# Chromium 6 Treatment Options




Presentation at WESTCAS

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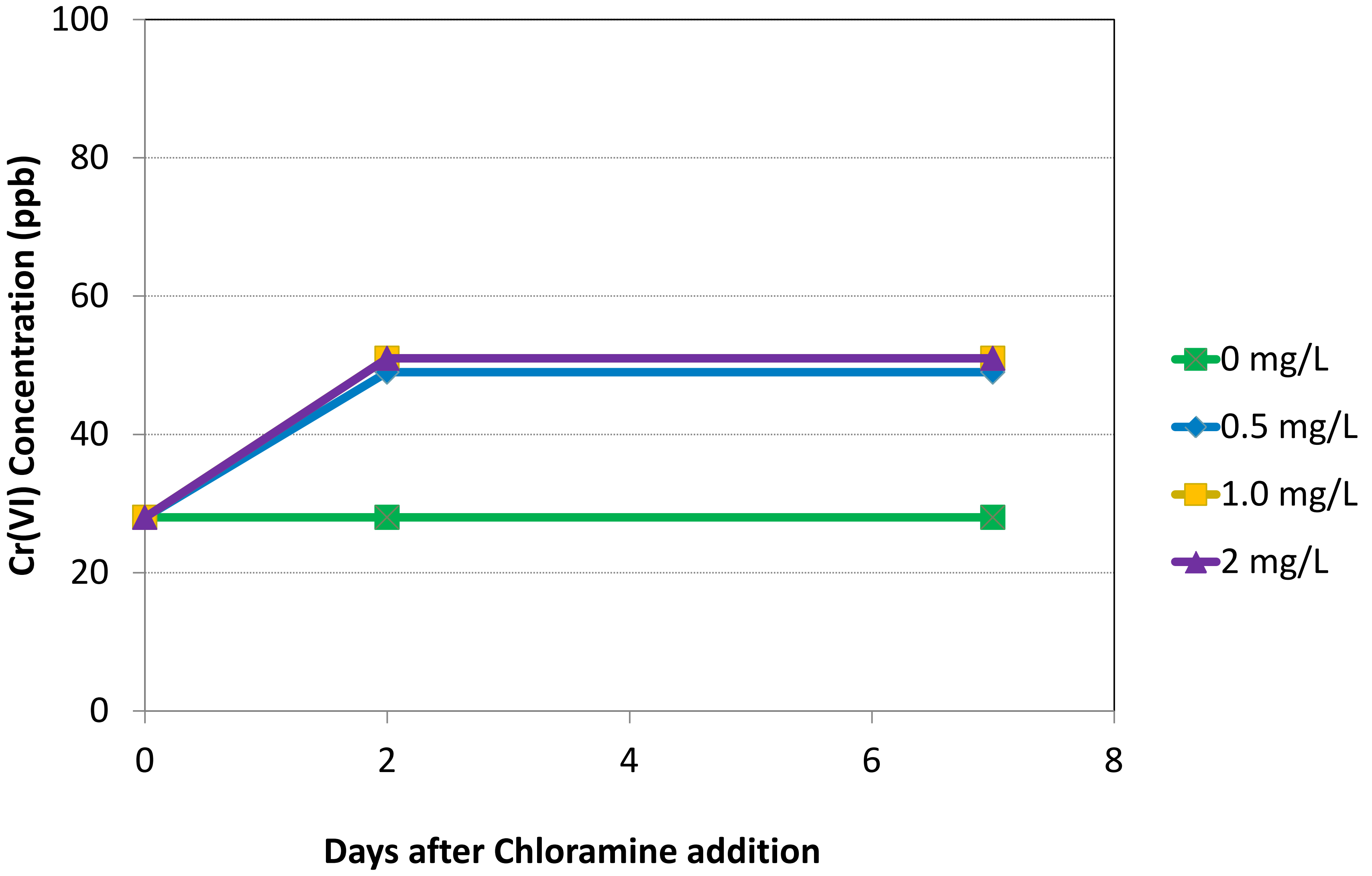
# Agenda

- Introduction
- Regulatory Update
- Leading Technologies
- Key Technology Selection Drivers
- Conclusions

# What is Chromium 6 and why is it a new regulatory concern?

- Chromium – Cr3 and Cr6 – is a naturally occurring element found in rock, soil, and groundwater.
- Cr3 is an essential human nutrient that is included as an element in food supplements.
- Cr6 can also occur as an industrial byproduct in manufacturing processes.
- These industrial byproducts were discharged to the ground, in rivers, etc. and eventually reached groundwater supplies.

# Cr3 may be converted to Cr6 if not removed



# What is the new draft California MCL for Cr6?

- Cr6 concentration of 10 ppb
- Regulated at points of entry
- Quarterly running annual average
- Best available technologies include:
  - Ion exchange
  - Coagulation/filtration (with reduction upstream)
  - Reverse osmosis
- CDPH can require chromium speciation study if monitoring results exceed 10 ppb and disinfection is used

# Will USEPA set a Cr6 MCL?

- UCMR3 – 2013-2015
  - Assessment Monitoring List includes Cr6 and Total Cr
    - Low detection limits
    - Entry point and maximum detention time location
    - Ground water – monitor twice in a 1 year period
    - Surface water – monitor quarterly in a 1 year period
- IRIS Toxicological Review underway

# What are important lessons learned from implementation of the Arsenic Rule?

- Careful selection of technologies is important, because some of the best available technologies may not work effectively in every water quality
- Residuals disposal was the tail that wagged the dog
- Costs were underestimated
- Many small communities are still out of compliance

# What are the options for achieving Cr6 MCL compliance?

- Non-treatment
  - Blending
  - Use of other sources
- Treatment

# Treatment technologies

Four treatment strategies emerged as leading options – All can achieve the draft MCL of 10 ppb

**Weak-Base Anion Exchange**

**Strong-Base Anion Exchange with Residuals Treatment**

**Reduction/ Coagulation /Filtration**

**Reverse Osmosis**

# Operational experience with WBA and RCF at Glendale, California

- Glendale chose to design and construct WBA and RCF removal facilities to treat their groundwater
- SBA not selected due to concerns about long-term brine disposal

