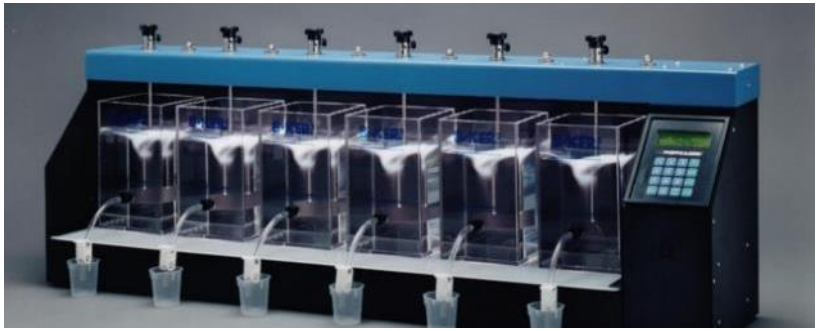
Hazen



Shock & Drop vs Floc & Drop

- An Evaluation of Spent IX Brine Treatment

Brine Disposal –

Options for Potential Waste Stream Management from CRRF

Presenters:

Mr. Steve Bigley, Director of Environmental Services, Coachella Valley Water District

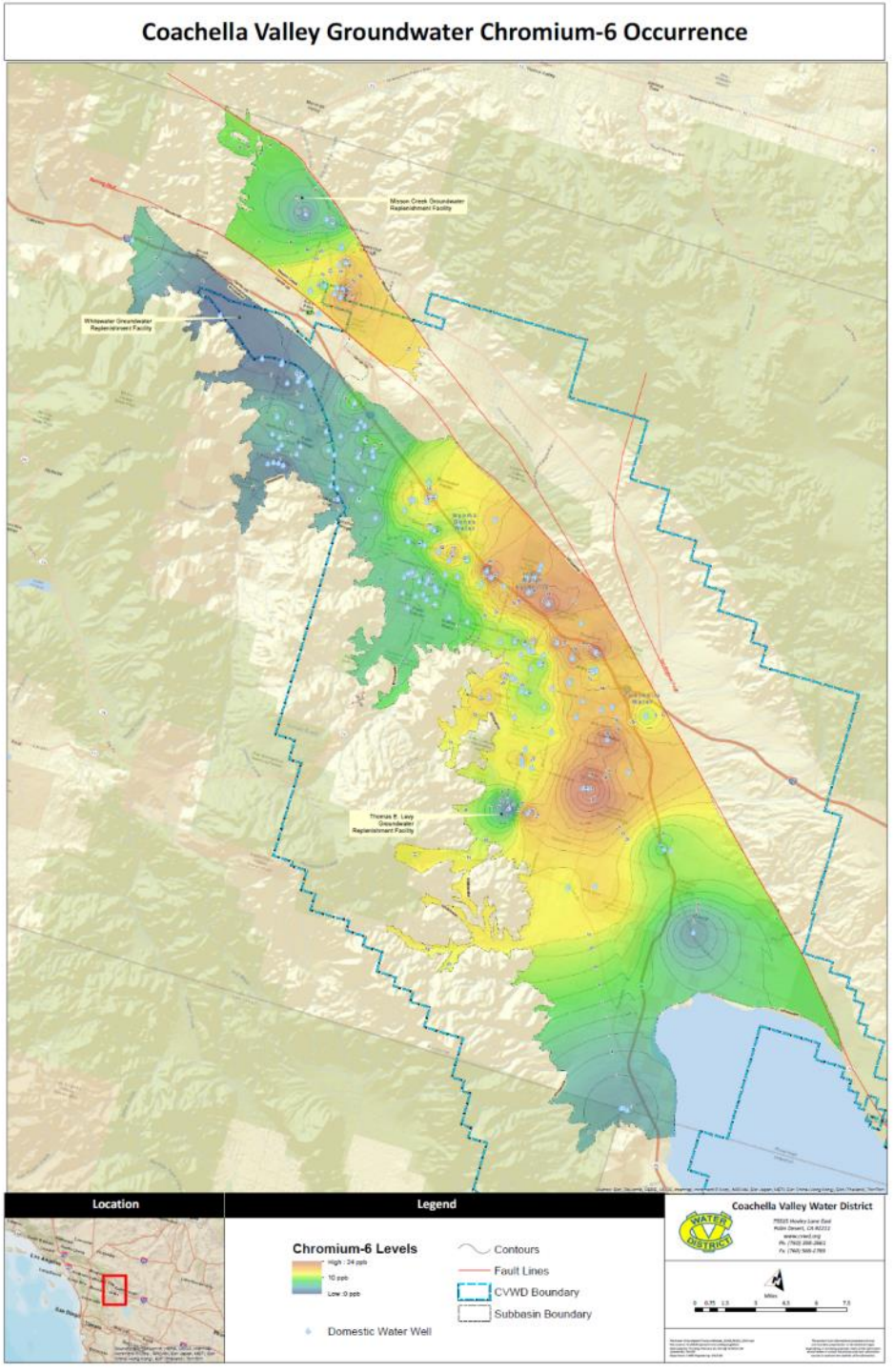
Mr. Eric Dole, PE, Western Regional Energy Efficiency Lead, Hazen & Sawyer

Hazen

1. Project background
2. Central Resin Regeneration Facility
3. Waste Classification / Regulations
4. Brine Treatment Testing
5. Brine Management Options
6. Cost comparison
7. Recommendation

Project Background – Local Cr6 Occurrence

- Found naturally in Coachella Valley groundwater
- Levels from <1 to 21 parts per billion (ppb) – new regulation of 10 ppb
- Cr6 levels below detection in Colorado River water used for aquifer replenishment



