

Arsenic and other Trace Contaminants

(effects of silica, pH and other interferences)

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Trace Contaminants (common features)

- Present at much less than 1% of the total ions concentration in the feed
- Strongly preferred by media compared to other species
- Result is very long bed life
- **Under these conditions the other contaminants in the water determine bed life, the concentration of the trace contaminant is relatively unimportant!**

Trace Contaminants (and their primary interferences)

- Arsenic
 - Silica
 - pH
- Uranium
 - Sulfate
 - TDS
- Radium
 - Calcium

Why trace contaminants get removed (even if they are not preferred)

- Resin TDS is much higher than water
 - Cation resin approx 100,000 ppm TDS
 - Anion resin approx 60,000 ppm TDS
- Resin does not contain the trace contaminant when new
- Even if trace contaminant is not the most preferred species it will still concentrate according to the ratio of the TDS
- For example if TDS is 100 ppm a cation will concentrate a contaminant by $100,000/100 = 1000$ times, even if that contaminant is not preferred

Arsenic Removal Options

- **Coagulation and Filtration**
 - Best for large municipal systems
- **Reverse Osmosis**
 - Best when water has high TDS
- **Arsenic Adsorption Medias**
 - Iron based granular adsorbents
 - Iron based ion exchange resin hybrids
 - Titanium and other metal oxides
- **Biological Treatments (too exotic for most?)**

Advantages of Iron based resin hybrids

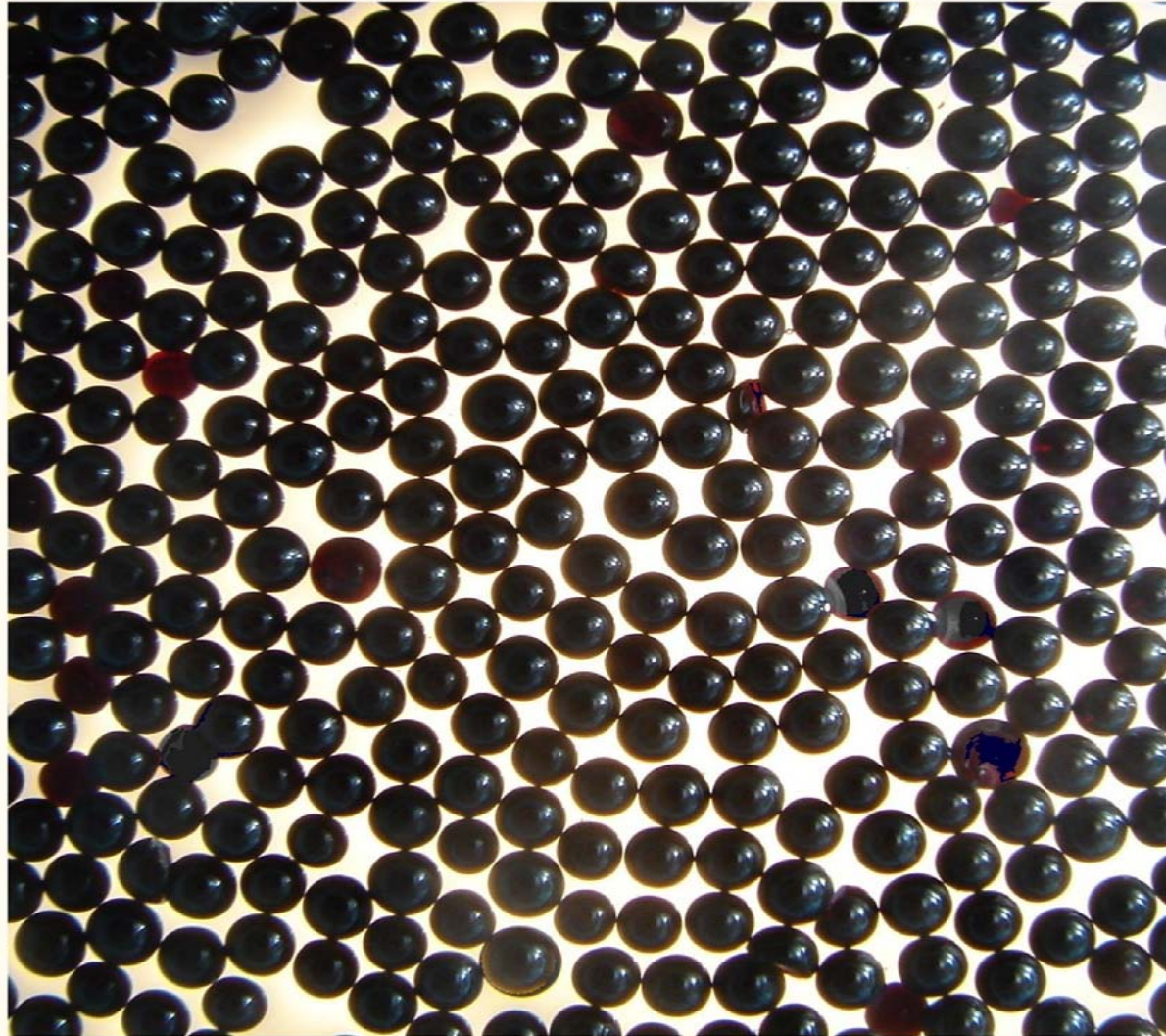
- Clean and easy to use
- Can operate at high volume flow rates
 - Less than 1 minute EBCT
- High void space, resistant to physical plugging
- Exchange and regeneration programs available
- Can exchange for other contaminants

Disadvantages of iron based resin hybrids

- Less iron content, therefore lower capacity than granular medias that are pure iron oxide
- Susceptible to organic fouling.
- More susceptible to bio fouling?
- Can exchange for other contaminants

