# Inorganics Accumulation in Distribution Systems – What are the Regulatory and Public Health Ramifications?

PNWS AWWA

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# AwwaRF 3118 – Assessment of Inorganics Accumulation in Drinking Water System Scales and Sediments

## Acknowledgements


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# Presentation Objectives

- Discuss significance of accumulation findings
  - Inventory of what might be out there
  - Potential exposure scenarios
- Describe evaluation approaches
  - Potential public health implications with regard to “MCL” violations
  - Limitations of approach
- Additional research needs

# Findings from AwwaRF 3118

# Field Sampling Approaches

| Approach | No. Samples Obtained |
| --- | --- |
| Approach 1 – Unidirectional Flushing and Pipe Specimen Extrication | 0 |
| Approach 2 – Pipe Specimen Extrication | 34 |
| Approach 3 – Bone yard Pipe Specimen | 12 |
| Approach 4 – Unidirectional Flushing | 0 |
| Approach 5 – Conventional Flushing | 26 |

Flushed Deposits Captured in Hydrant Nets

- Bulk Water collected at or near site of solid sample collection
- Point of entry historical water quality data provided by utility

# Summary of Sample Pool

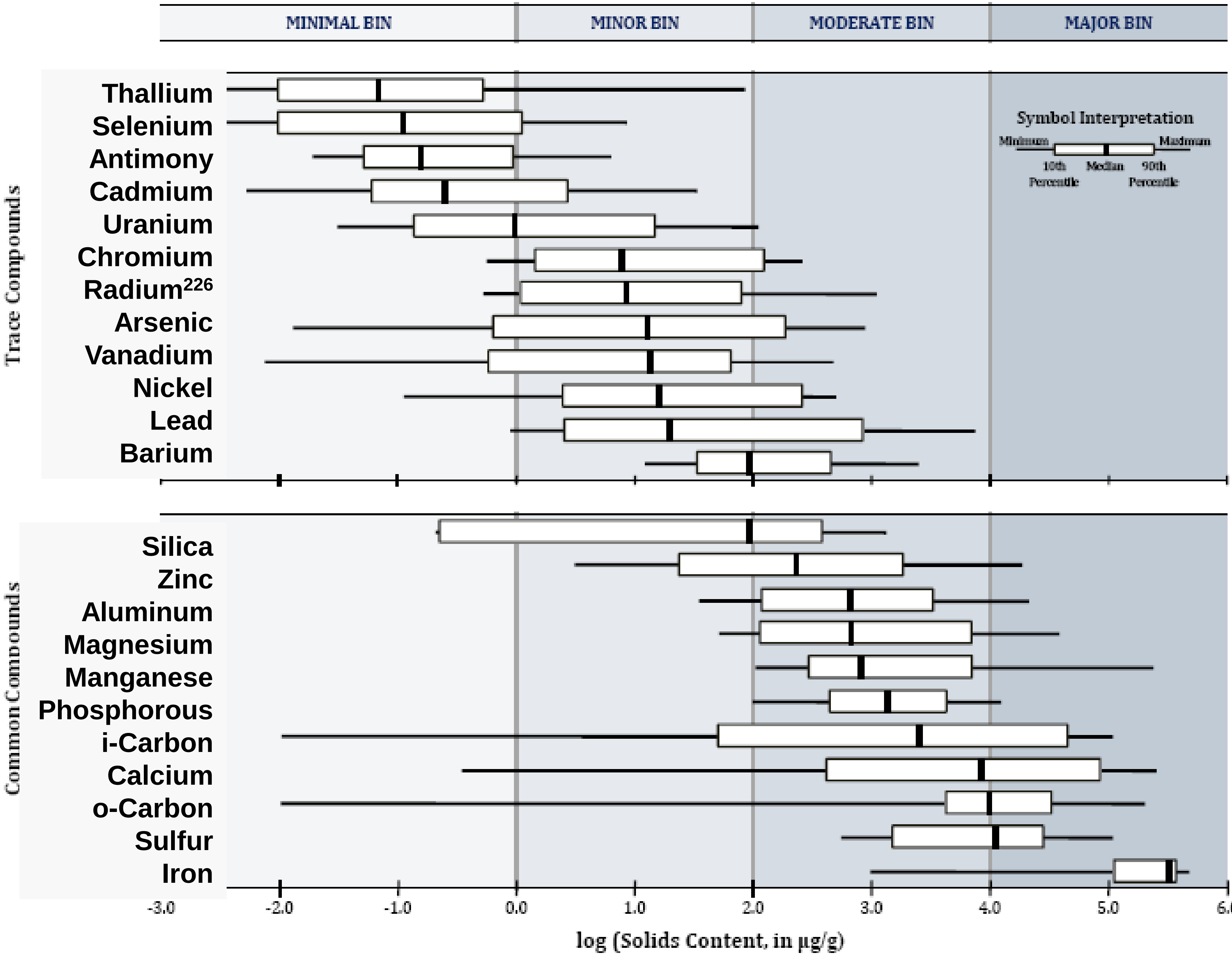
- 72 solid samples from 20 different utilities