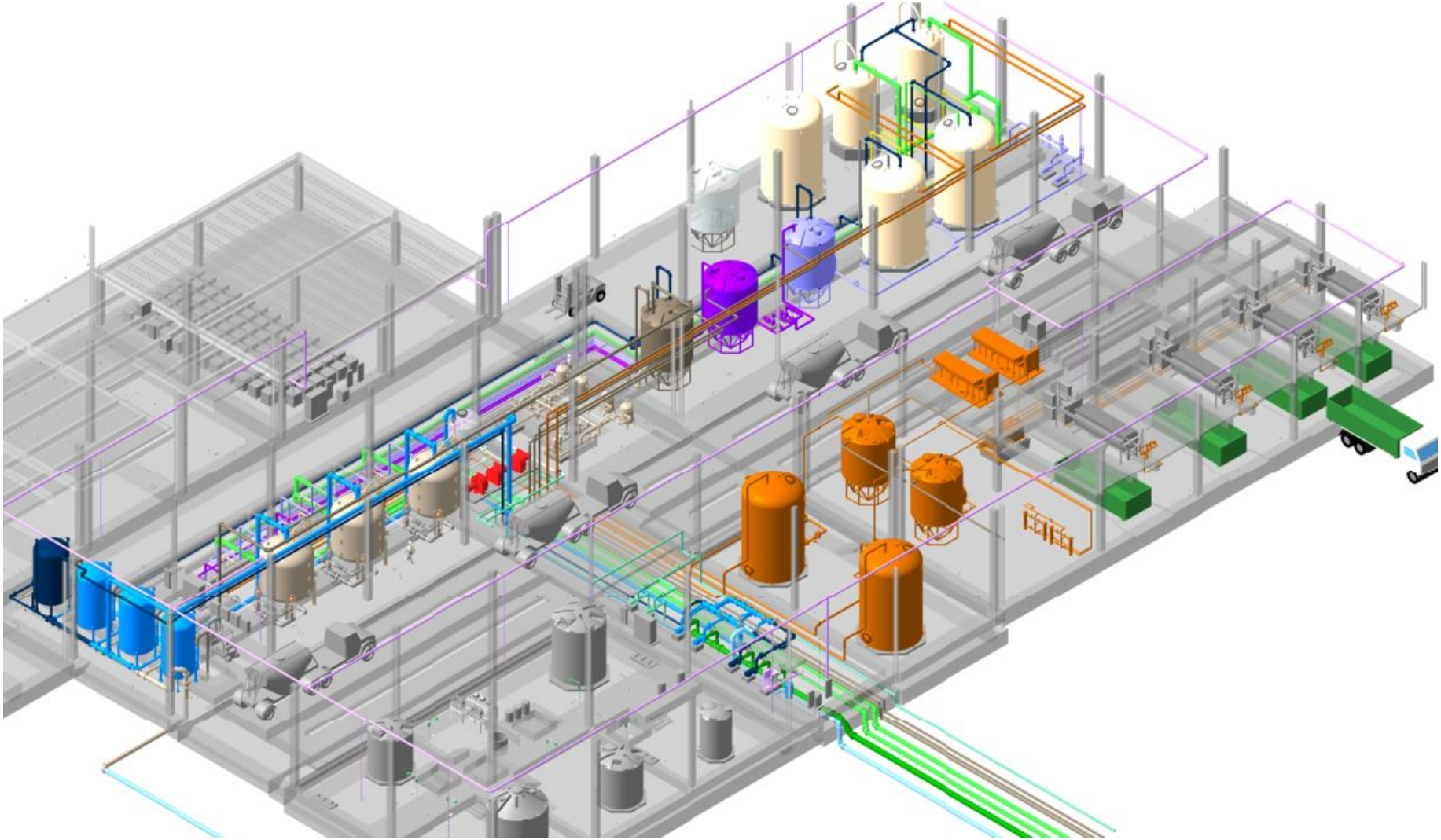
Project Background (cont.)

- 30 of CVWD's 96 requiring Cr6 treatment – 78 MGD
  - CA Dept. of Drinking Water new MCL = 10 ppb
  - SBA / WBA Treatment results in 99.95% water recovery (0.05% loss)
- 6 wells combine at 2 separate centralized Weak Base Anion (WBA) treatment systems…1 well is blended
  - 11.5 MGD capacity with 7,200 cubic feet of resin
  - Throw away resin lasts 1 - 2 years
  - Used for higher sulfate wells

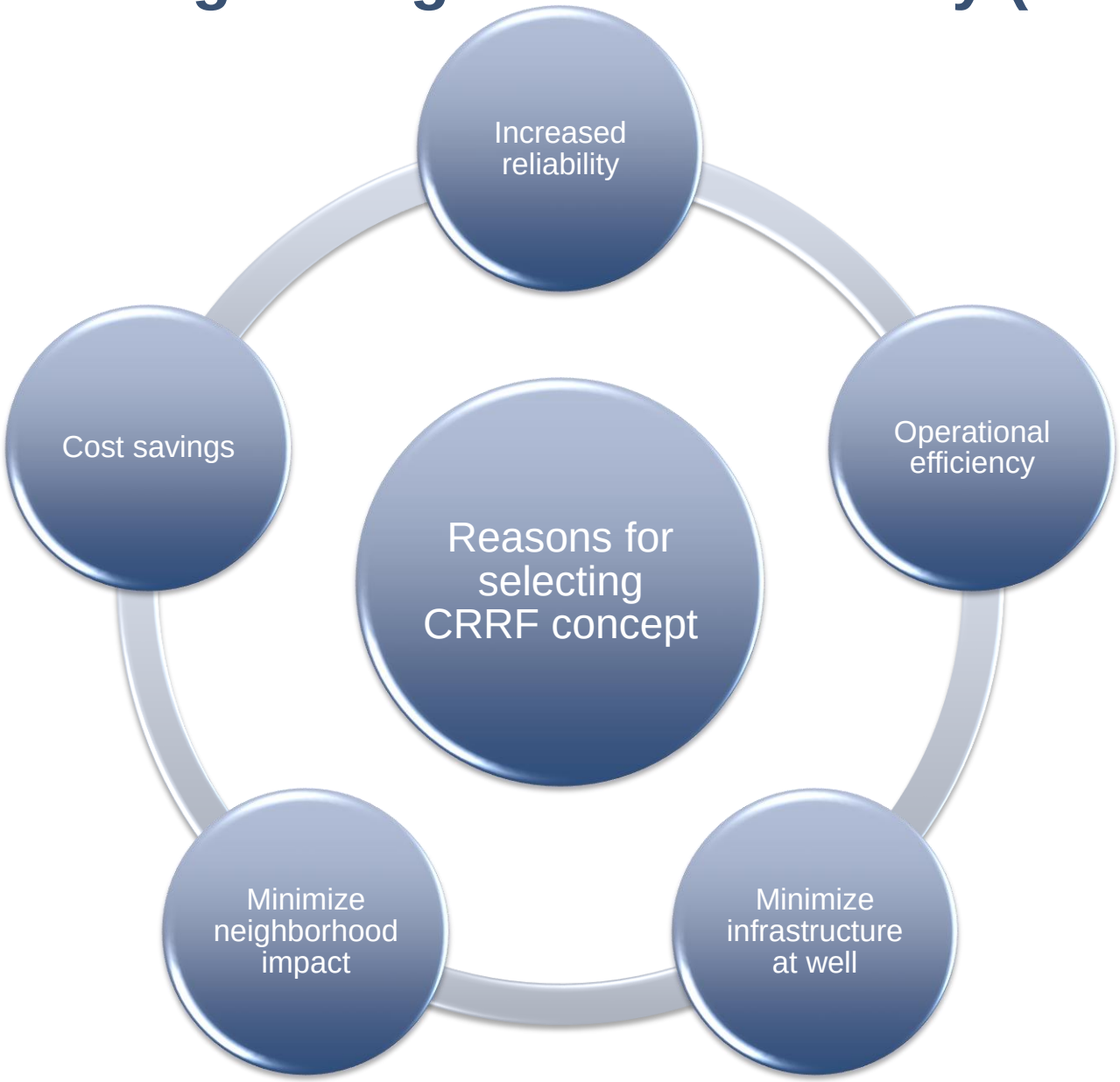
Project Background (cont.)