# Operational experience with SBA at Coachella Valley Water District

- CVWD is operating three SBA facilities (up to 4,000 gpm) for arsenic removal, and also observing removal of Cr(VI) to less than 1 ppb
- Brine treatment and disposal is cost driver

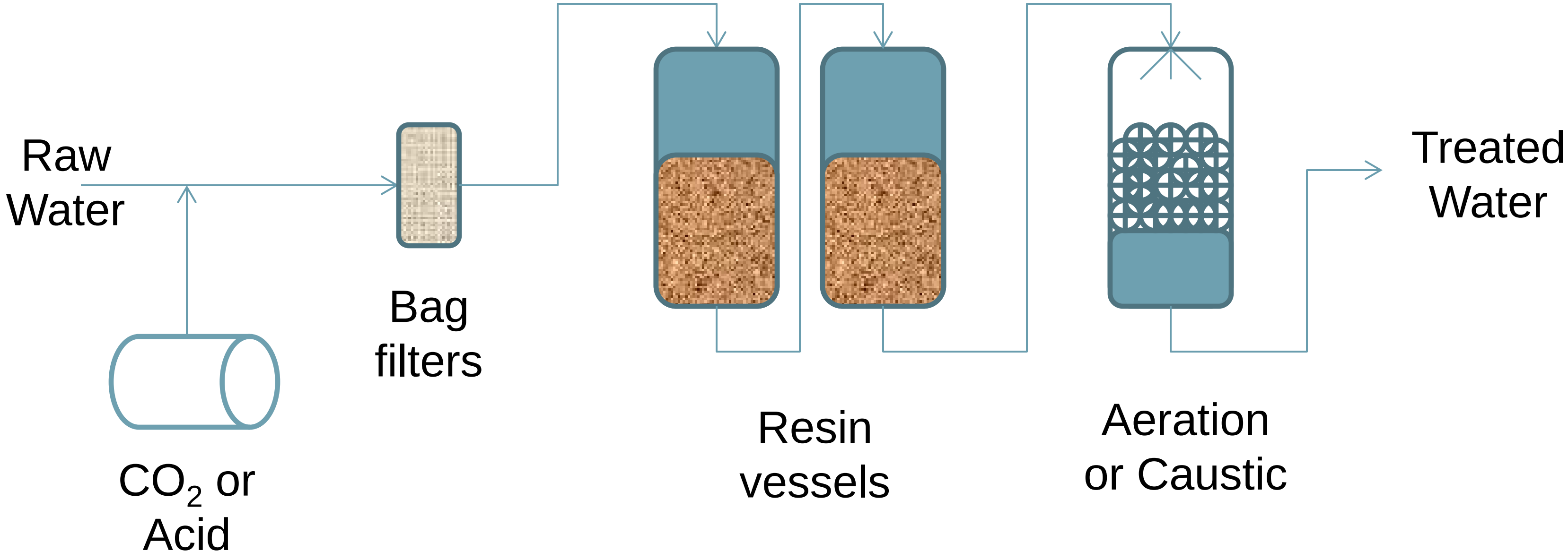
# Weak Base Anion Exchange (WBA) treatment process

- Cr6 exchange and conversion to Cr3

- Requires pre- and post-treatment for pH control

**City of Glendale, California**

# WBA unit processes



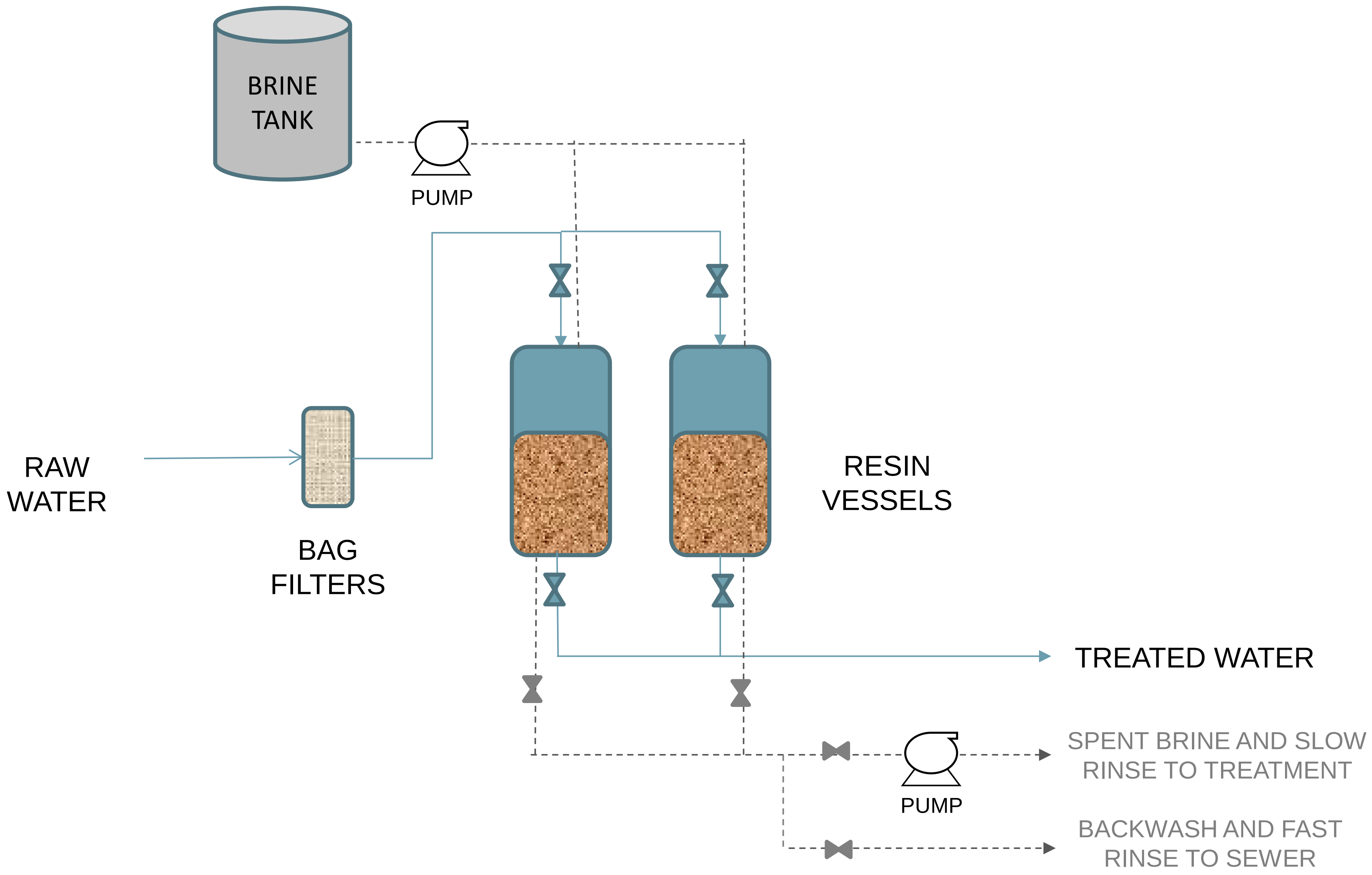
# Strong Base Anion Exchange (SBA) treatment process