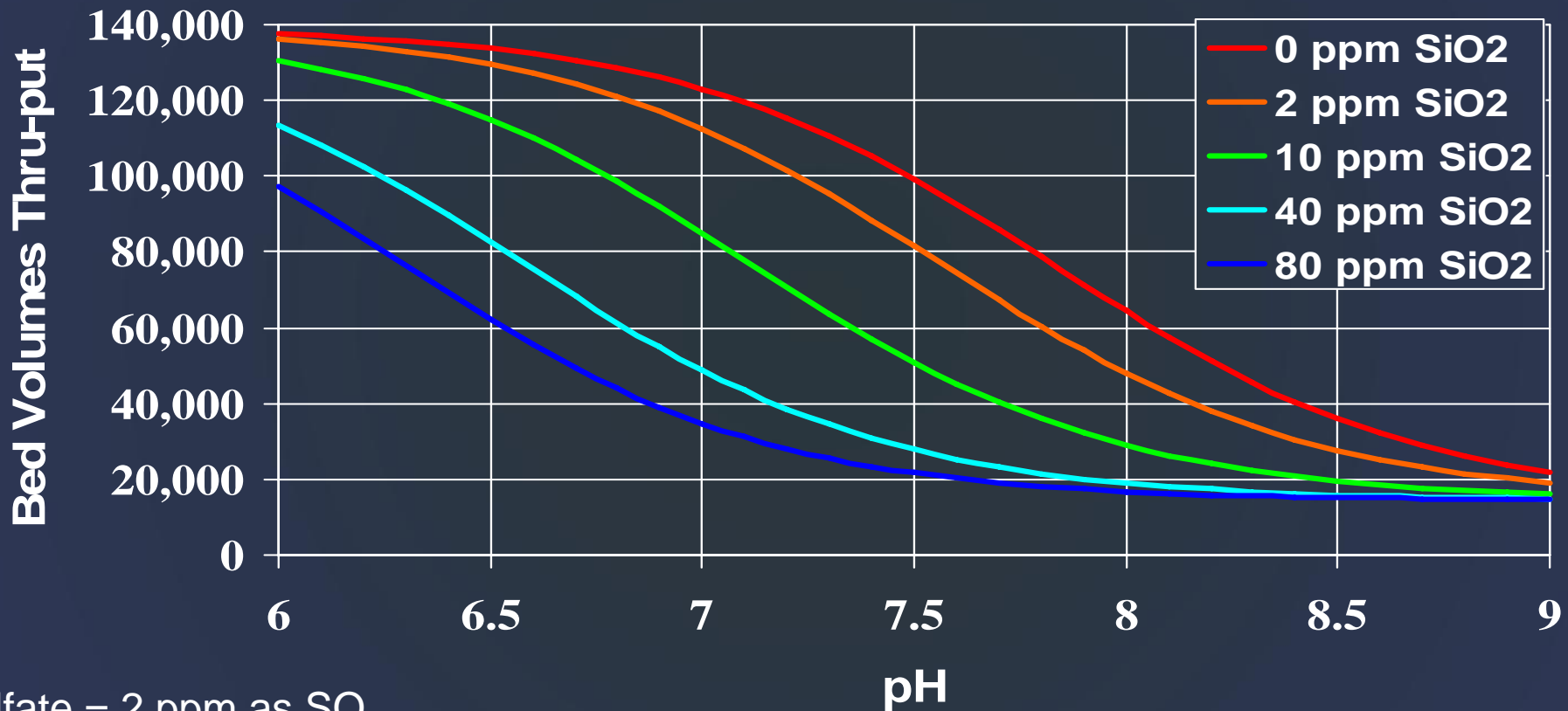
ASM-10 HP

(microscope photo)