- 23 wells equipped with Strong Base Anion (SBA) treatment systems
  - 66.5 MGD capacity with 27,600 cubic feet of resin
  - Require regeneration every 2 to 3 months @ CRRF – 600 cf / day
  - Regenerated with a 10-12% NaCl solution

Central Regen Regeneration Facility (CRRF)

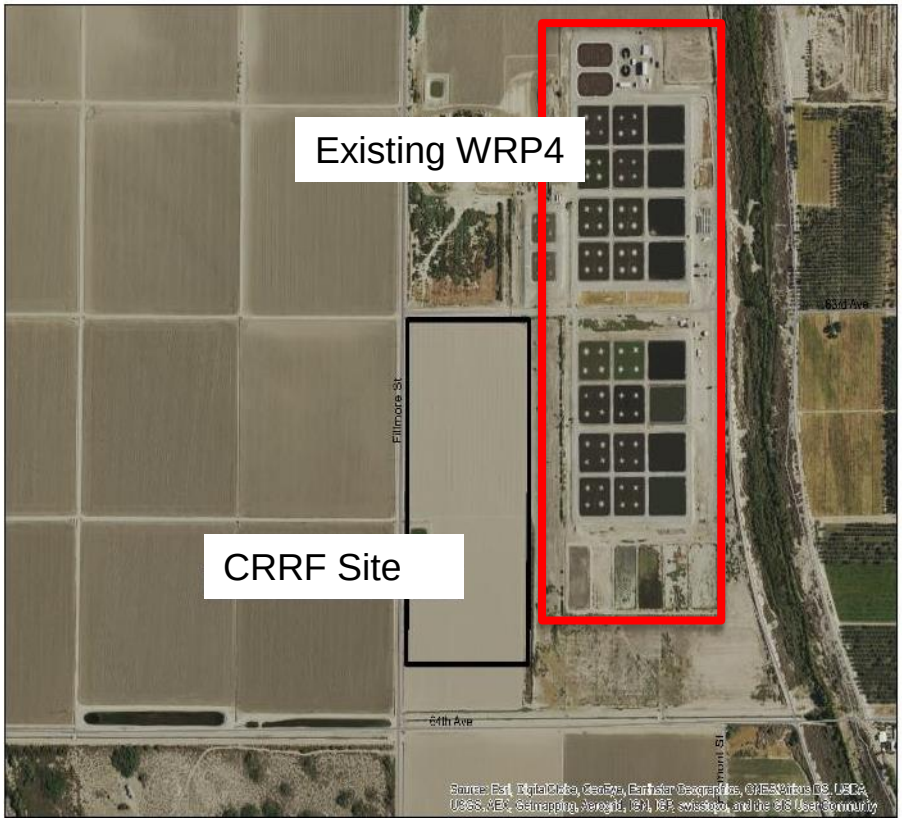


Central Regen Regeneration Facility (CRRF)

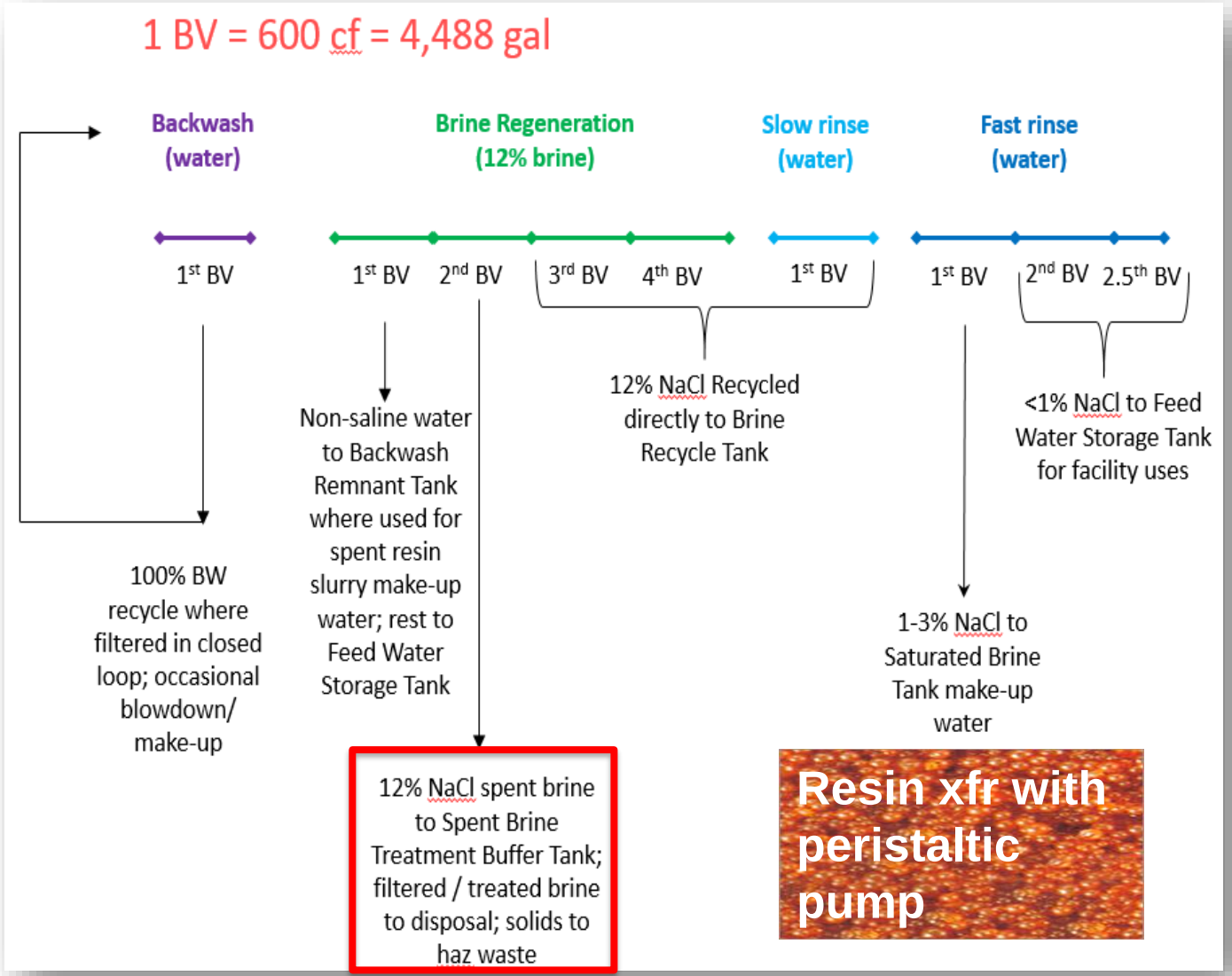


Central Resin Regeneration Facility (CRRF)

- The SBA resins must be regenerated when they are saturated with Cr6
- Centralizing the regeneration process achieves:
  - Cost savings
  - Increased reliability
  - Operational efficiency
  - Reduced footprint at well sites
- Resin is extracted from vessels at well sites and transported to CRRF, then returned to well sites after regeneration



Central Regen Regeneration Facility (CRRF)