- Exchange of Cr(VI) anions for less strongly held chloride ions on resin beads

- Requires periodic regeneration with salt solution (brine) and disposal and/or treatment of Cr(VI)-laden brine

**Coachella Valley Water District**

# SBA unit processes



# SBA brine treatment

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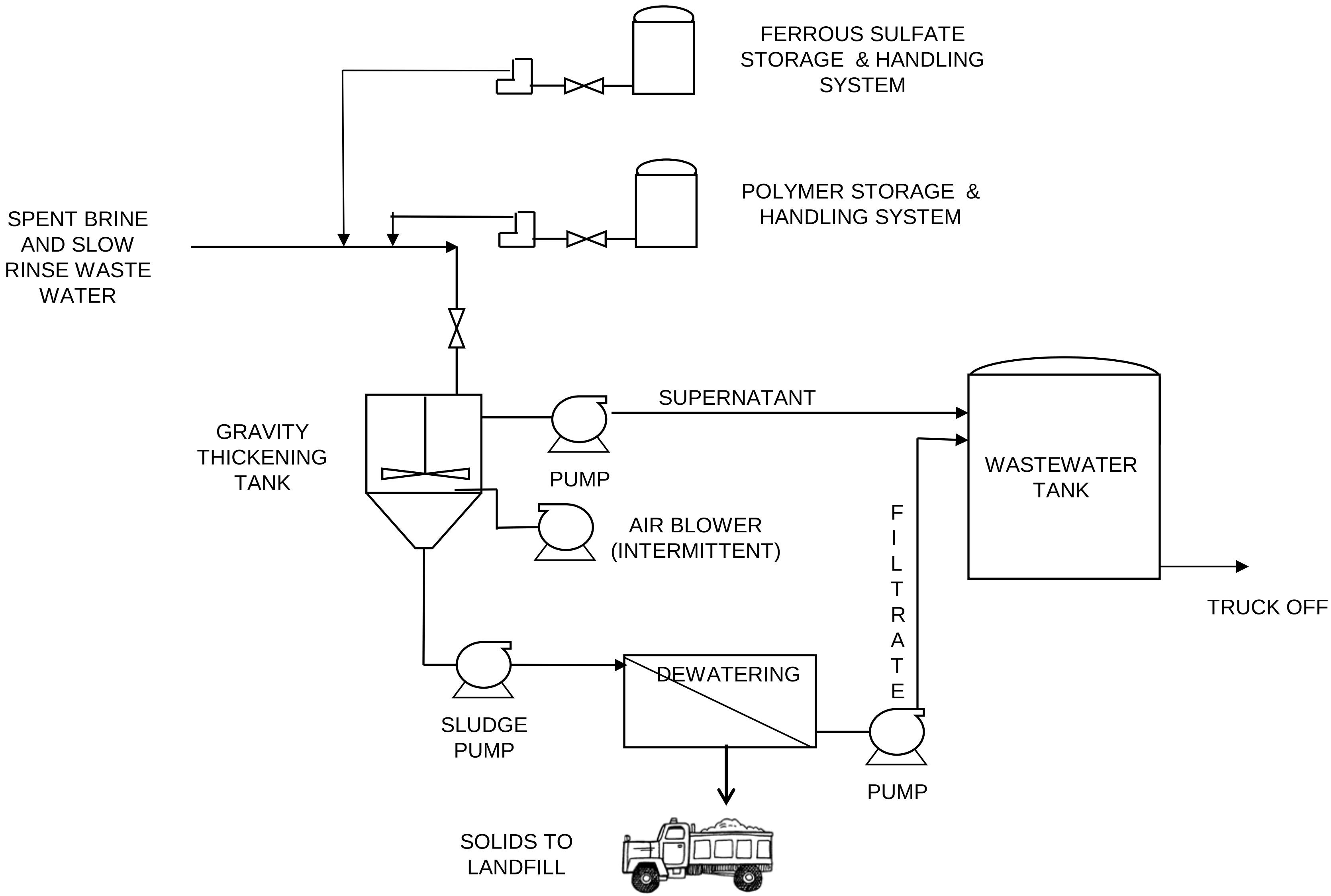
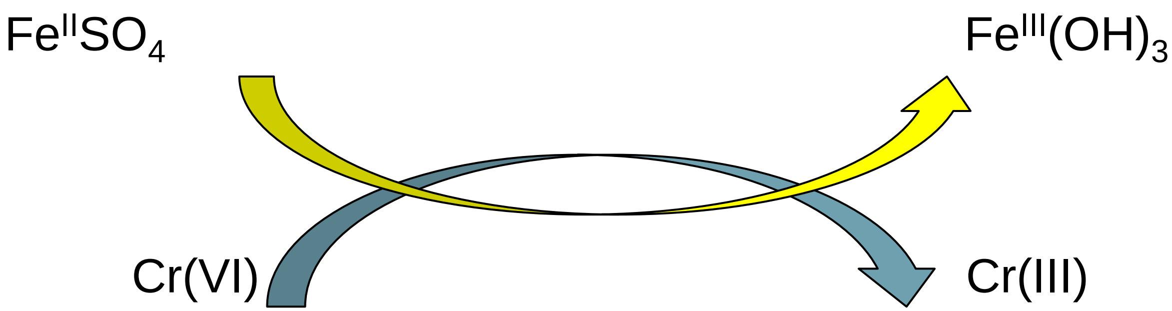