ASM-10 HP

Effect of pH and Silica



Sulfate = 2 ppm as SO₄

Arsenic = 50 ppb as As⁺⁵

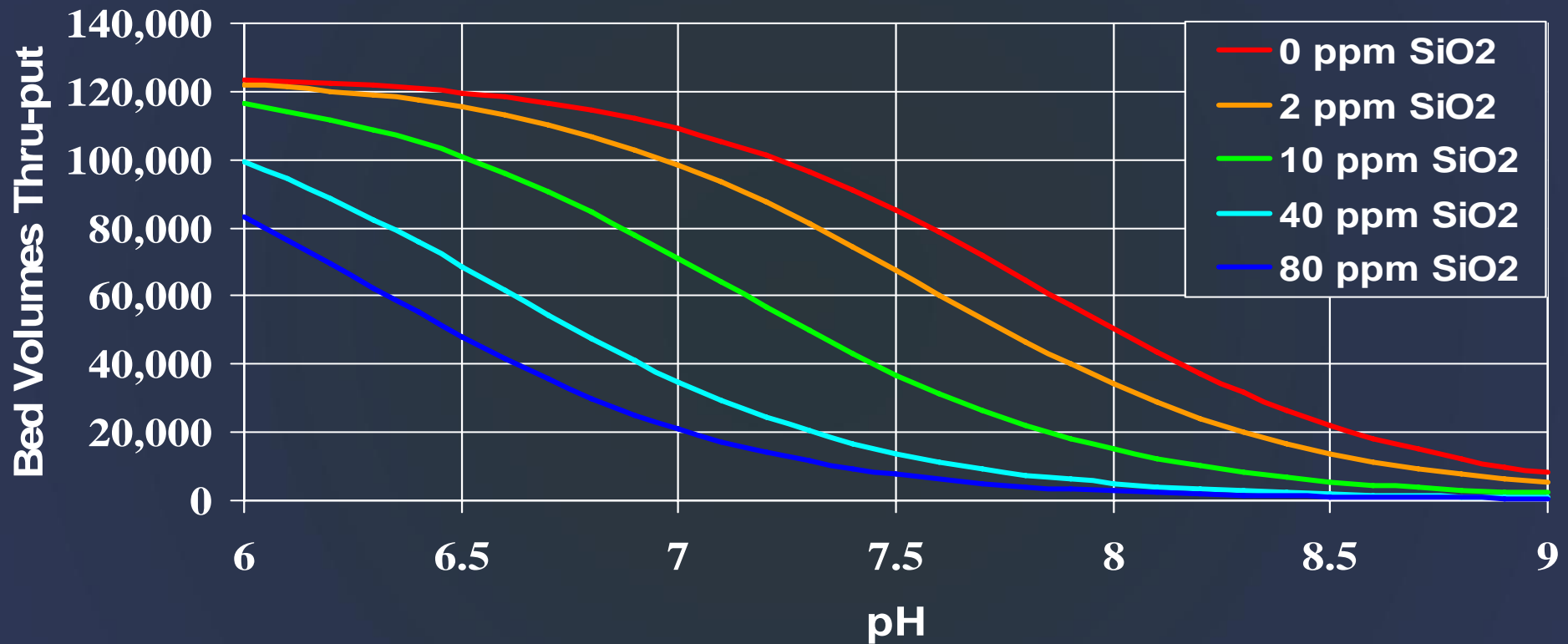
Nitrate = 2 ppm as NO₃

Chloride = 64 ppm as Cl

Bicarbonate = 50 ppm as HCO₃

ASM-10 HP

Effect of pH and Silica



Sulfate = 200 ppm as SO₄

Arsenic = 50 ppb as As⁺⁵

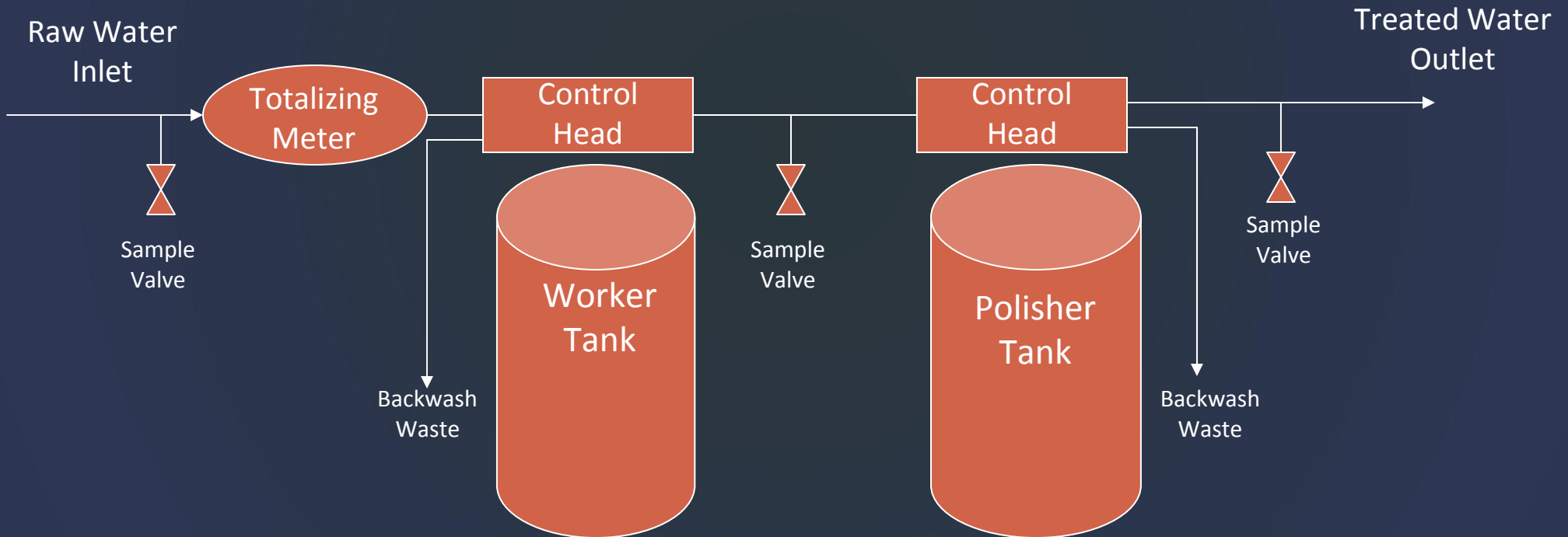
Nitrate = 2 ppm as NO₃

Chloride = 64 ppm as Cl

Bicarbonate = 50 ppm as HCO₃

