Future of Reclaimed Water Coagulation

From Flintstone to Electro-Chemistry

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TACWA
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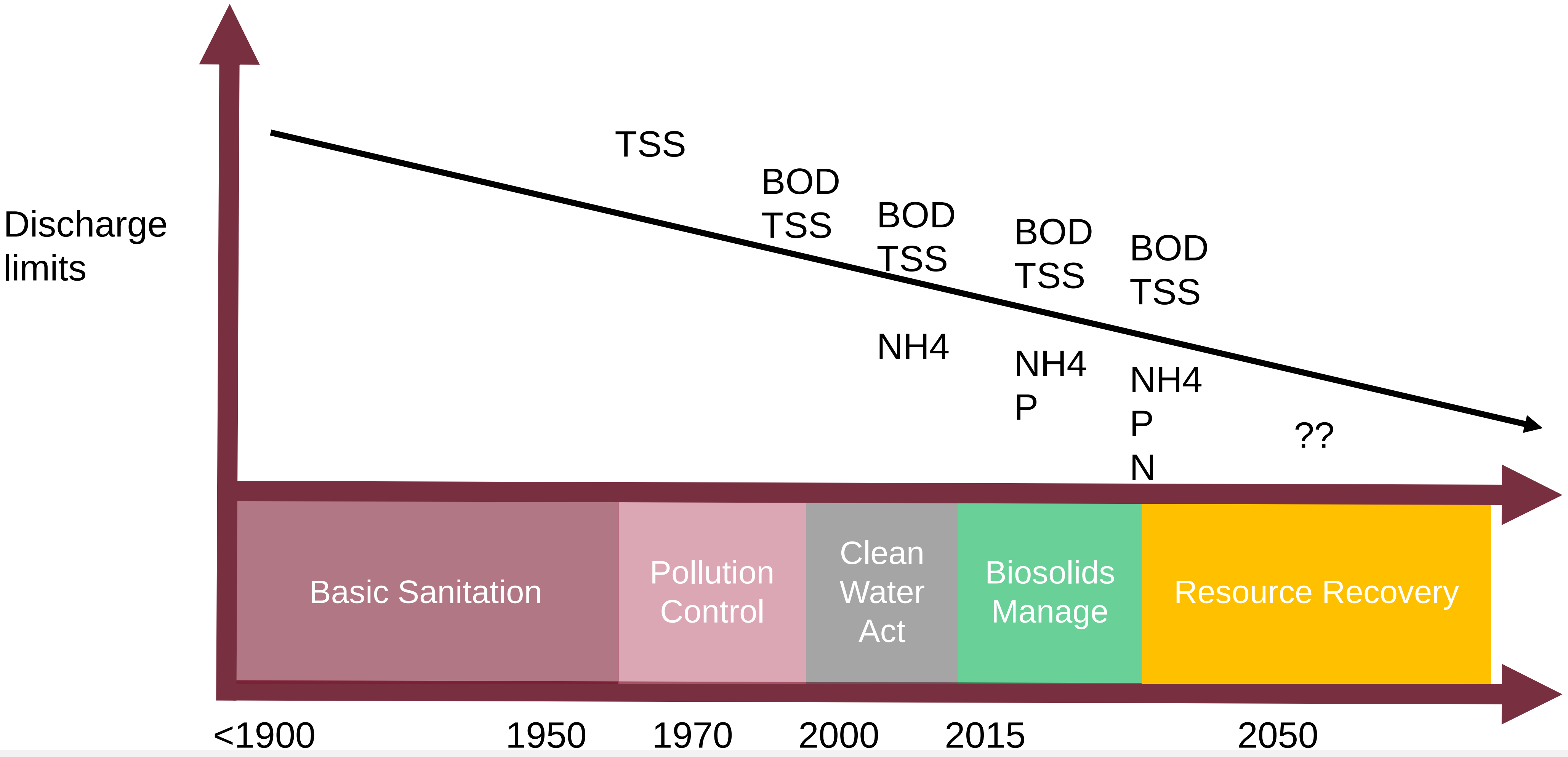