Waste Handling Operational Modes

Spent Brine 4,500 gpd

Pretreatment

1. No pre-treatment
2. Low Dose Coagulation
   CC or EC (Fe = 2 g/L)
   (*Remove Cr (99%) and some U and V)
3. High Dose Coagulation
   EC 1st Stage Fe = 8 g/L (2 min/L)
   (*Remove Cr, U, other metals except Se)

Iron Solids Disposal

Iron Solid
- 1,000 lb/regen
- $ 1,150/regen
- 1 bin LLRW every 36 regens

Iron Solid
- 3,900 lb/regen
- $ 4,400/regen
- 1 bin LLRW every 9 regens

Brine Disposal

With rinse water, Se <1 mg/L

With rinse water, Se <1 mg/L

- Hazardous Brine
  Offsite
  - 4,500 Gal/regen
  - $7,200/regen @$ 1.6/Gal
  - 1 truck/regen
- a. WRP4 Discharge
  WRP4
  - 18,000 Gal/Regen
  - $180/regen @$10/kGal
- b. Non-Hazardous Brine
  Offsite
  - 18,000 Gal/regen
  - $5,400/regen @ $300/kGal
  - 4 trucks/regen
- a. Evap Ponds (*May require legislation)
- b. WRP4 Discharge
  WRP4
  - 18,000 Gal/regen
  - $180/regen @$10/kGal
- c. 2 Stage Evap/Crystallizer
- d. 1 Stage Crystallizer

Salt Cake Disposal

Salt Cake
- 5.6 tons/regen
- $620/regen @ $110/ton (non-Haz)

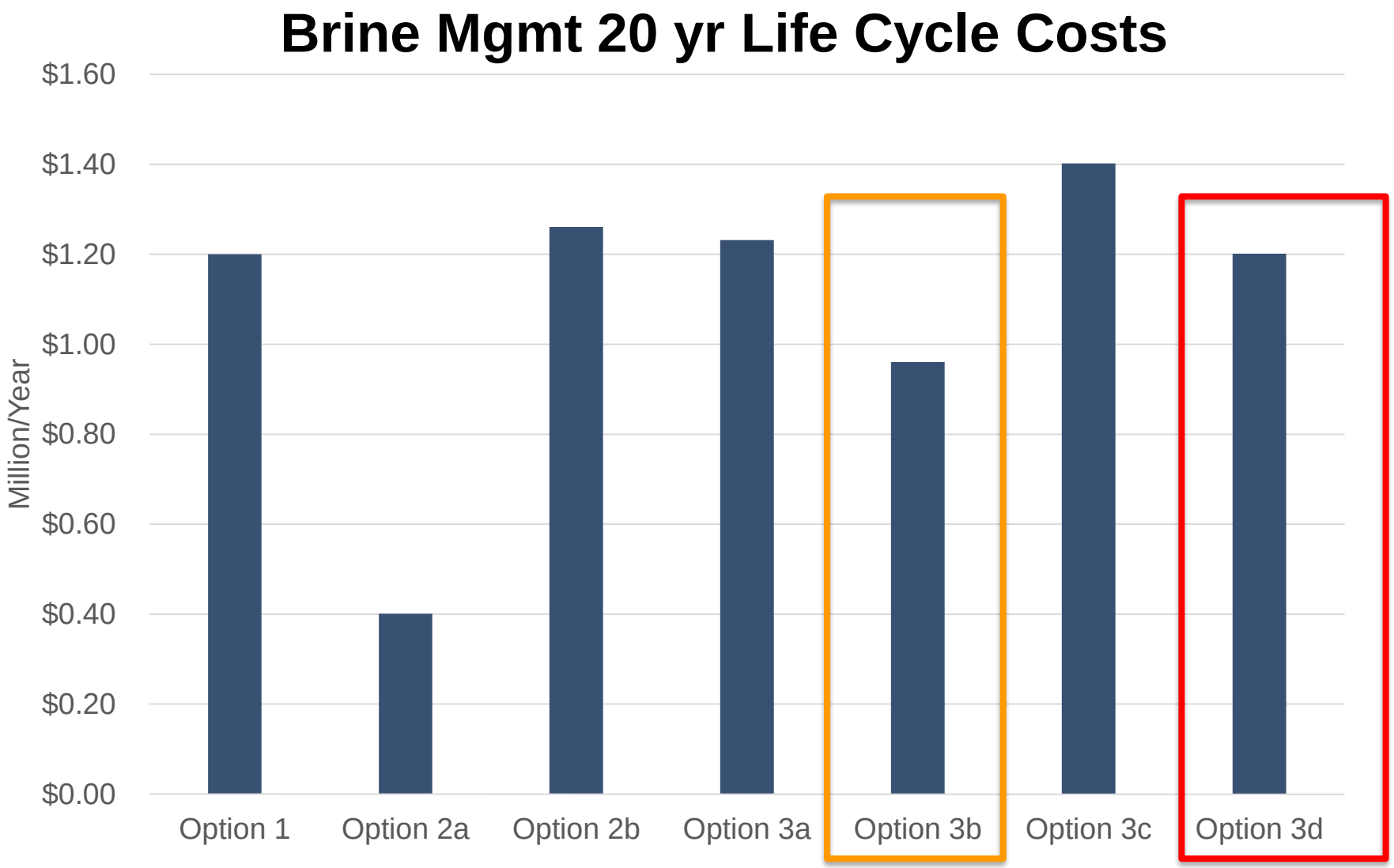
Salt Cake
- 3.5 tons/regen -
$390/regen @ $110/ton (non-haz)

Salt Cake
- 3.5 tons/regen -
$390/regen @ $110/ton (non-haz)

Approx. total cost

$7,200/regen	$1,350/regen	$6,550/regen	$5,080/regen	$4,630/regen	$4,850/regen	$4,850/regen

Central Resin Regeneration Facility (CRRF)



Waste Classification

STLC Title 26 California Regulation (liquid)

- Liquid sample is filtered, and the filtrate is captured for analysis
- No leaching process is needed with solid content < 0.5% (mg/L)

TTLC Title 26 California Regulation (solid)