| Pipe Material | No. Pipe Samples (% of Total) | No. Flush Samples (% of Total) |
|---|---|---|
| Unlined Cast Iron | 22 (47%) | 21 (81%) |
| Unlined Ductile Iron | 6 (13%) | 0 (0%) |
| Cement-Lined Ductile Iron | 7 (15%) | 4 (15%) |
| Galvanized Iron | 4 (9%) | 0 (0%) |
| Steel | 2 (4%) | 0 (0%) |
| Polyvinyl Chloride | 4 (9%) | 1 (4%) |
| High-Density Polyethylene | 2 (4%) | 0 (0%) |
| | 46 | 26 |

# Deposit/solids Processing

- Removal of deposit from known representative area
  - Drying at $103\ ^{o}C$
  - 300 mesh sieving
- EPA method 3050B-Acid Digestion of Sediments, Sludges, and Soils

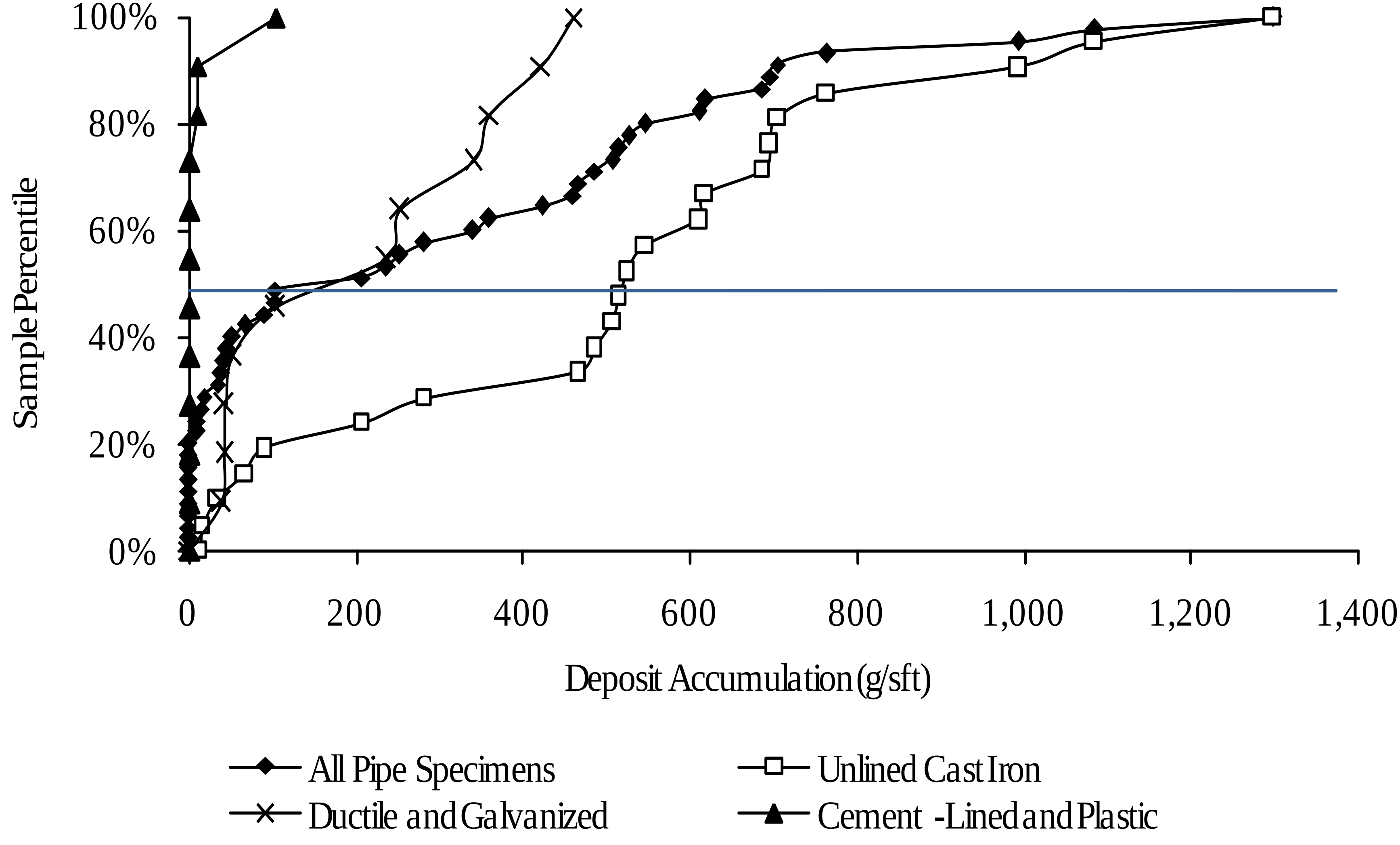

**Source: R. Valentine**


MINIMAL BIN
MINOR BIN
MODERATE BIN
MAJOR BIN
Trace Compounds
Thallium
Selenium
Antimony
Cadmium
Uranium
Chromium
Radium226
Arsenic
Vanadium
Nickel
Lead
Barium
Symbol Interpretation
Minimum
Maximum
10th Percentile
Median
90th Percentile
Common Compounds
Silica
Zinc
Aluminum
Magnesium
Manganese
Phosphorous
i-Carbon
Calcium
o-Carbon
Sulfur
Iron
-3.0
-2.0
-1.0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
log (Solids Content, in µg/g)