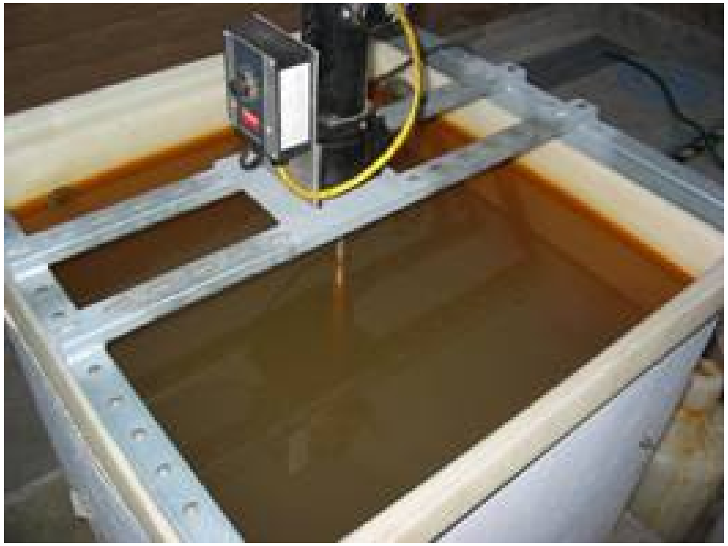
# Reduction/Coagulation/Filtration (RCF) treatment process