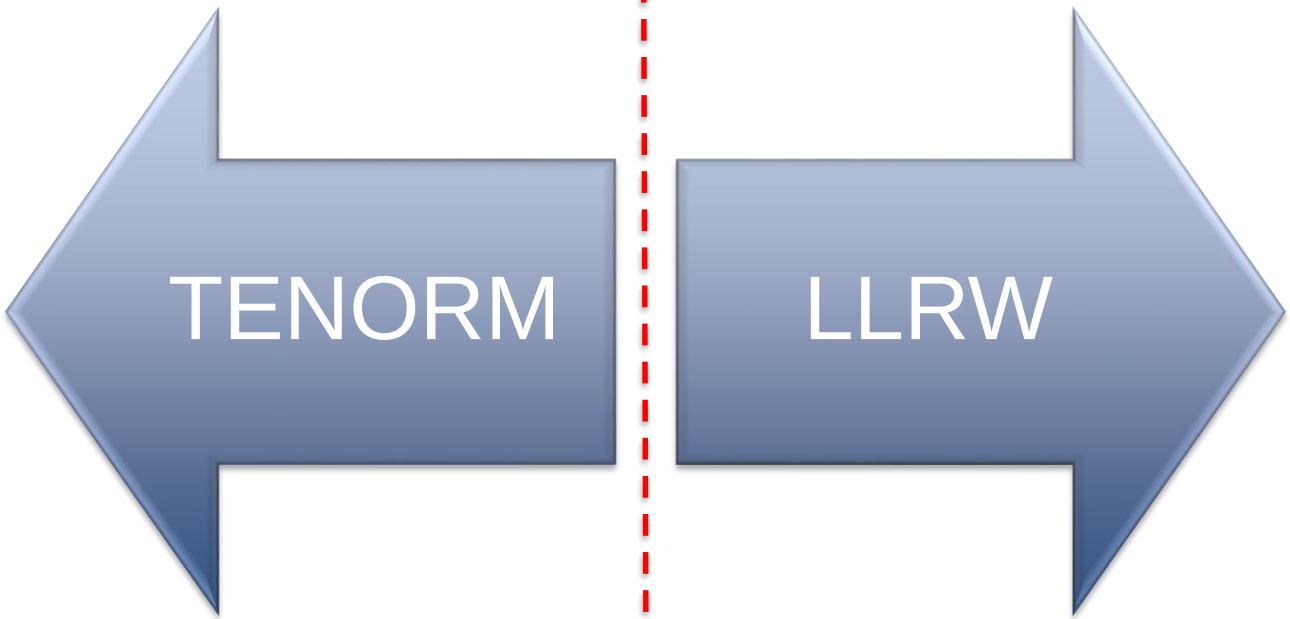
- Solid sample goes through a digestion process prior to analysis
- Analysis for total concentration in wet waste (mg/kg)

TCLP Federal Regulation (solid)

- Solid sample goes through the leaching condition mimics the landfill
- 100 g wet solids leached in 2L of solution (mg/L)

Waste Classification – Radioactivity (U)