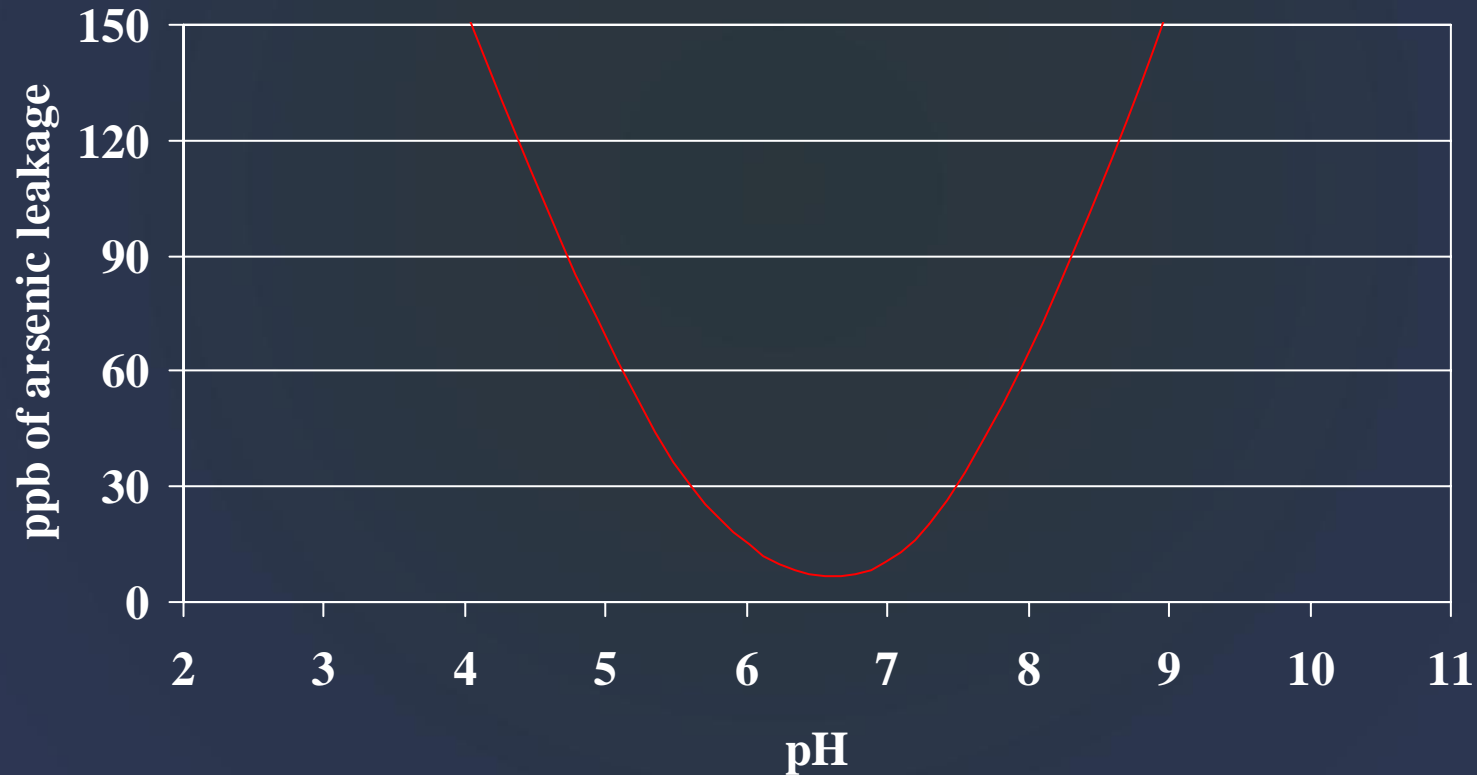
ASM-10 HP

Suggested System Components



Stability of exhausted ASM-10 HP

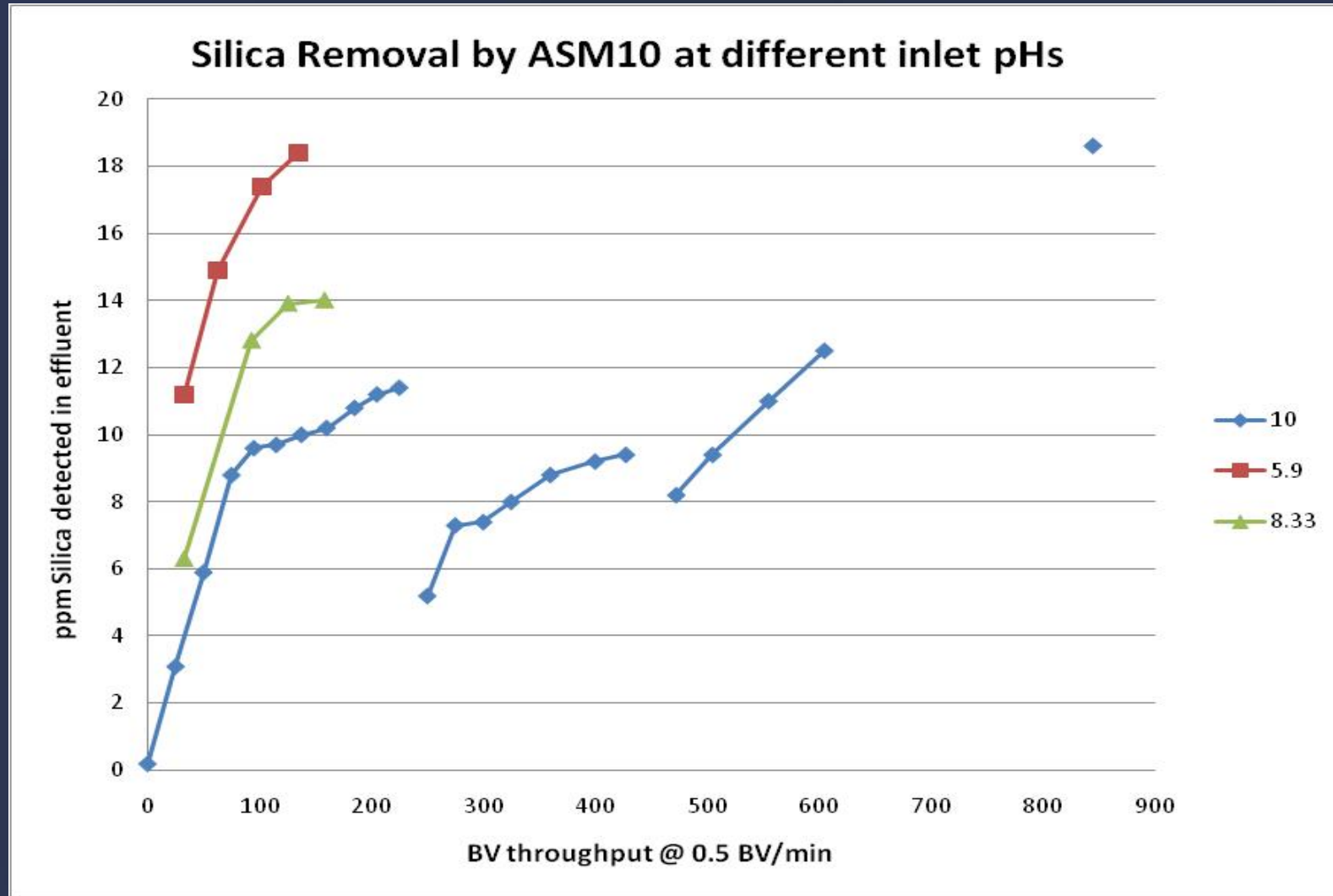
ASM-10 HP fully loaded with arsenic in equilibrium at various pH



ASM-10 HP Arsenic leakage

125 ppb As⁺³ at various inlet pH





Inlet approx 100 ppm sodium sulfate and 100 ppm calcium chloride plus 30 ppm silica and enough additional alkalinity or HCl to adjust pH