- Use of ferrous iron to reduce Cr6 to Cr3
- Removal of particle-bound Cr3

**City of Glendale, California**

# Reduction/Coagulation/Filtration (RCF) treatment process



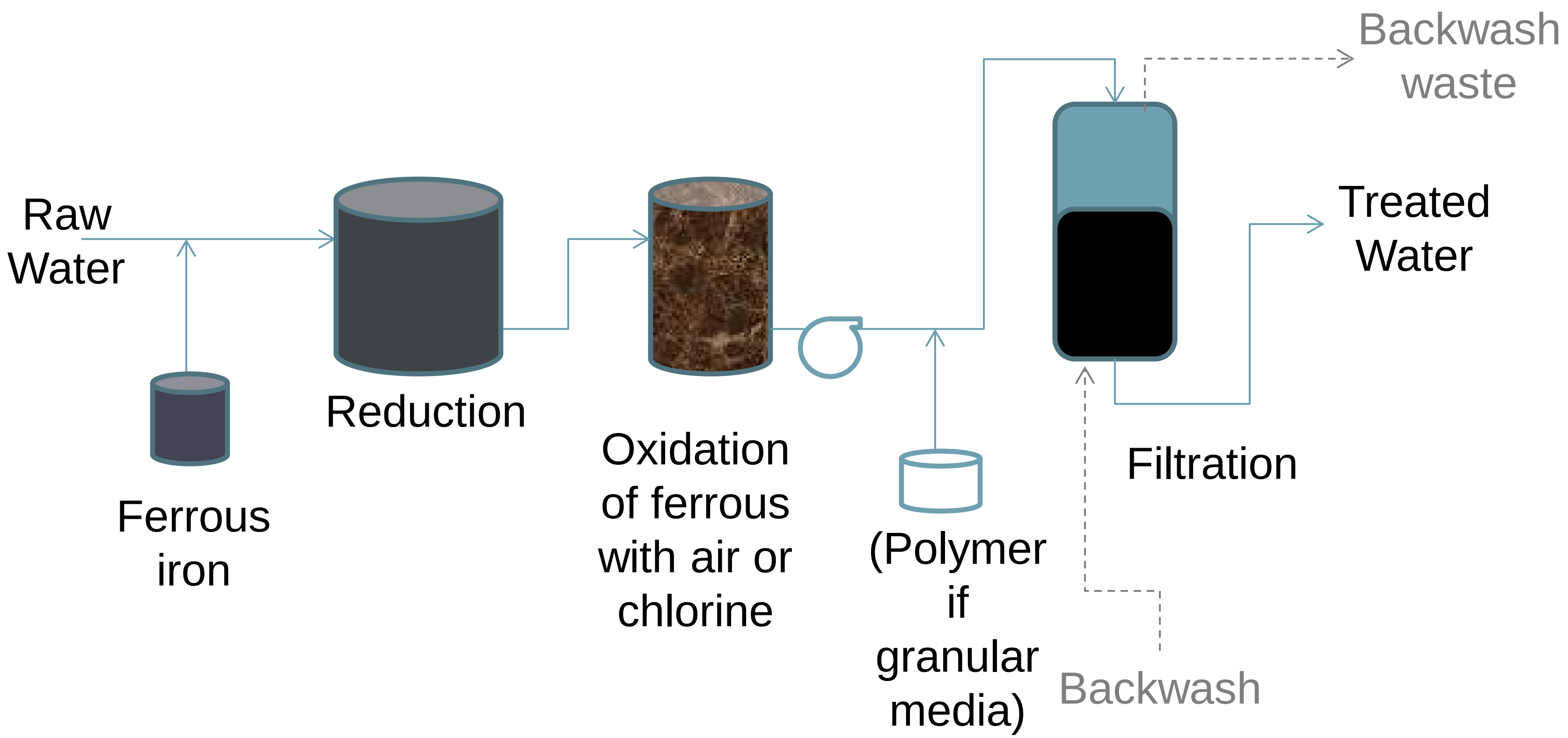



**Reduction**

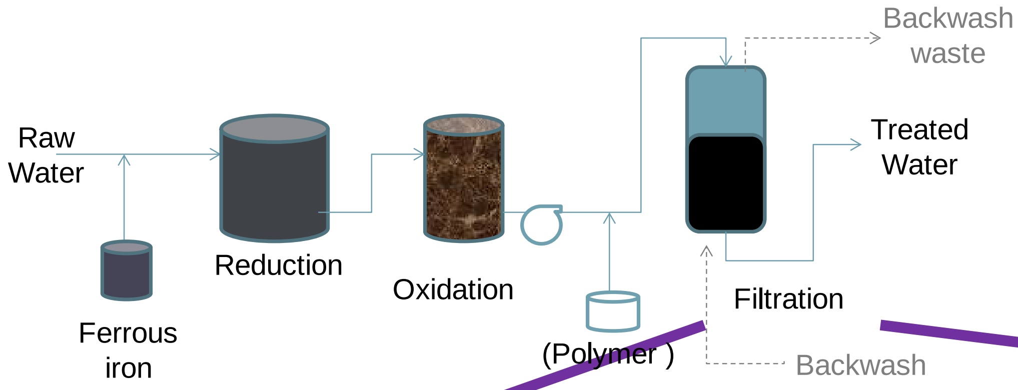
**Coagulation**

**Filtration**

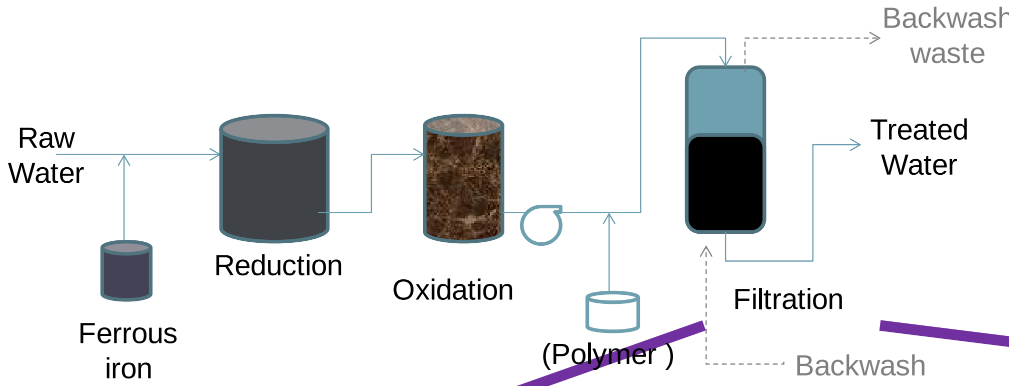
# RCF unit processes



# RCF – with granular media filtration




# RCF – with microfiltration

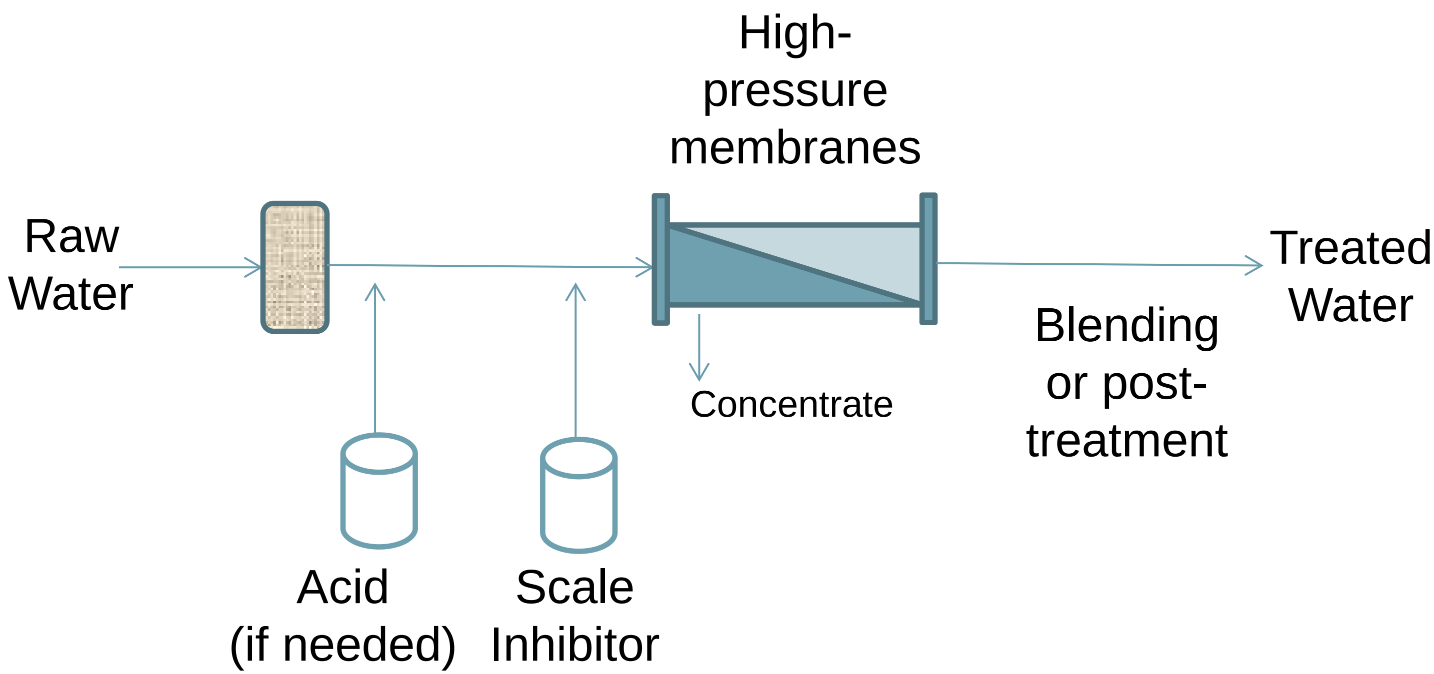



**Microfiltration**: Submerged and Pressure

# Reverse Osmosis (RO) treatment process

- Use of high pressures to exclude chromium molecules through size and charge exclusion
- Requires pretreatment chemical dosing to avoid scaling
- Will require downstream blending or mineral addition to avoid distribution and service pipe corrosion