0.05% (or 500 mg of U / kg) = solids disposal

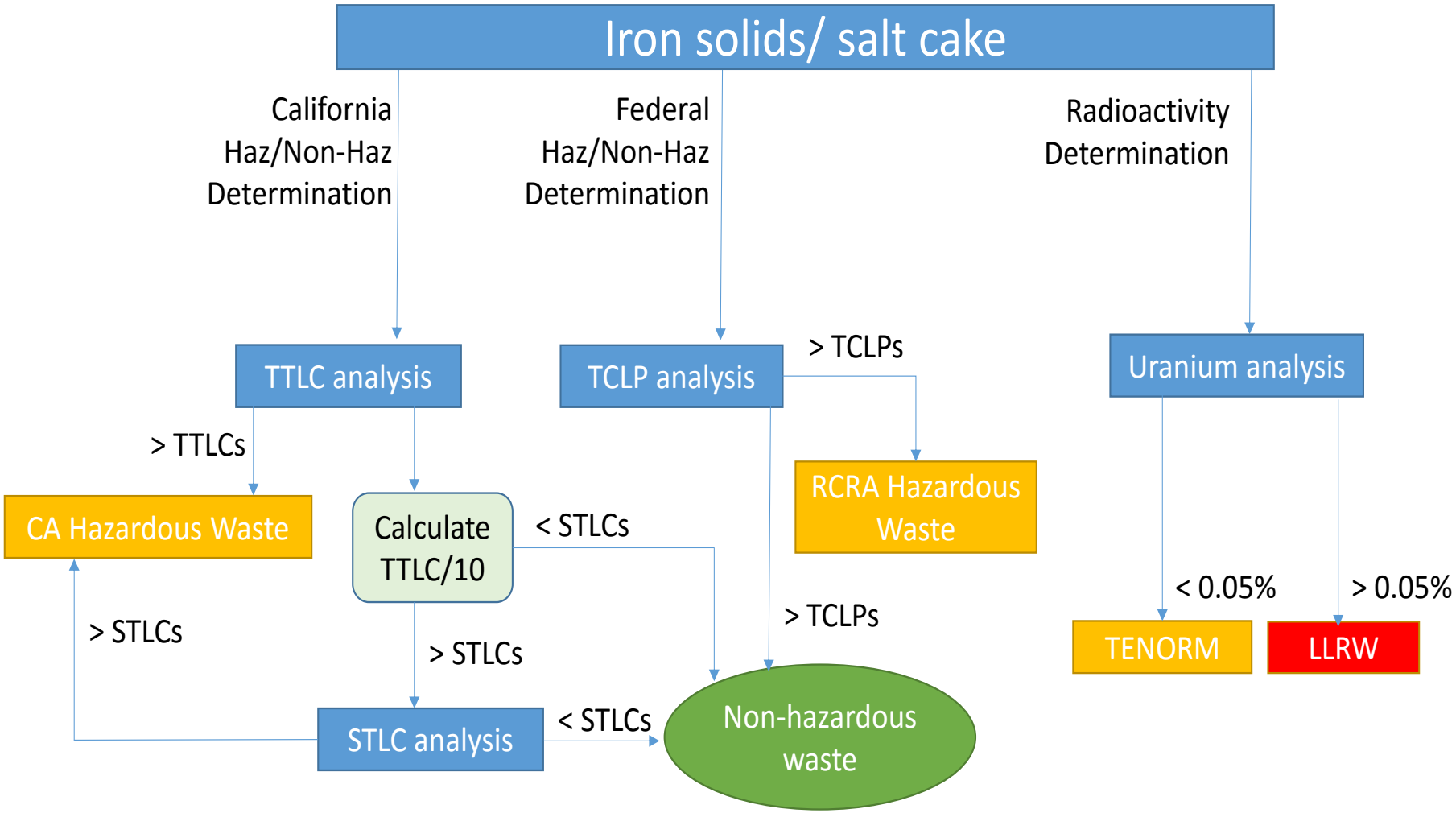


- Uranium content 5000 mR/yr = OSHA/NRC

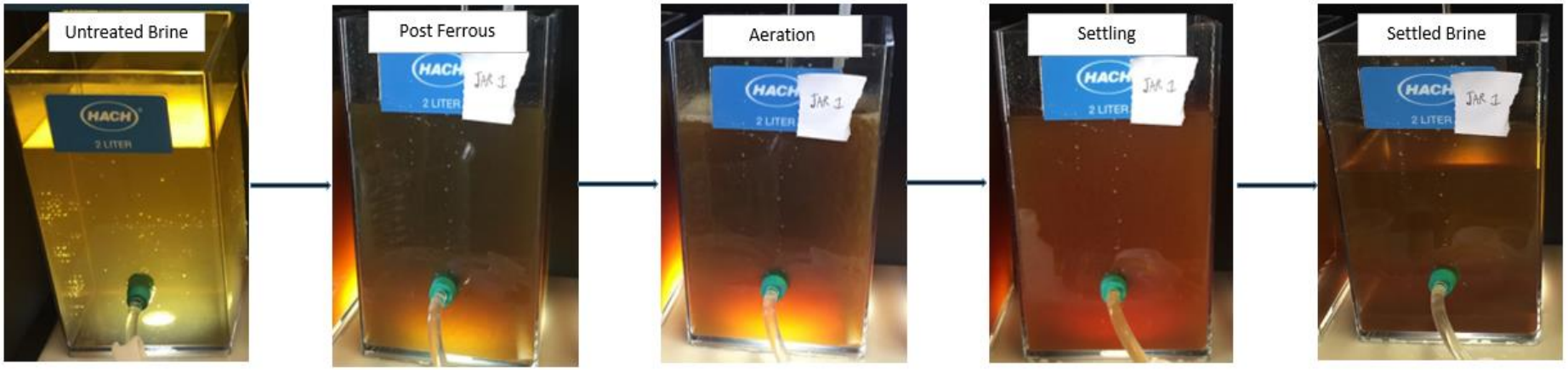
Waste Regulatory Limits

Inorganic Compound	STLC, mg/L	TCLP, mg/L	TTLC, mg/kg, wet weight	LLRW limit mg/kg, wet weight
Arsenic	5.0	5.0	500	N/A
Chromium	5.0	5.0	500	N/A
Molybdenum	350	N/A	3,500	N/A
Nickel	20	N/A	2,000	N/A
Selenium	1.0	1.0	100	N/A
Vanadium	24	N/A	2,400	N/A
Uranium	N/A	N/A	N/A	500

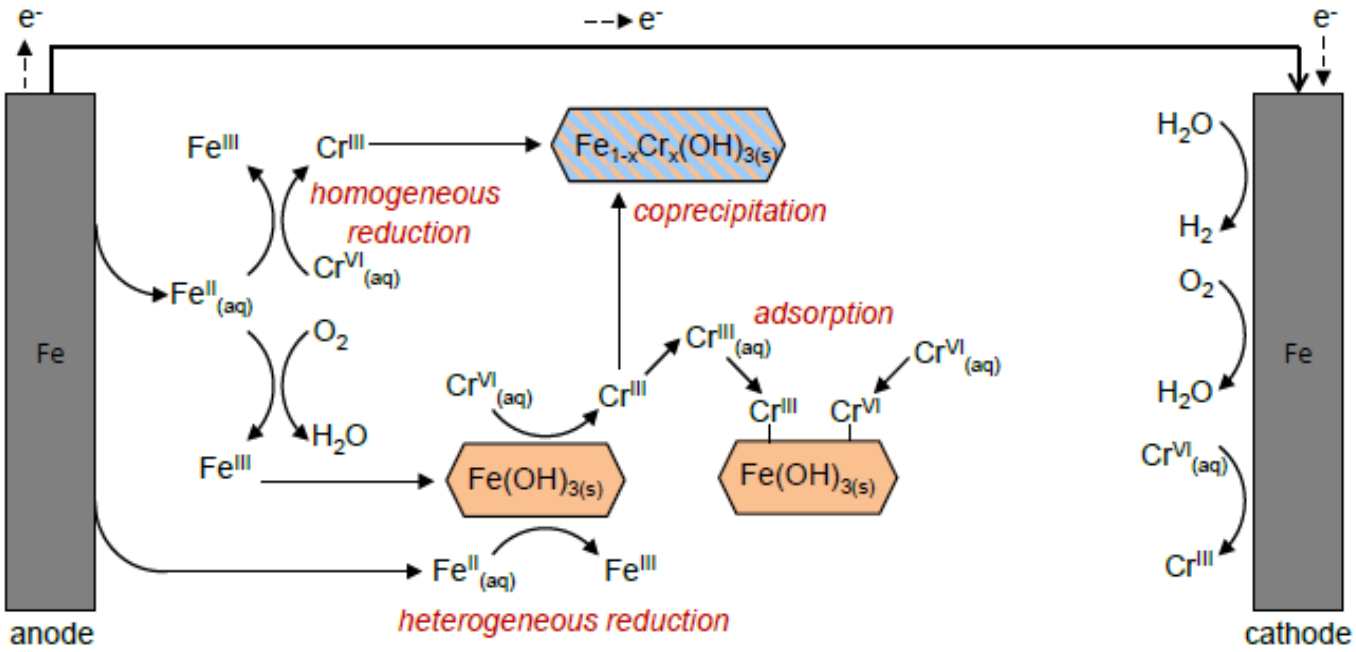
Waste Classification Decision Tree



Brine Treatment Field Tests– CC



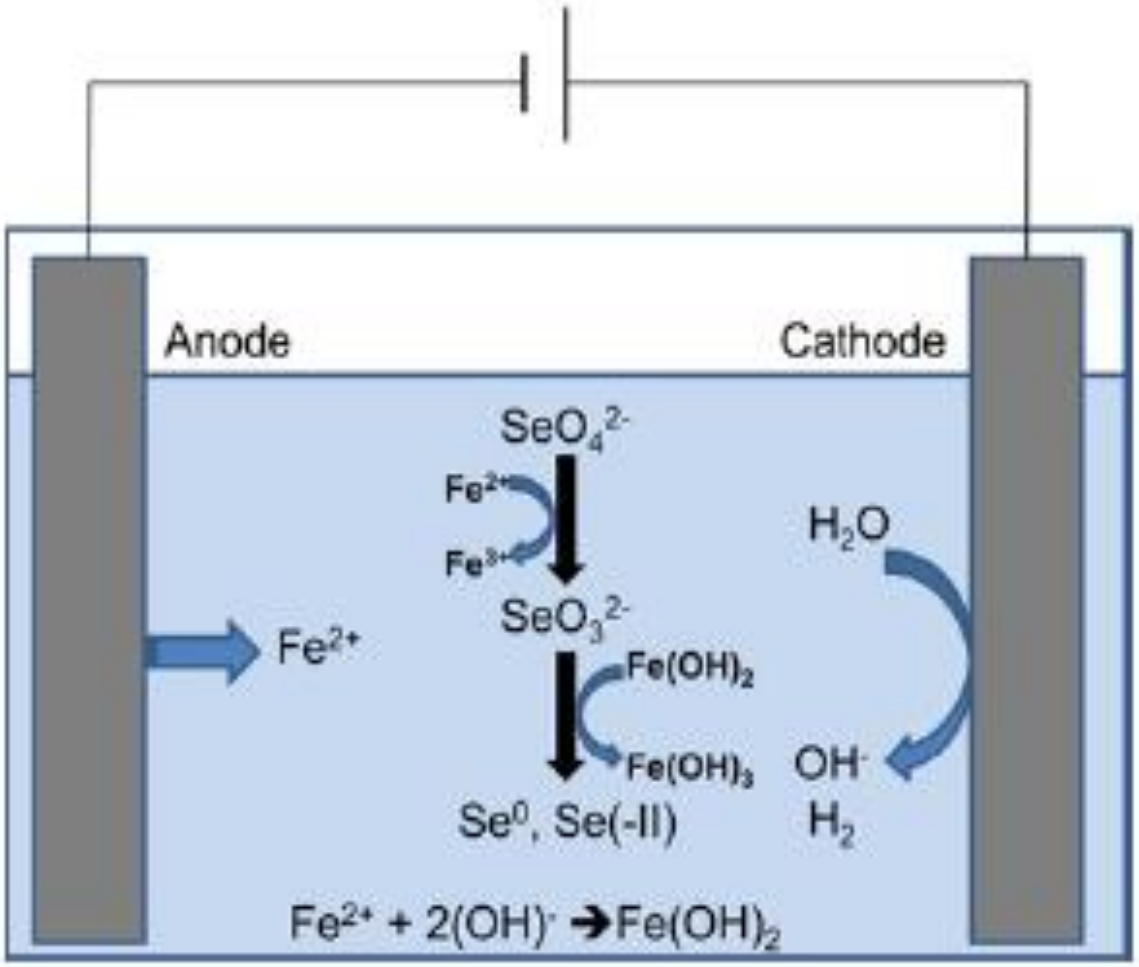
Brine Treatment Field Tests – Electro-coagulation (EC)