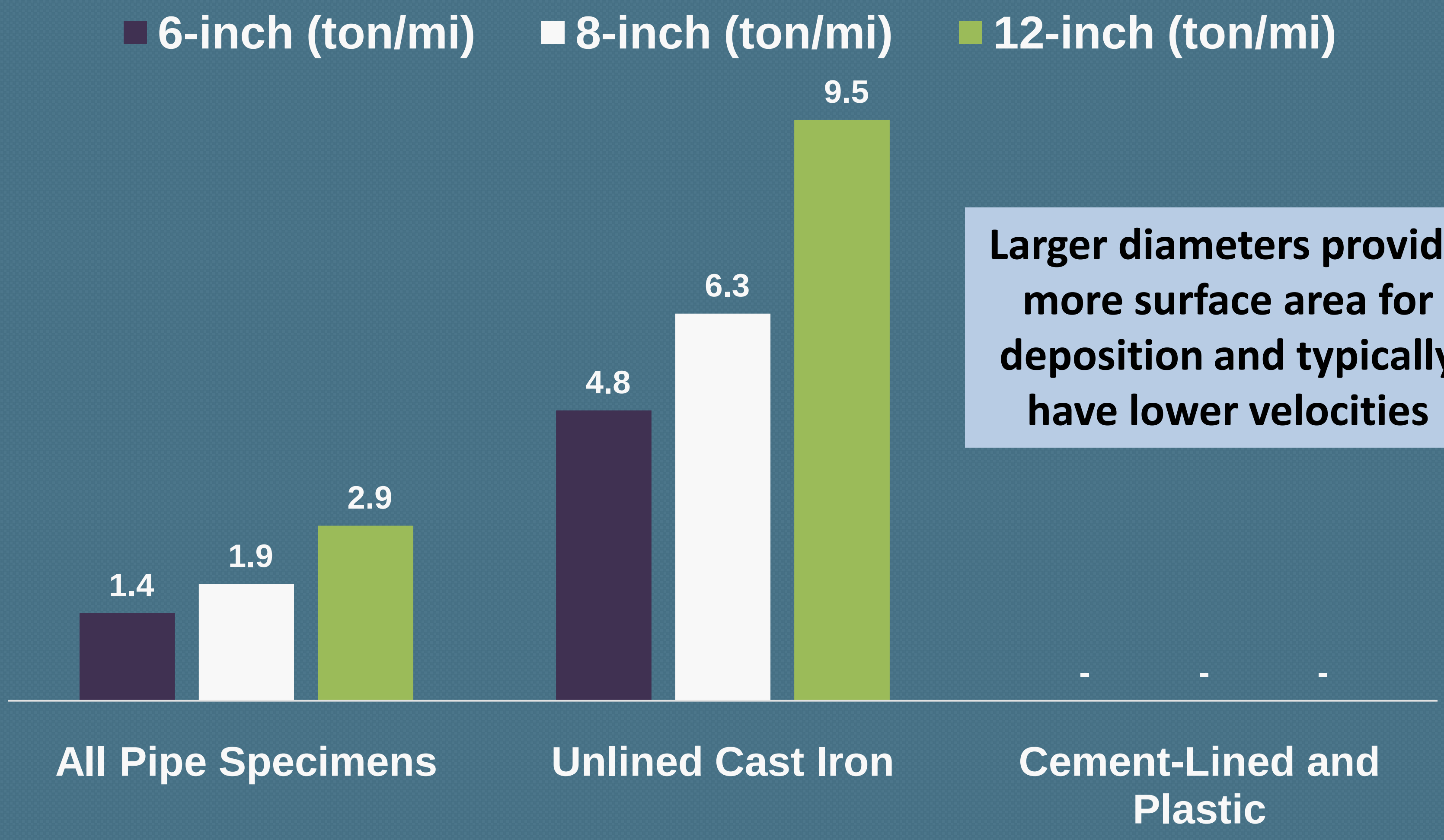
# Turning this into "meaningful" information....

- Calculate the mass of deposits per square foot of pipe
- Calculate the mass of trace compounds per foot or per mile of pipe
  - As a function of pipe type
  - Normalized by pipe diameter
- Calculate the volume of water exposed to scale
  - Normalized by pipe diameter
- Start evaluating potential concentrations as function of percent of scale released/desorbed
- Assess potential "MCL" implications for each constituent