# RO unit processes



# Key deciding factors in technology selection

Water Quality

Residuals Disposal

Operational Preferences and Flexibility

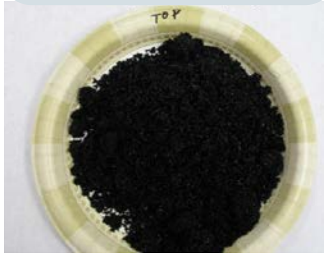
Cost Considerations

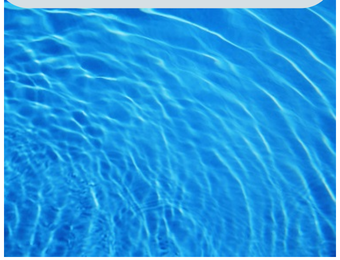
# Impacts of water quality of technology selection

| | |
|---|---|
| Alkalinity | • High alkalinity increases $CO_2$ or acid doses needed for pH reduction on WBA resin |
| Sulfate | • High sulfate increases brine generation rate for SBA resin |
| TOC | • High TOC can impact RCF coagulation, requiring smaller particle size removal |
| Uranium | • One WBA resin effectively accumulates uranium |

# Residuals for each technology

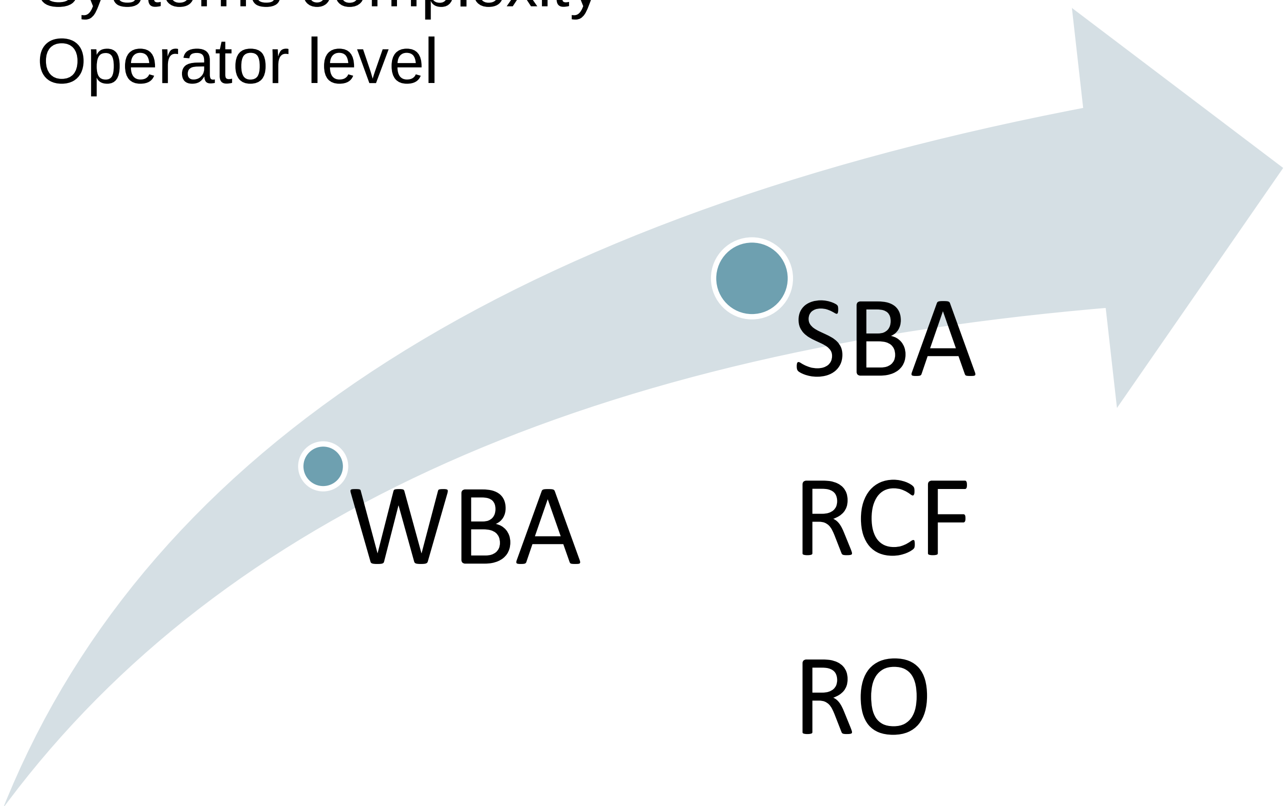
| WBA | SBA | RCF | RO |
|---|---|---|---|
| Minimal backwash water | Brine | Backwash water (3-5%) | Concentrate (15-25%) |
| Spent resin | Precipitated Cr from brine | BW water solids if settled | None |