(Source: 1.) Washington University Presentation "Contaminant Removal from Water through Oxidation-Reduction and Adsorption of Iron Oxides Generated during Electrocoagulation" March 25, 2015, 249th Annual American Chemistry Society Meeting, Denver CO; 2.) Powell Water Solutions, Inc.)

- Already established spent brine treatment for industrial
- Reduce Cr6 to Cr3 with ferrous iron from anode and natural reduction at cathode, settle, filter
- Removes Se at high iron doses…lots of Fe solids

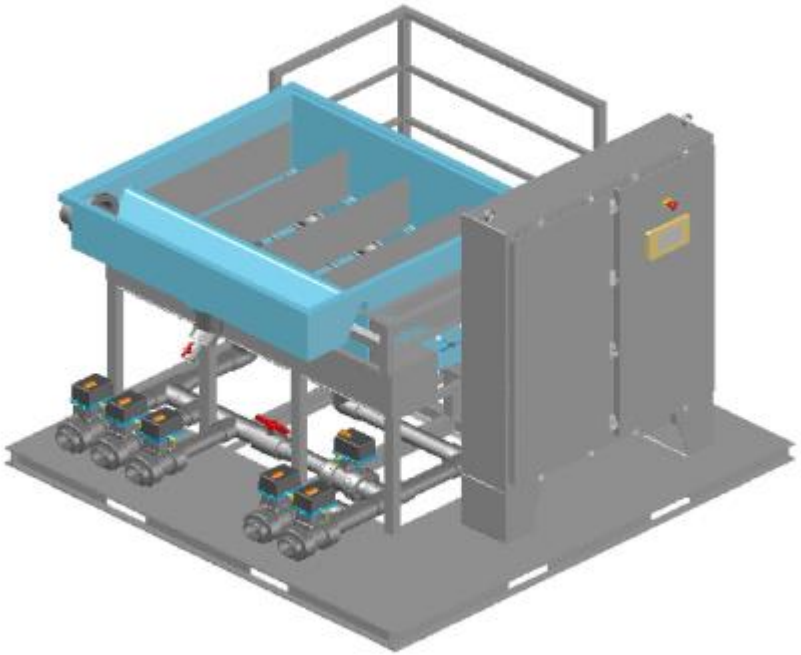
Brine Treatment Field Tests – EC



(Source: Chemical Engineering Journal "Electrochemical Removal of Selenate from Aqueous Solutions" May 2, 2012)