# Surface Area-Normalize Mass as Function of Pipe Type



# Median Length-Normalized Accumulation Rates (tons per mile)



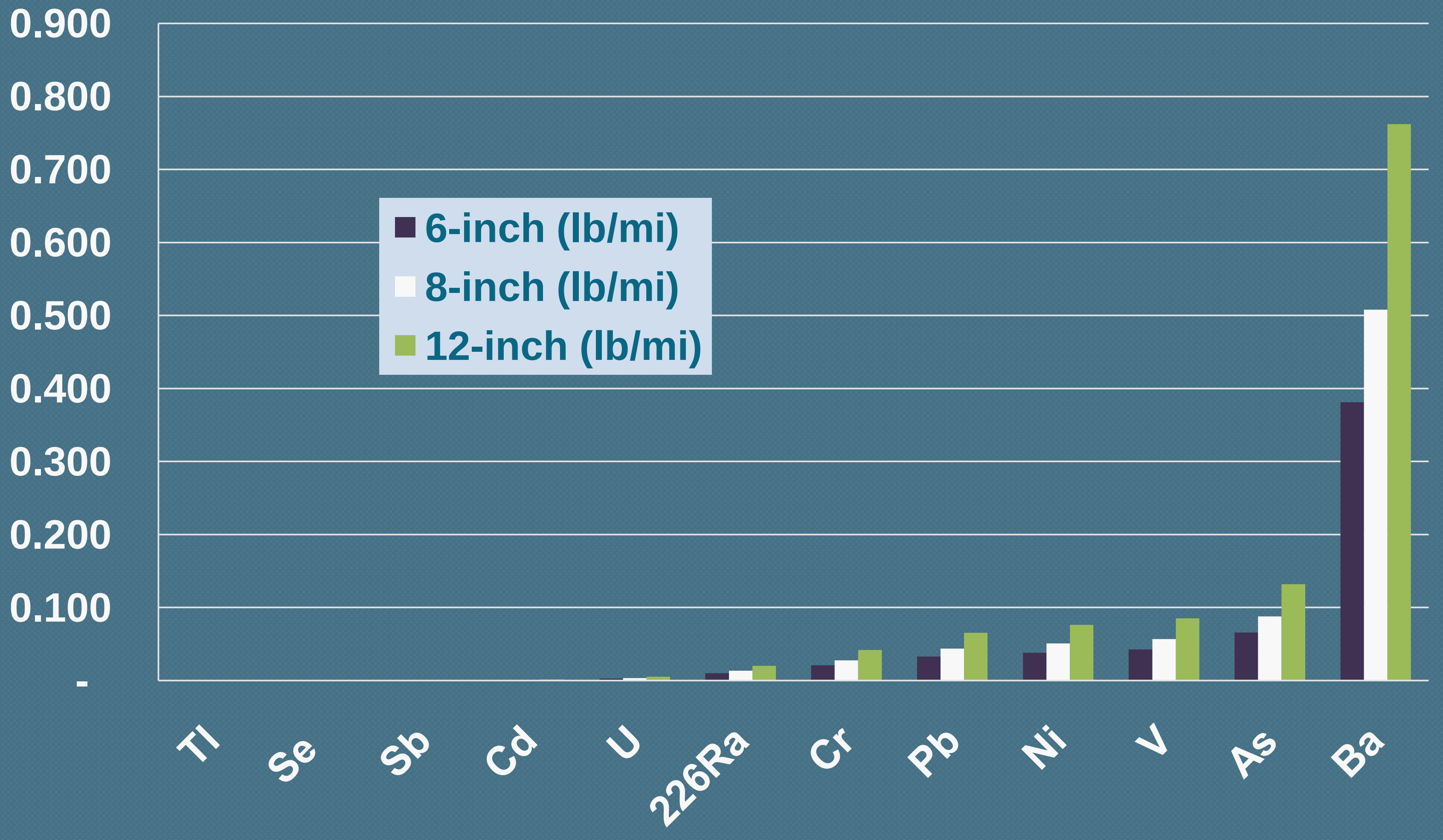

**Larger diameters provide more surface area for deposition and typically have lower velocities**

# Length-Normalized Mass for Individual Trace Compounds

- Developed by coupling accumulated deposit parameter ($m_L$ in g/ft) with the contaminant content of the sample ($C_i$, in µg/g or pCi/g)

$$m_{i,L} = m_A \pi D C_i = \mu g/ft$$

# Trace Compound Accumulation (All pipe types)



# Length-Normalized Accumulation of Trace Compounds
## (Pounds per 100 miles Pipe)

| Trace Compound | 6-inch | 8-inch | 12-inch |
|---|---|---|---|
| Tl | 0.01 | 0.02 | 0.03 |
| Se | 0.03 | 0.05 | 0.07 |
| Sb | 0.05 | 0.07 | 0.10 |
| Cd | 0.08 | 0.11 | 0.17 |
| U | 0.28 | 0.37 | 0.56 |
| $^{226}Ra$ | 1.0 | 1.4 | 2 |
| Cr | 2 | 3 | 4 |
| Pb | 3 | 4 | 7 |
| Ni | 4 | 5 | 8 |
| V | 4 | 6 | 9 |
| As | 7 | 9 | 13 |
| Ba | 38 | 51 | 76 |