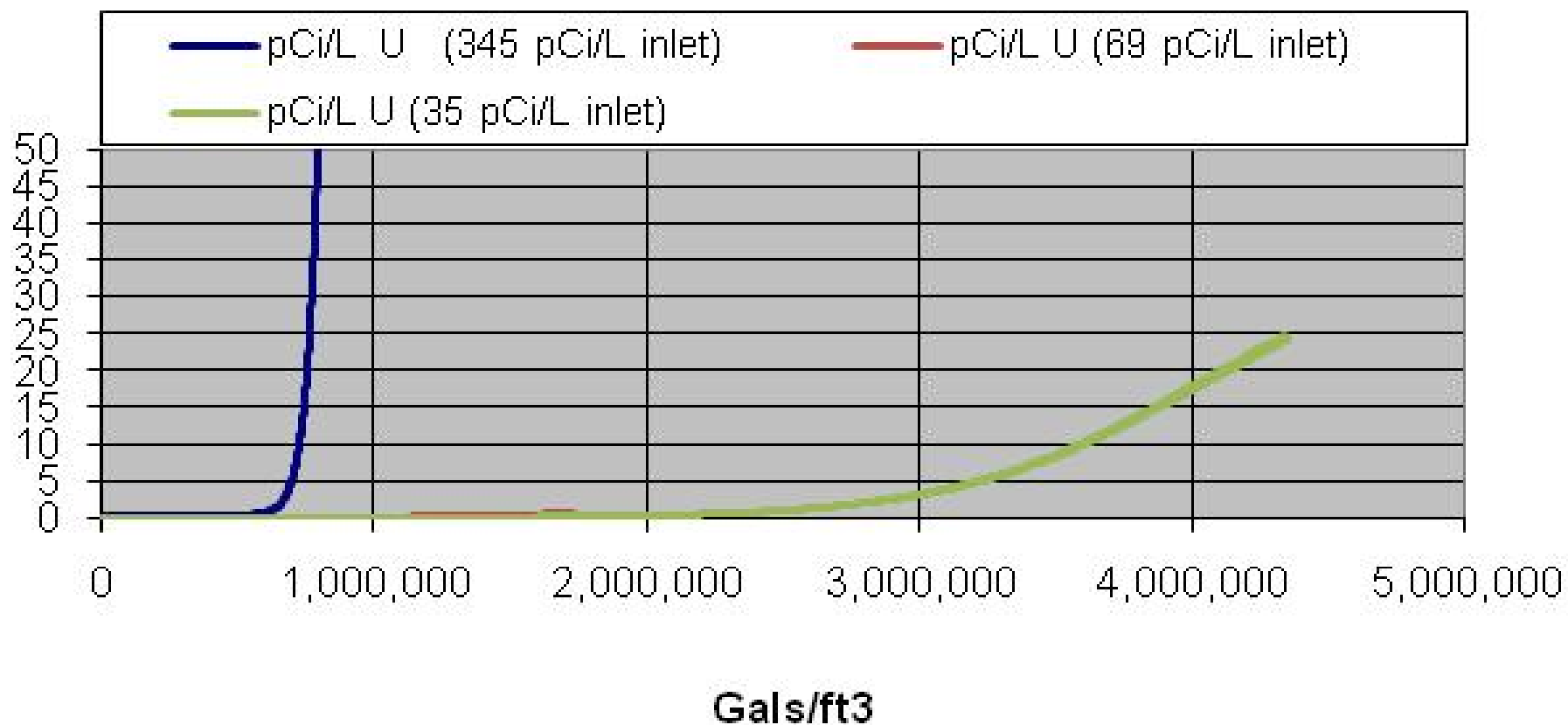
Uranium removal Options

- Ion exchange is by far the best available technology
- Any Strongly basic anion resin will work
 - Type II anion resins preferred by some due to lower taste and odor issues and greater resistance to organic fouling

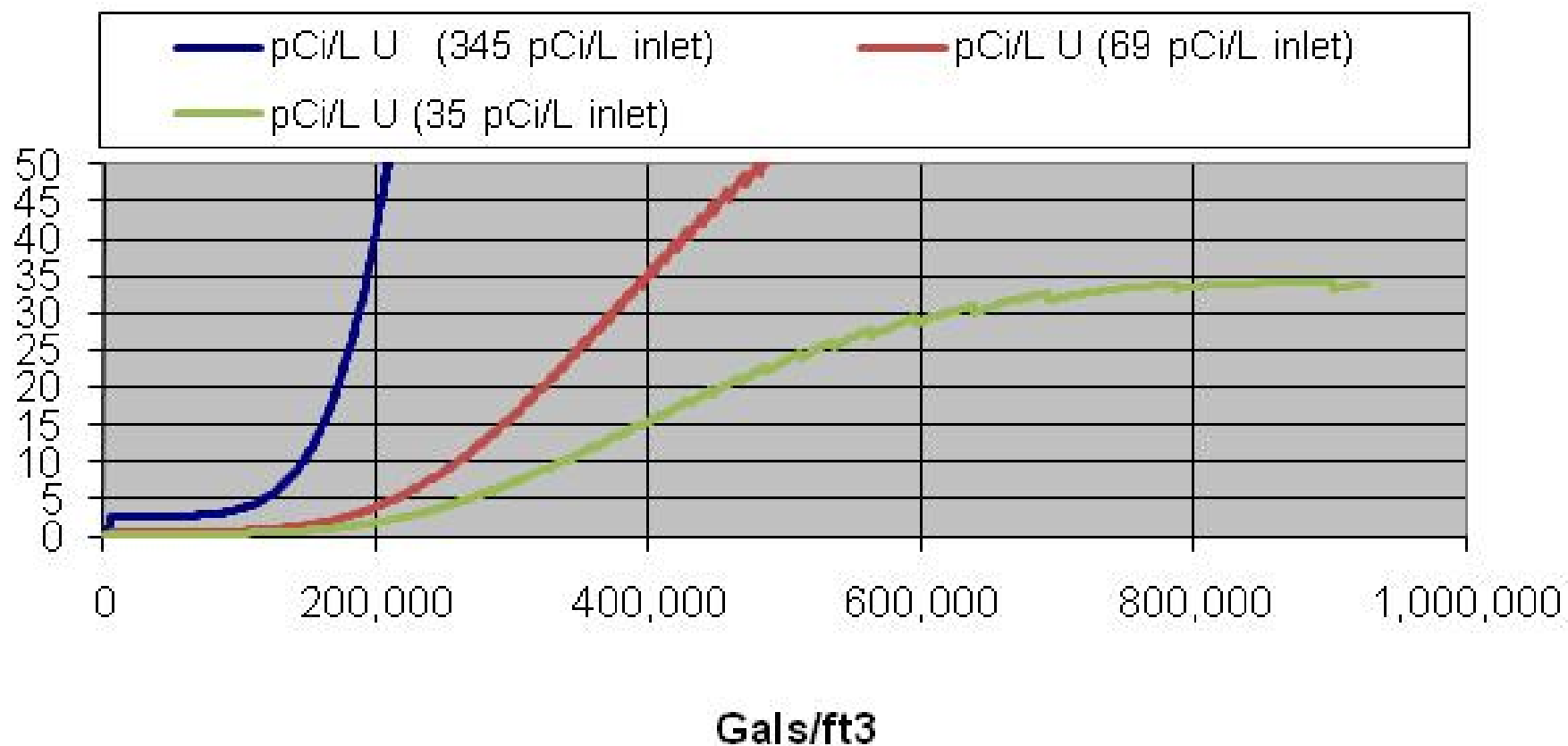
Uranium Removal Interferences and competition

- Sulfate and TDS are the main competitors
 - As TDS goes up, anion resin loses it's preference for uranium
 - This is both an advantage and a disadvantage, it makes the service cycle shorter but regeneration is much easier
- Other anionic species are much less important
 - However, because regeneration is infrequent contaminants such as suspended solids, iron, organics etc are problematic.

