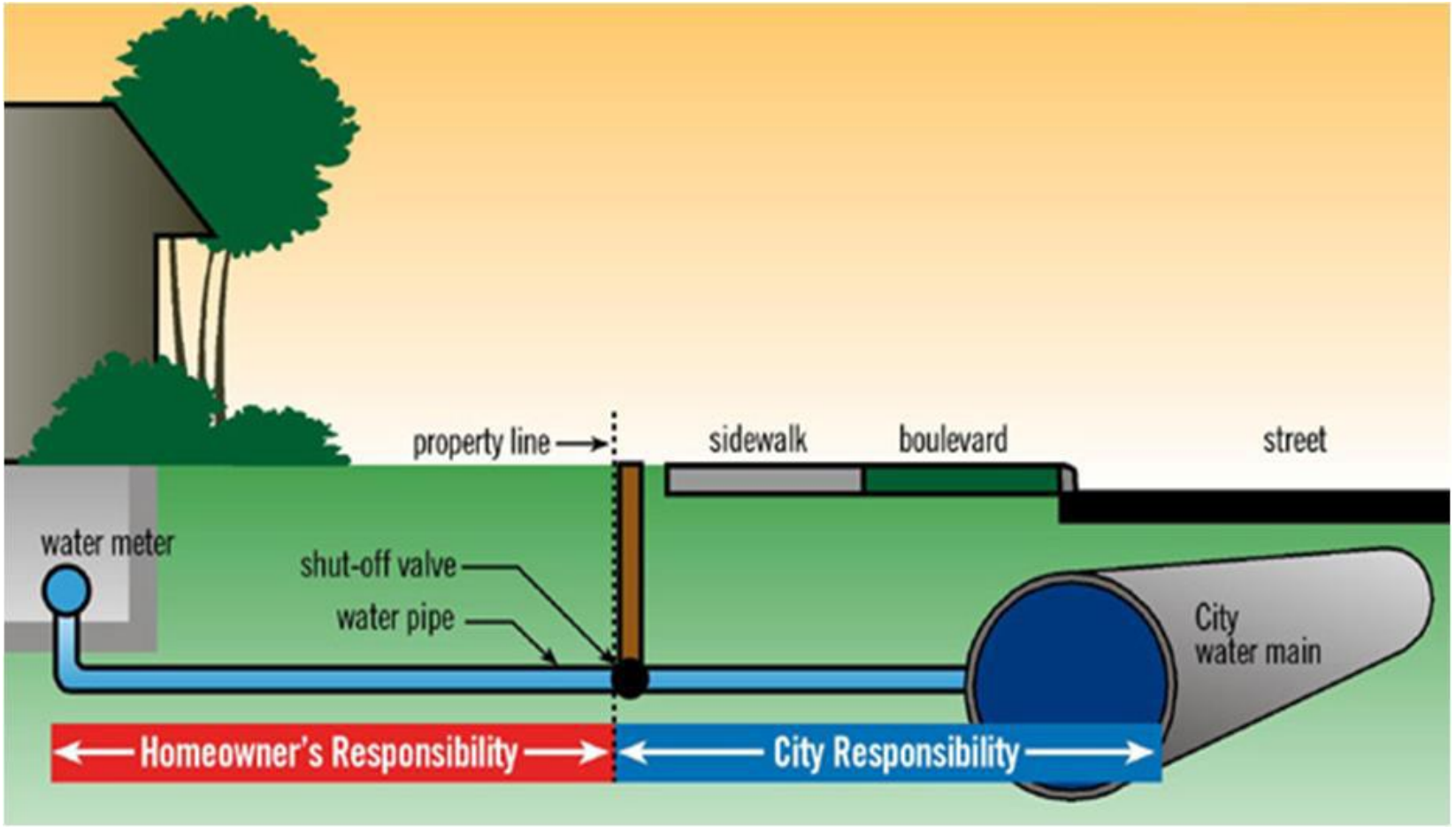
Control Option Selection	
Step 1 -	Understand water chemistry
Step 2 -	Evaluate options
Step 3 -	Implement selected option
Step 4 -	Monitor and manage performance

Control Options (cont'd)

- LSL Replacement (LSLR)
  - Partial (PLSLR) or full (FLSLR) replacement
  - Most partial; homeowners reluctant to pay for full
  - Can cause short-term increases in lead levels
  - Expected to be beneficial over time, esp. full
  - Most to date voluntary
  - Proposal to require FLSLR by 2050 (NDWAC, 2015)
  - Noteworthy examples: Madison, Wisc. (mandatory FLSLR); Saskatoon, Sask. (FLSLR mandatory if the City replaces an LSL; voluntary if no problems occur)*

* https://www.saskatoon.ca/services-residents/power-water/water-wastewater/drinking-water/lead-pipes-drinking-water

Typical LSL Ownership



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Source: http://winnipeg.ca/waterandwaste/water/pipeResponsibilities.stm

Madison's FLSLR Program

- 66,000 connections (est.)
  - Approx. 11,000 LSLs, 5,600 customer-owned
- CCT found to increase lead levels
- City ordinance: MGO Section 13.18
  - All LSLs must be replaced within 10 years; sooner for higher risk sites
  - City to reimburse customer for half their cost, up to $1,000 (average paid was $670)
- Completed by Jan. 1, 2011
- Cost ~$2,985 per FLSLR, incl. reimbursements ($15.5M total)
- 90th-percentile Pb dropped from ~16 ppb to 2.6–3.6 ppb

Please visit http://www.cityofmadison.com/water/, or review the presentation by Grande (ACE 2012) for more information.