# Volume-Normalized Mass and Trace Compound Accumulation

- Estimates the grams of material per liter of pipe volume
- Allows for **CONCEPTUAL** determination of compound-specific concentration “spikes” if deposit material is released into water column

$$m_{i,v} = 4m_A D^{-1} C_i = \mu g/ft^3 \text{ or } g/L$$

# Conceptual Estimate of MCL Exceedance
## (Assumes 100% of Scale Dissolved)

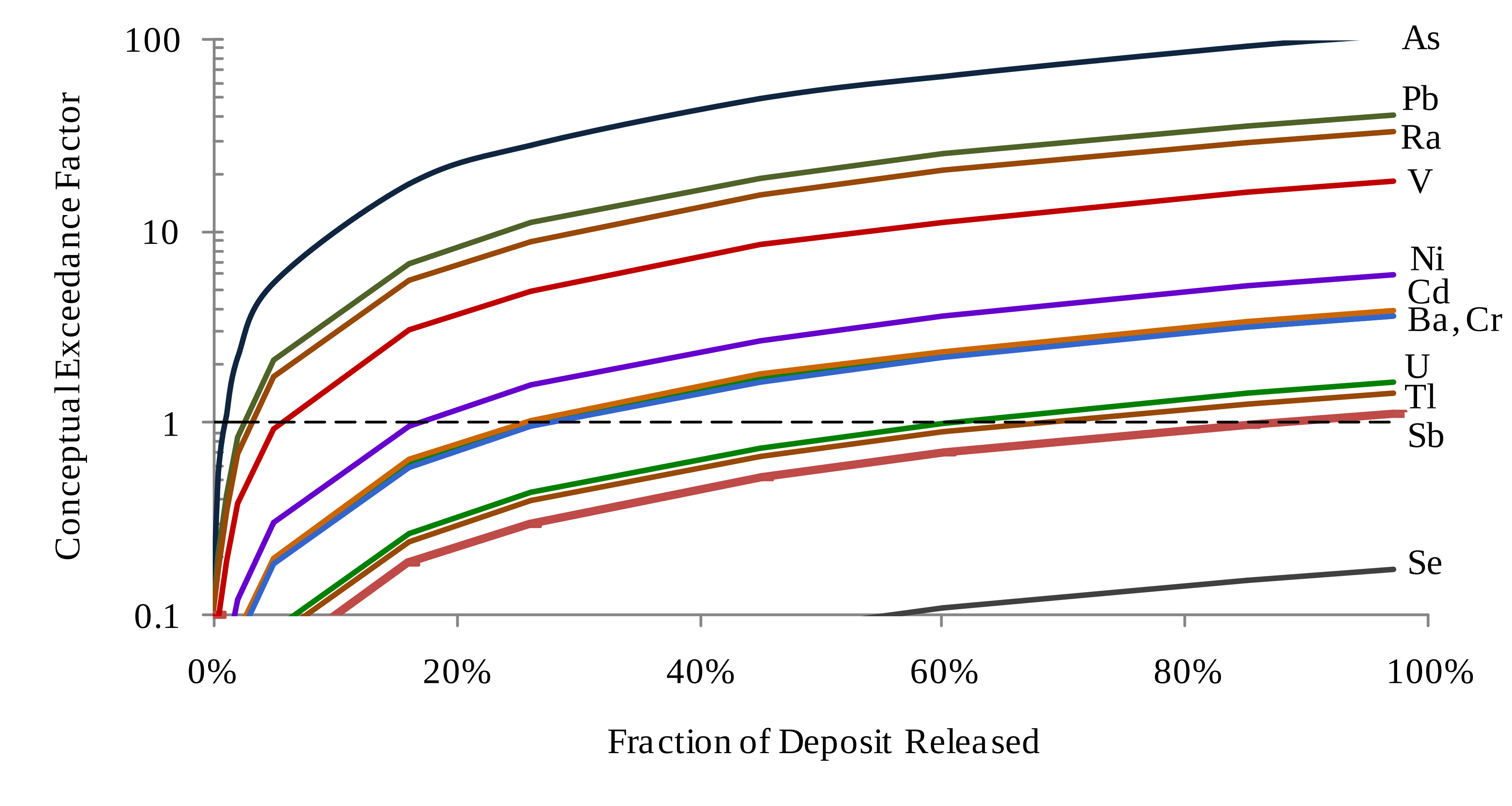
| Trace Compound | Calculated Median Volume-Normalized Accumulation |
|---|---|
| As (mg/L) | 1.1 |
| Ba (mg/L) | 7.6 |
| Cd (mg/L) | 0.02 |
| Cr (mg/L) | 0.37 |
| Ni (mg/L) | 0.61 |
| Pb (mg/L) | 0.64 |
| $^{226}$Ra (pCi/L) | 174 |
| Sb (mg/L) | 0.007 |
| Se (mg/L) | 0.009 |
| Tl (mg/L) | 0.003 |
| U (mg/L) | 0.05 |
| V (mg/L) | 0.95 |