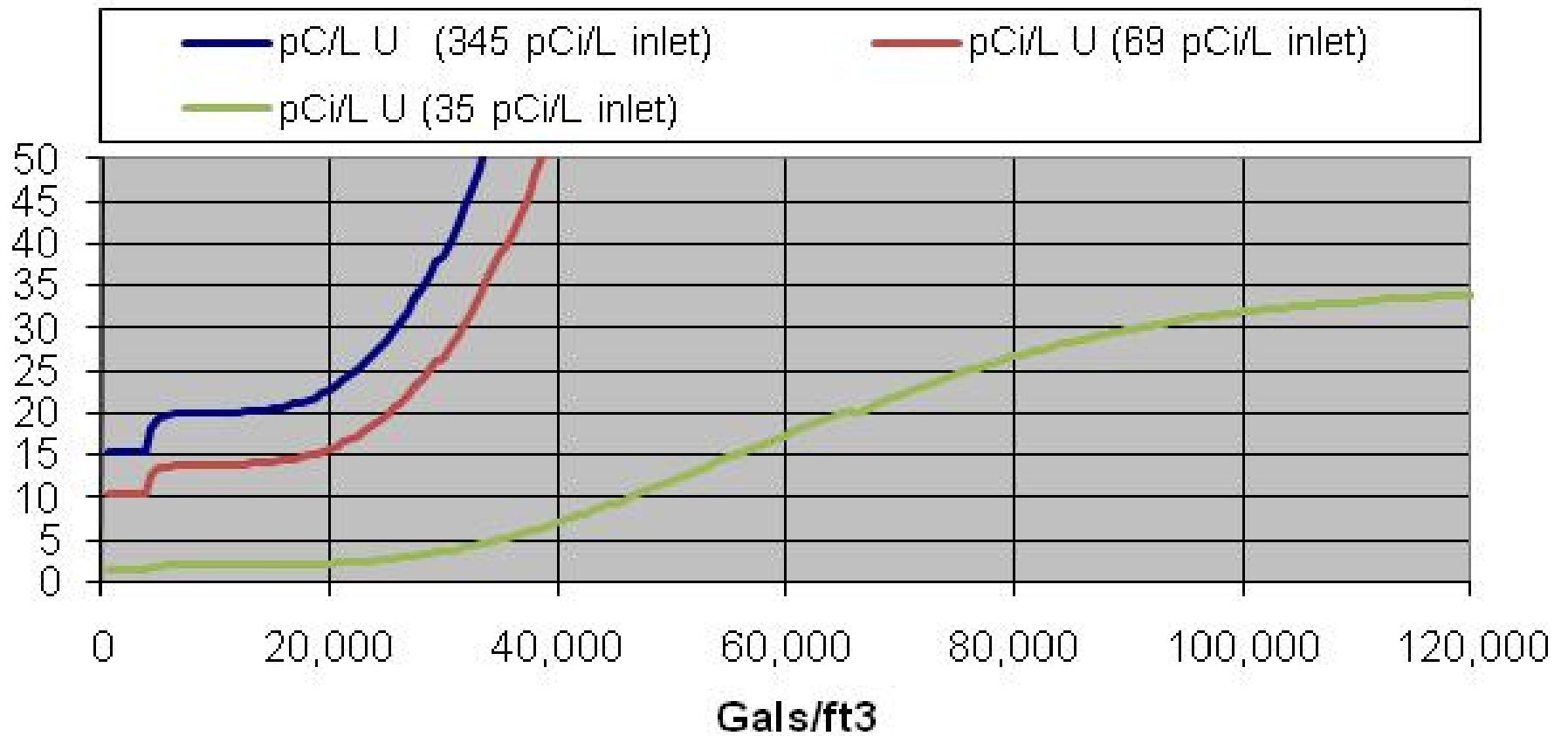
Uranium Removal by Strong Base Anion Resin Very Low TDS Single use 50 ppm Cl and 50 ppm SO4



Uranium Removal By Strong Base Anion resin Medium TDS Single use 200 ppm Cl and 200 ppm SO4



Uranium Removal by Strong Base Anion resin Very high TDS Single use 500 ppm Cl and 500 ppm SO4



Drawbacks to using Strong Base Anion resin for uranium removal

- Promises of bed life in excess of a million gallons per cu ft are greatly exaggerated, the resin is almost certain to foul out before it is exhausted
- Although the resin does not become as “hot” as the radium removal resins do, disposal is still problematic and many landfills refuses to consider resin with uranium in it

Radium Removal Options

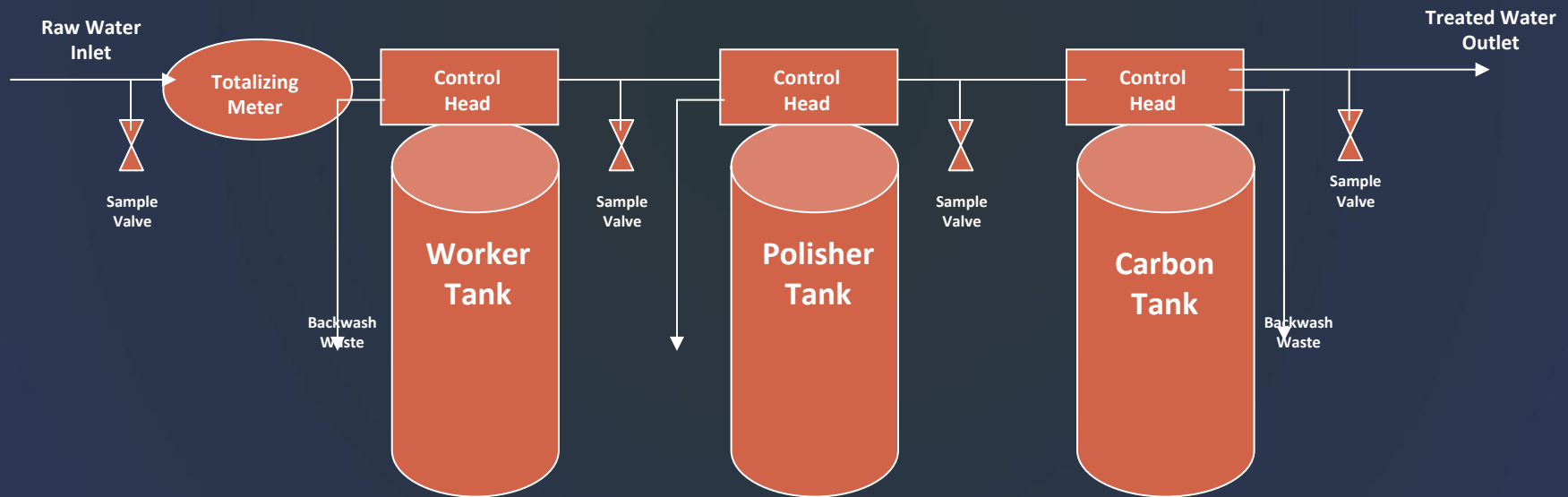
- **Sodium form Strong acid cation resin**
 - Works by straight ion exchange (resin is highly selective for radium over sodium)
 - The more highly crosslinked the better for single use applications
- **Radium Complexer cation resin**
 - Works by a combination of ion exchange and adsorption
 - Contains barium sulfate precipitated inside the polymer
 - Radium replaces barium according to the rules of the least soluble precipitant