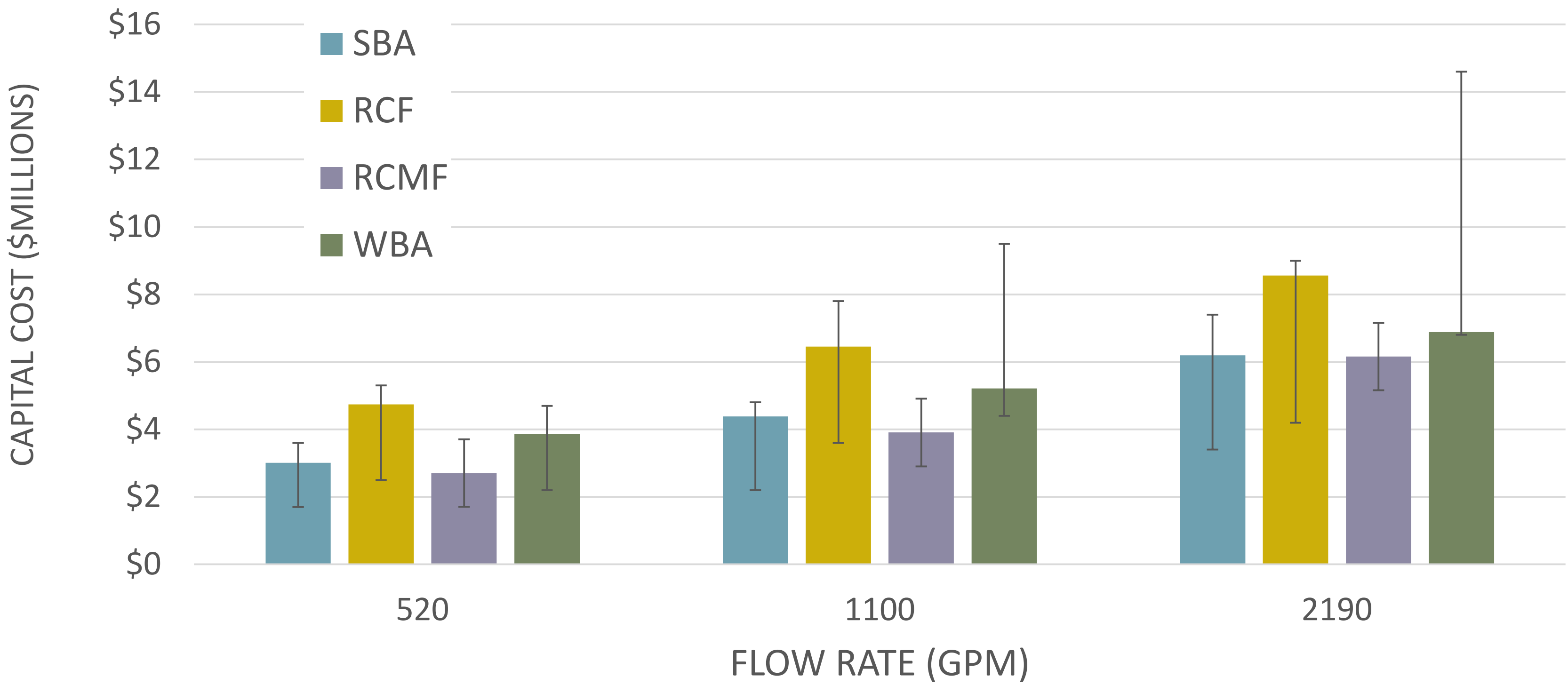


# Operational preferences and flexibility

- Time
- Systems complexity
- Operator level



# Capital costs – An example




Three sets of cost estimates used to develop this specific example.

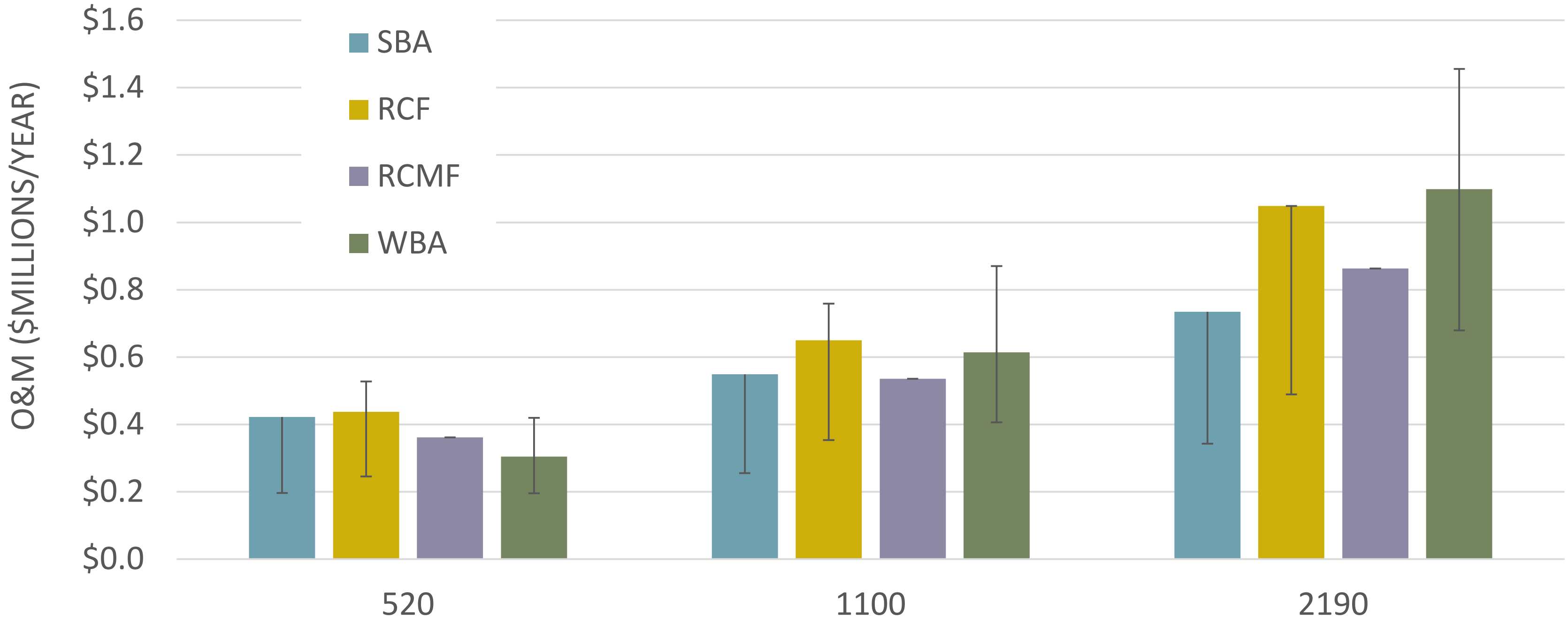
Treatment process assumptions:

- SBA - On-site regeneration with brine
- RCF - 45 minute reduction time and aeration (for bars)
- RCMF - 15 minute reduction time and chlorination
- WBA - pH adjustment with $CO_2$ and air stripping

Residuals management assumptions:

- SBA clarified waste brine hauled off-site
- RCF backwash water treated and recycled
- RCMF backwash water discharged to sewer