**Assumes 100 % of scale released into solution (!!)**

# Estimate of Scale Dissolution Needed to Equal MCL/AL

| Trace Compound | % Scale Dissolution Needed to Equal MCL/AL |
|---|---|
| As (mg/L) | 0.9 |
| Ba (mg/L) | 26.3 |
| Cd (mg/L) | 25.0 |
| Cr (mg/L) | 27.0 |
| Ni (mg/L) | 16.4 |
| Pb (mg/L) | 2.3 |
| $^{226}$Ra (pCi/L) | 2.9 |
| Sb (mg/L) | 85.7 |
| Se (mg/L) | 555.6 |
| Tl (mg/L) | 66.7 |
| U (mg/L) | 60.0 |
| V (mg/L) | 5.3 |

# Summary of Conceptual Exceedance Factors

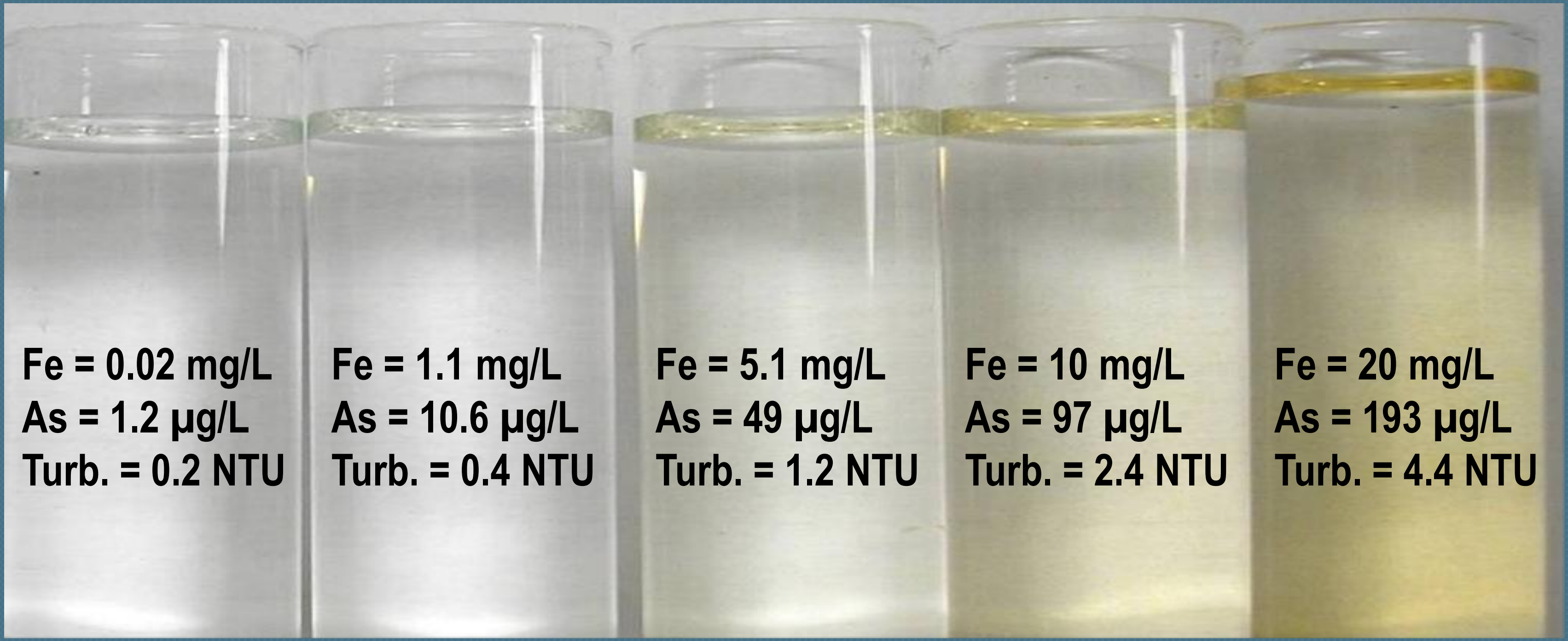


# Comparison of Median Occurrence Levels by Sample Type

| Trace Element | More Concentrated in Pipe Deposits | More Concentrated in Flush Deposits |
|---|---|---|
| Uranium | * | |
| Thallium | ** | |
| Cadmium | *** | |
| Arsenic | **** | |
| Selenium | **** | |
| Vanadium | **** | |
| Antimony | | * |
| Barium | | * |
| Chromium | | ** |
| Nickel | | *** |
| Lead | | **** |
| Radium-226 | | **** |

| | | | |
|---|---|---|---|
| * | ≤ 50% difference | *** | 101-200% difference |
| ** | 50–100% difference | **** | > 200% difference |

# Tap Water Discoloration Due to Solids Mobilization




Can't always rely on the "chunky water" argument!
Can exceed an "MCL" prior to major discoloration

# Further Consideration of the "MCL" Paradigm

**Is it valid to compare our findings to the MCL paradigm?**

**What are some of the limitations?**

There are issues all over the place!!

Some tend to overestimate or underestimate potential risk