Control Options (cont'd)

- Lining or coating LSLs
  - Options include PET linings and epoxy coatings
  - May be advantageous if replacement is difficult
- Options for consumers include:
  - Flush lines (gently) and draw water from the main
  - Install "lead-free" faucets, valves, etc.
  - Install (and maintain) filters certified for removal of the applicable forms of lead (particulate and/or dissolved)

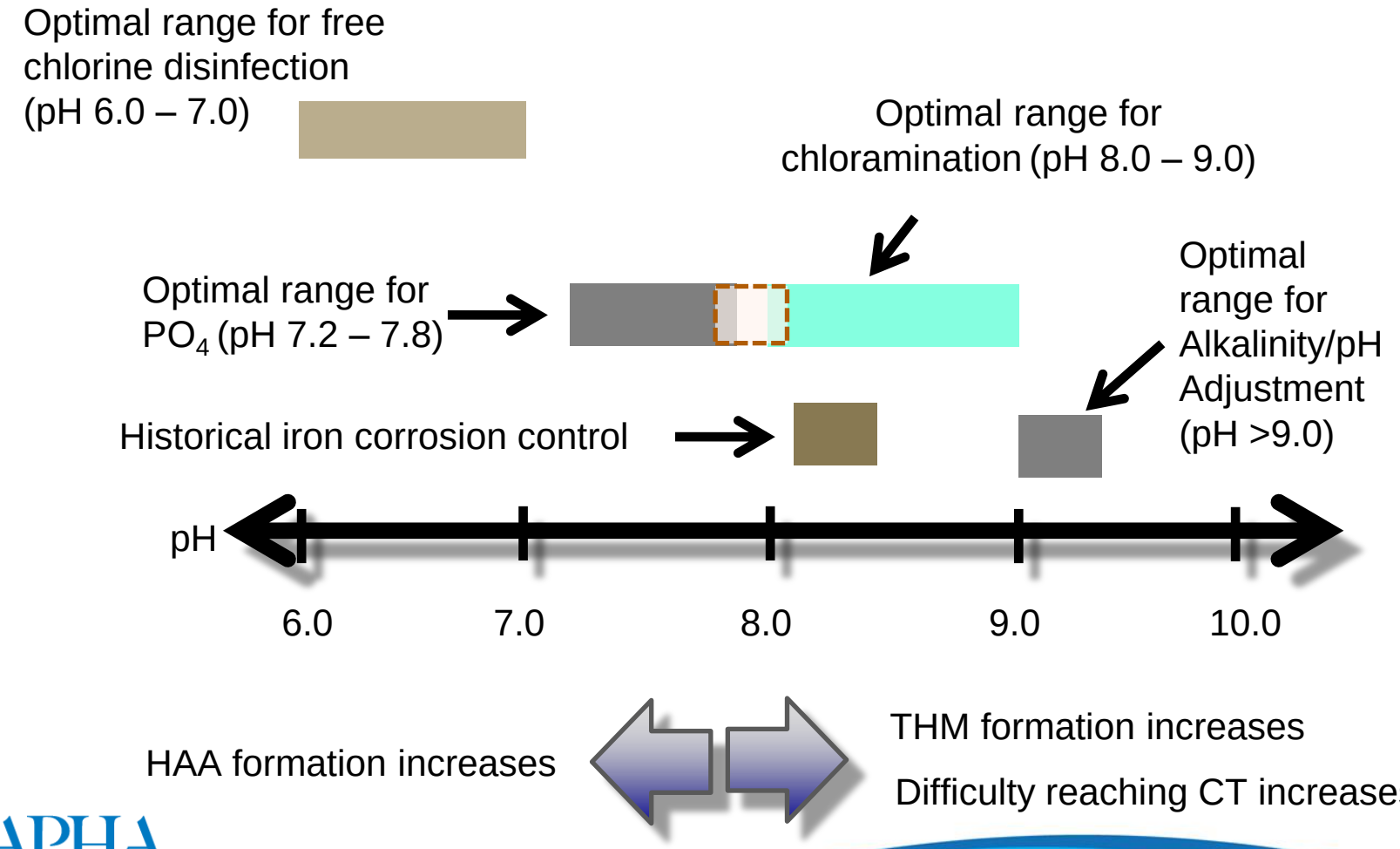
Within the Home

- Is water in the home … at particular faucets in routine use?
- Are newer lead-free faucets and other fixtures installed?
- Are faucet aerators cleaned regularly?
- Are treatment devices changing water chemistry?

Lead Control Challenges

- Understanding the chemistry
- Monitoring and data collection
- Maintaining water quality
- Regulatory uncertainty
- Public policy — private property tensions
- Communicating effectively with all of the stakeholders
- Balancing competing objectives

Balancing Competing Objectives



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Lead Control Challenges (cont'd)

- Economic, social, managerial, educational, and other challenges
- Reaching community consensus on a path forward – and deciding who will pay for it!

Summary & Concluding Remarks

- The chemistry of lead in tap water is complex, typically involving multiple sources and forms of lead, with many different factors influencing the levels present in a given sample.
- Controlling lead in tap water can be a challenging task on many different levels.

Summary & Concluding Remarks

- It is important to recognize and appreciate the complex nature of the issue, and the challenges involved, to:
  - Adequately understand the problem
  - Communicate effectively with stakeholders
  - Identify, and reach consensus on, the best option(s) for a given set of circumstances
  - Avoid unintended consequences

Summary & Concluding Remarks

- Do not hesitate to seek help – the sooner the better in most cases!

Acknowledgement

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