Radium Removal

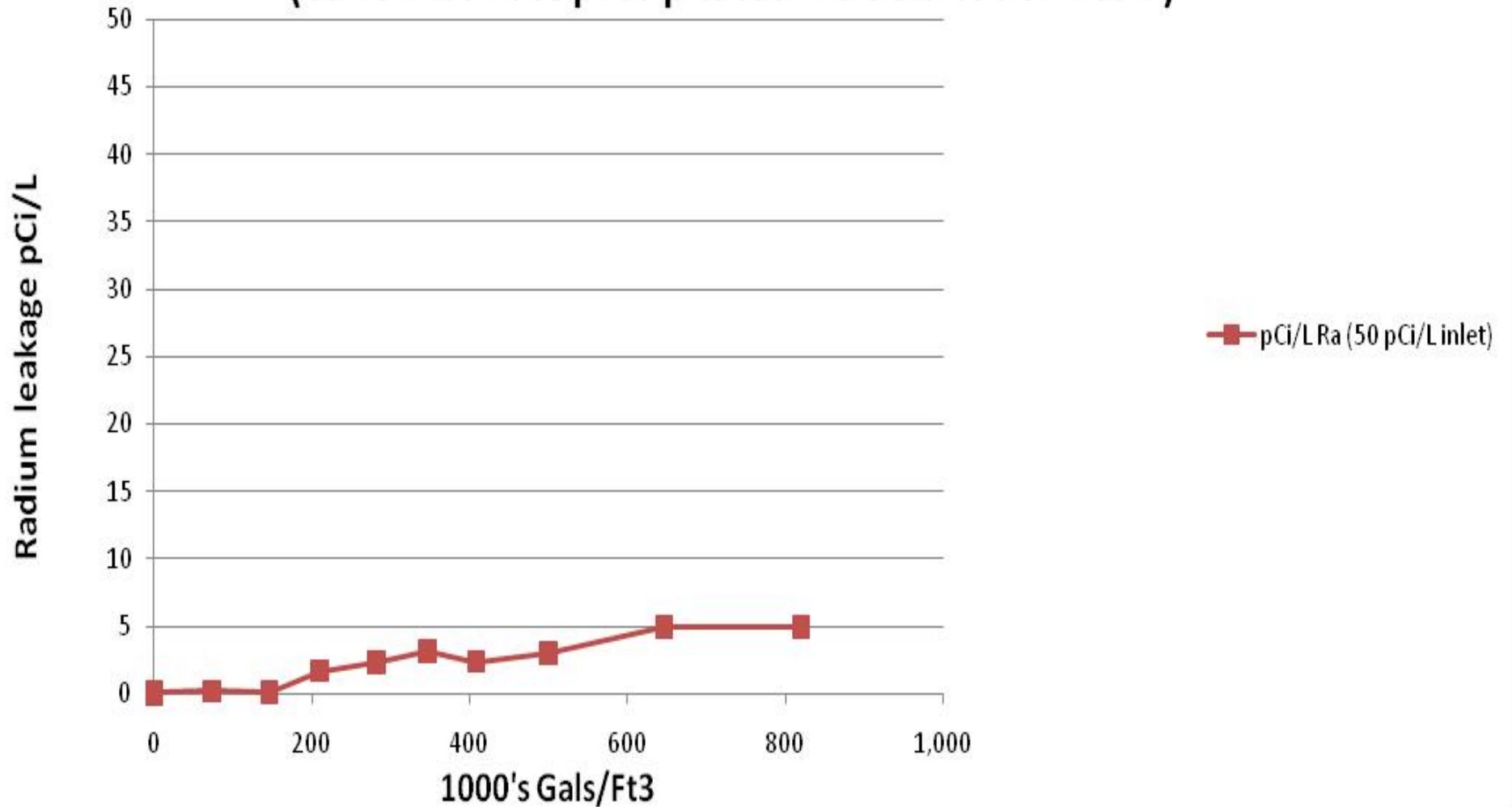
Interferences and competition

- Barium (if present in soluble form) is very significant. However, barium sulfate is so insoluble this is seldom an issue
- Iron is not a strong competitor but is well known to foul ion exchange resins over time
- Calcium is a strong competitor for straight ion exchange systems but fairly unimportant to the radium complexer
- High TDS limits thruput in all cases

Radium Removal Suggested System Components (worker/polisher system)

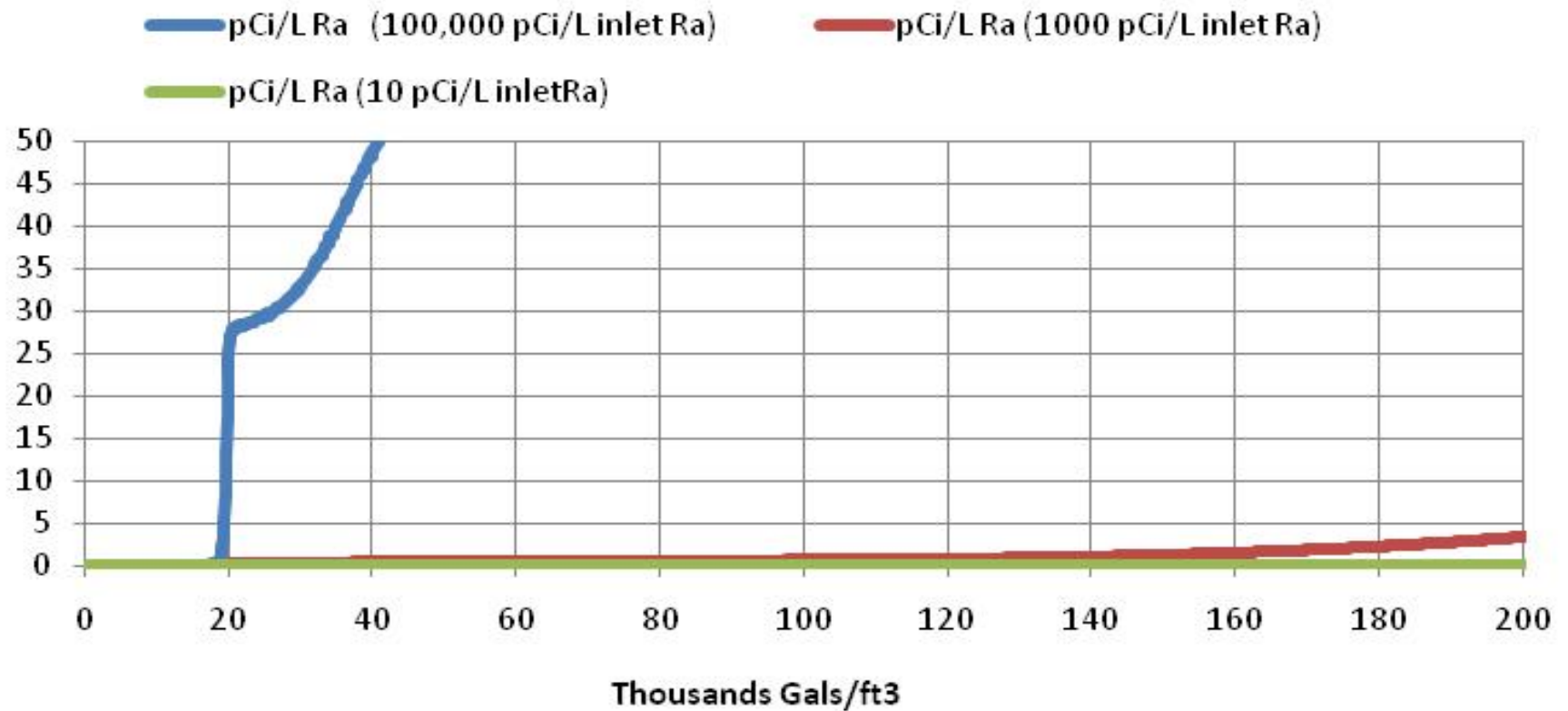


Radium Complexer resin (barium sulfate precipitated inside a cation resin)