But it is a start.....

| Issue | Considerations | Tend to Overestimate or Underestimate Risk? |
|---|---|---|
| Structure of IOC MCL in SDWA | -Assumes chronic exposure,<br>-Assumes in=out | **Underestimates**<br>Chronic to acute exposure |
| | | |
| | | |
| | | |
| | | |
| | | |

# Proactive Steps to Take for Your Systems

- Install and/or optimize treatment
  - Provide stable finished water
  - Assess/address water quality during blending
  - Get the iron, manganese, and other solids out
    - Fe $\leq$ 0.05 mg/L
    - Mn $\leq$ 0.01 mg/L
  - Avoid sidestream treatment for primary IOCs
- Implement and/or Optimize Flushing
  - UDF only – no more conventional flushing!!
  - Identify UDF frequency & termination metrics
  - UDF is not a “cure-all” – will only remove loose materials
  - Pigging may be more effective
- Remove or rehabilitate mains with high degree of accumulation

# Future Research Needs

- Further inventory of what is out there
- Further assessment of potential for acute and/or chronic health risks due to inorganics release
  - If desorption/dissolution, then may not be visible
- Factors most significant to inorganics *release* and actual concentrations that can be reached
  - Chemical and physical
- USEPA is beginning to take a closer look at this issue as part of the Revised TCR/Distribution System Rule process.  Research and information needs are currently being assessed.

# Questions?

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