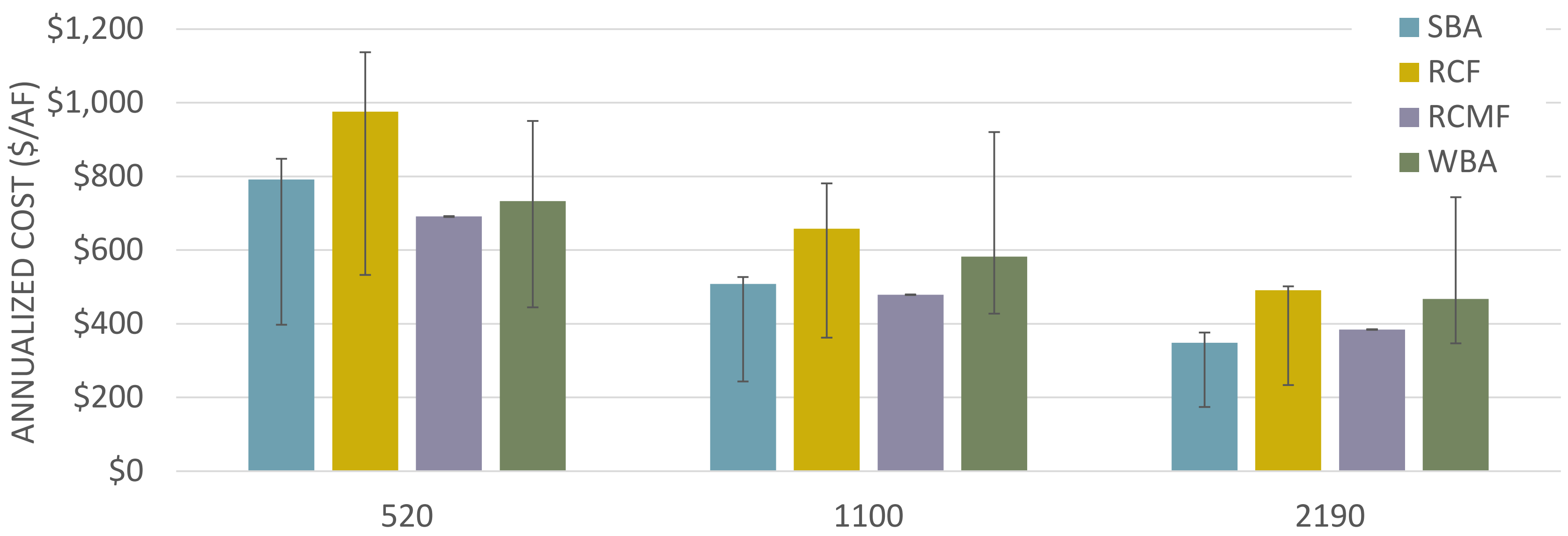
# O&M costs – An example




Assumptions:

- Assumes water quality of approximately 20 mg/L sulfate and 165 mg/L alkalinity
- Assumes 100% utilization for O&M costs

# Annualized costs – An example




Assumptions:

- 20 year equipment life
- 5% interest rate

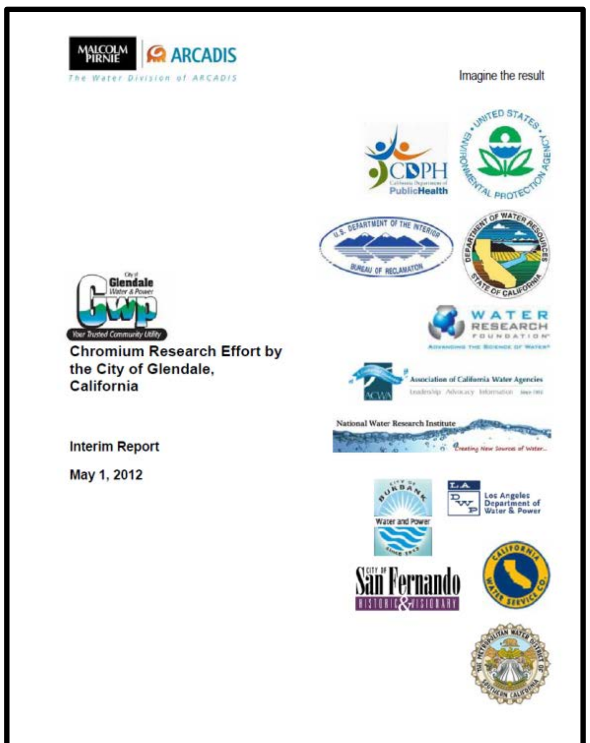
# Summary

- New draft Cr(VI) MCL in California of 10 ppb
- Research identified several possible technologies for Cr(VI) removal to achieve this MCL
  - Ion Exchange (weak- and strong-base)
  - Reduction/Coagulation/Filtration
  - Reverse Osmosis
- Key drivers for technology selection are water quality, residuals disposal options, operational preferences, and cost

# Reference Materials

City of Glendale Final Report
(February 28, 2013)

*Available on City website*


MALCOLM PIRNIE | ARCADIS
The Water Division of ARCADIS

Imagine the result

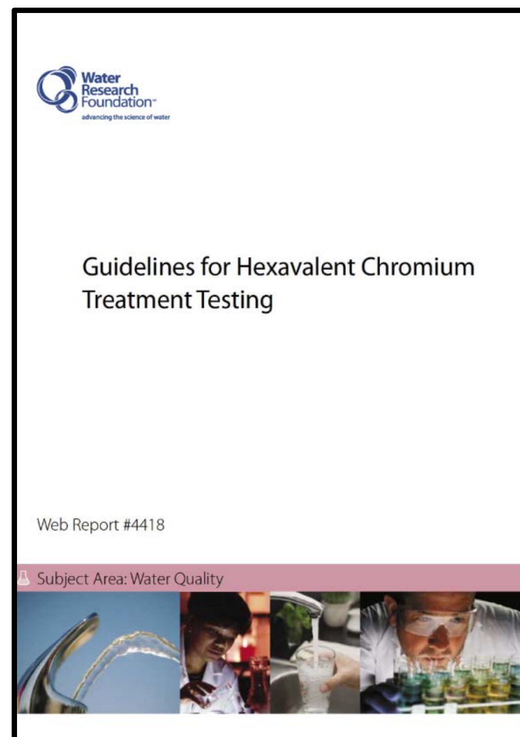
Chromium Research Effort by the City of Glendale, California

Interim Report

May 1, 2012

Water Research Foundation sponsored study – *Guidelines for Hexavalent Chromium Treatment Studies, #4418*

*Available on WaterRF website*


Water Research Foundation
advancing the science of water

Guidelines for Hexavalent Chromium Treatment Testing

Web Report #4418

Subject Area: Water Quality

# Questions?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