Inlet Calcium approx 100 ppm as Ca

Radium removal macroporous strong acid cation resin Single use 10 ppm calcium as Ca in the influent

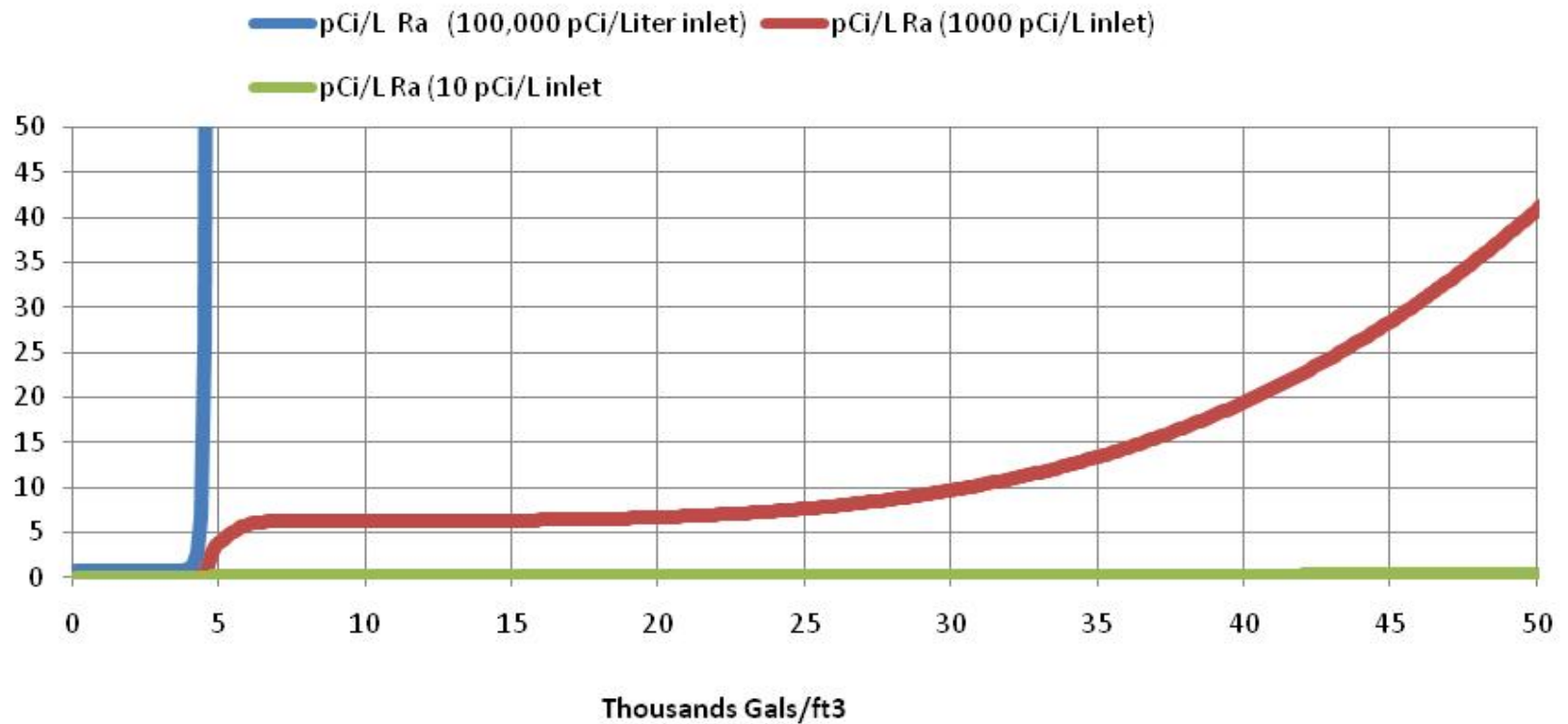


Inlet approx 25 ppm Sodium as Na plus 5 ppm Magnesium as Mg plus 10 ppm Calcium as Ca

Radium removal

Macroporous strong acid cation resin

Single use 100 ppm Ca as Ca in influent



Inlet approx 25 ppm Sodium as Na plus 5 ppm Magnesium as Mg plus 100 ppm Calcium as Ca

Drawbacks to Radium Removal Systems

- Radium builds up on resin, even if resin is regenerated as a softener
 - No guarantee it will stay non hazardous over time
- Radium decays into radon
- Gross alpha goes up over time due to radon
- Better to use low crosslinked resin for systems that regenerate
- Complexer resin can become hot enough to require shielding?
- Some barium can come off the complexer?

Why is it going to Fail?

- Long Life resins and medias are prone to failing before their promised capacity has been reached
 - Suspended solids cause bed plugging and channeling. Backwashing causes increased leakage by moving some of the depleted media from the top of the bed down toward the bottom
 - Bio organisms coat the media and prevent the capture of the targeted contaminant (and that's the good news)

Why's it going to Fail?

- Other trace contaminants may also be removed, eventually reaching a concentration where they cause problems
- And of course all those other reasons
 - Crappy equipment
 - Lousy resin
 - Poor installation
 - Wrong type of equipment
 - Failure by customer to operate properly

General observations about Fouling

■ The plastic bag effect

- Any foulant that coats the resin beads is going to act like a plastic bag and will block the exchange of ions. This will increase leakage and make the resin flow sensitive (OK at low flow, progressively worse as flow increases). It may or may not decrease thru-put.

■ The sponge effect

- Any foulant that collects and surrounds the resin beads is going to act like a sponge and cause long rinses after regeneration. This may or may not cause channeling and high pressure loss. The sponge is a wonderful place for bio-organisms to grow.

A photograph of a sunset over a body of water. The sky is filled with soft, colorful clouds in shades of orange, pink, and purple. The sun is low on the horizon, creating a bright glow. The water in the foreground is calm, reflecting the colors of the sky. In the background, there is a dark silhouette of a forest. The word "Questions?" is written in a large, bold, yellow font across the middle of the image.

Questions?