Brine Treatment – EC Full Scale Unit

600 gpm Powell EC System

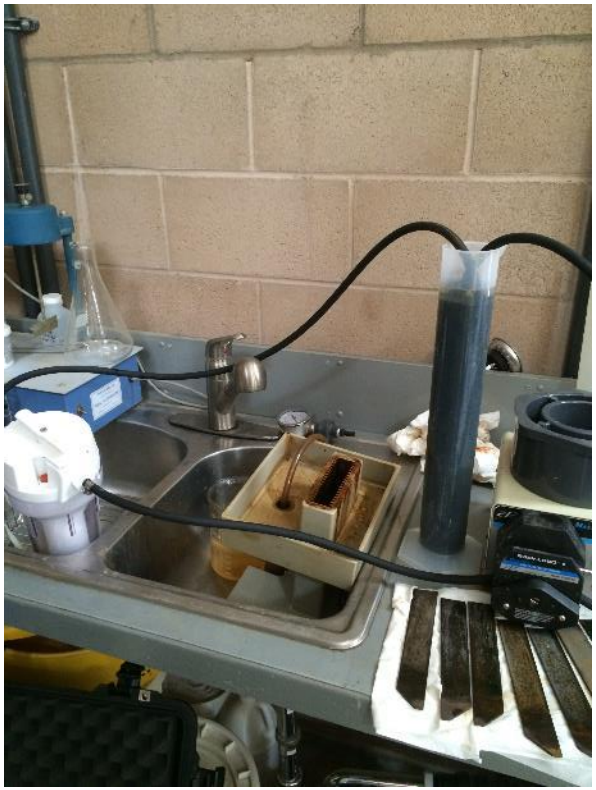


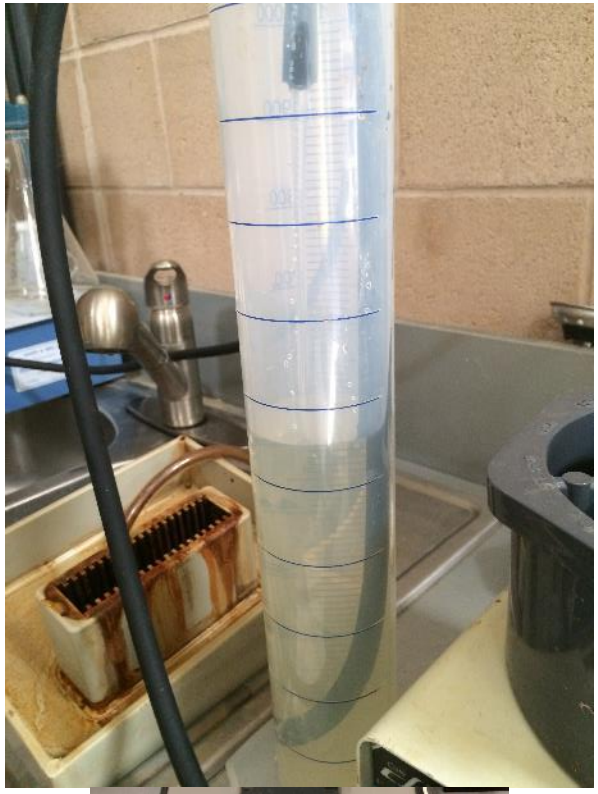
135 gpm Powell EC System

Brine Treatment Field Tests– EC

Brine Treatment Field Tests– EC

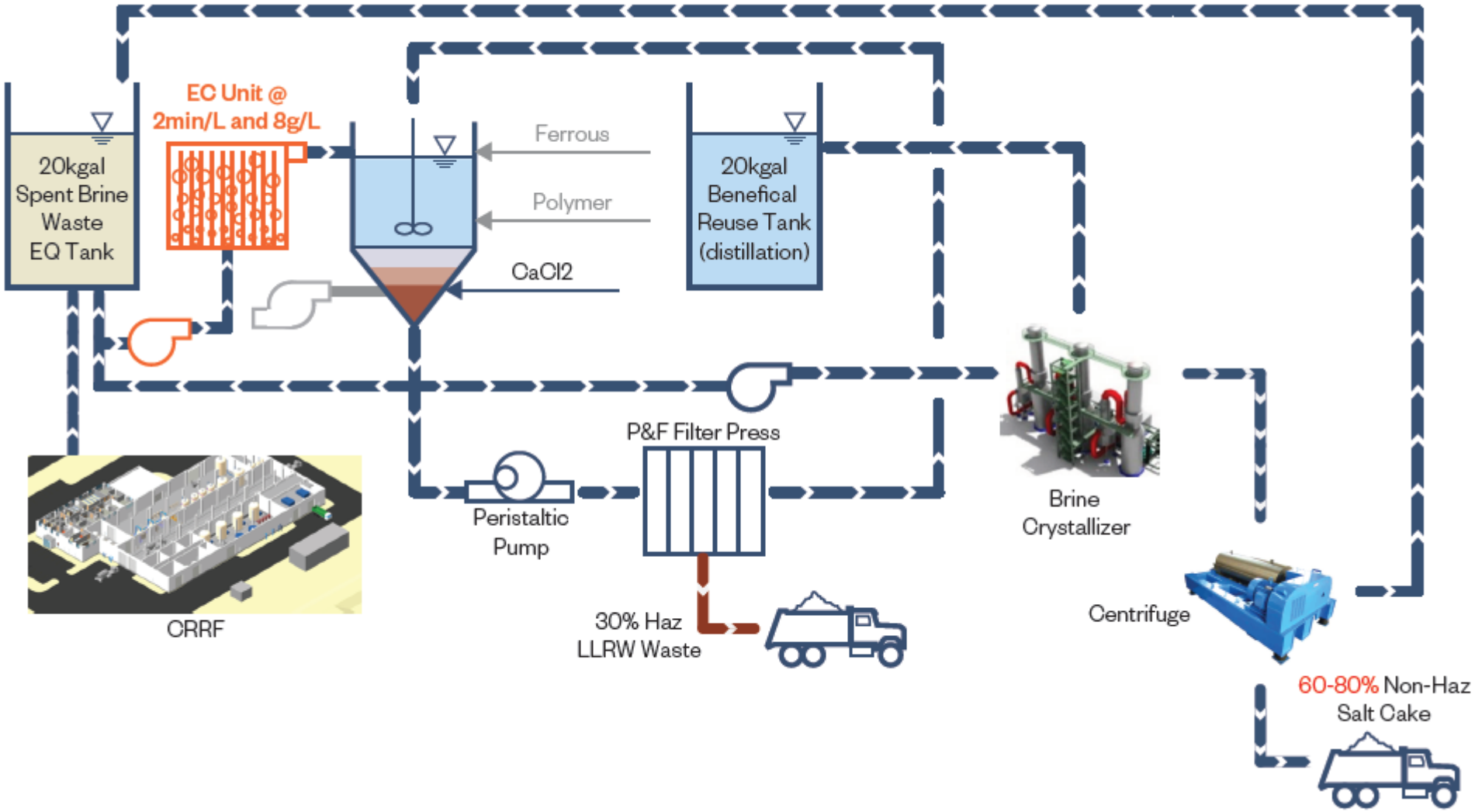
Brine Treatment Field Tests– EC





Brine Treatment – ZLD (EC + BC)

- **Back-up Treatment = CC – grey components**



Brine Treatment Field Tests – 5-um filtered brine

Parameter	Unit	STLC Limits	Untreated Brine	CC Test 1	CC Test 2	CC Test 3	EC (30 s/L)
Fe Dose	g/L	-	-	1.4	0.9	1.2	2.0
Antimony	mg/L	15	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Arsenic	mg/L	5	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Barium	mg/L	100	0.066	0.044	0.029	< 0.02	< 0.02
Beryllium	mg/L	0.75	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Cadmium	mg/L	1	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Chromium	mg/L	5	180	< 0.2	< 0.2	< 0.2	< 0.2
Cobalt	mg/L	80	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Copper	mg/L	25	0.15	0.073	0.041	0.14	0.076
Lead	mg/L	5	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Mercury	mg/L	0.2	0.00025	0.00022	0.00021	0.0002	0.00025
Molybdenum	mg/L	350	87	26	81	48	92
Nickel	mg/L	20	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Selenium	mg/L	1	1.5	1.5	1.6	1.3	1.7
Silver	mg/L	5	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Thallium	mg/L	7	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Vanadium	mg/L	24	28	< 0.3	< 0.3	< 0.3	< 0.3
Zinc	mg/L	250	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Uranium	mg/L	500	150	99	130	110	110

Brine Treatment Field Tests – 5-um filtered brine

Parameter	Unit	STLC Limits	Untreated Brine	1st stage EC 15 S/L	1st stage EC 30 S/L	1st stage EC 2 min/L	2nd stage EC 6 min/L	2nd stage EC w/ chem
Antimony	mg/L	15	< 3	< 3	< 3	< 3	< 3	< 3
Arsenic	mg/L	5	< 1	< 1	< 1	< 1	< 1	< 1
Barium	mg/L	100	< 20	< 20	< 20	< 20	< 20	< 20
Beryllium	mg/L	0.75	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15
Cadmium	mg/L	1	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Chromium	mg/L	5	160	< 1	< 1	< 1	< 1	< 1
Cobalt	mg/L	80	< 16	<	< 16	<	<	< 16
Copper	mg/L	25	< 5		< 5			< 5
Lead	mg/L	5	< 1		< 1			< 1
Mercury	mg/L	0.2	< 0.0017	< 0 17	< 0.0017	< 0 17	< 0 17	< 0.0017
Molybdenum	mg/L	350	< 70	<	79		<	< 70
Nickel	mg/L	20	< 4	< 4	< 4	< 4	< 4	< 4
Selenium	mg/L	1	1.7	2	2	2	1	0.63
Silver	mg/L	5	< 1	< 1	< 1	< 1	< 1	< 1
Thallium	mg/L	7	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4	< 1.4
Vanadium	mg/L	24	19	< 4.8	< 4.8	< 4.8	< 4.8	< 4.8
Zinc	mg/L	250	< 50	< 50	< 50	< 50	< 50	< 50
Thorium	mg/L	500	< 2	< 2	< 2	< 2	< 2	< 2
Uranium	mg/L	500	78	64	69	0.25	< 0.06	0.10

3 kWh/kgal

25 kWh/kgal

75 kWh/kgal

Summary

- Residuals disposal is one of the most challenging aspects of CRRF chromium treatment
- Chemical coagulation and electrocoagulation provided good removal of chromium, uranium and most other metals
- Selenium remains a challenge and can be reduced with very high EC doses and/or chemical addition
  - but waste production and operational requirements are high…potential for iron doped gypsum generation
- Brine crystallizer used to manage EC filtrate = true ZLD facility
  - Solid make-up – majority NaCl and Na_2SO_4

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