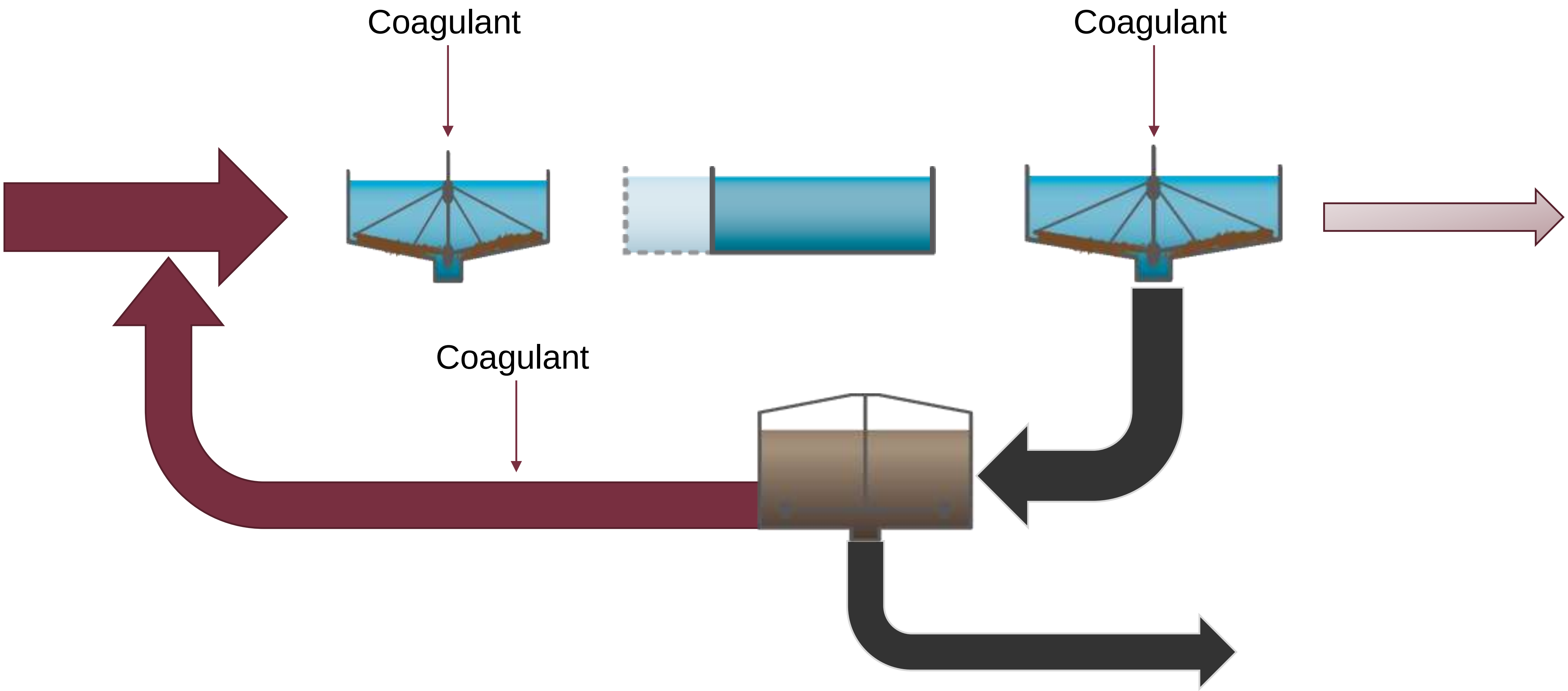
More stringent discharge limits have necessitated new treatment and resource recovery approaches



Adding chemical coagulants has helped reduced organic and phosphorus loadings in multiple locations (solids and liquids)

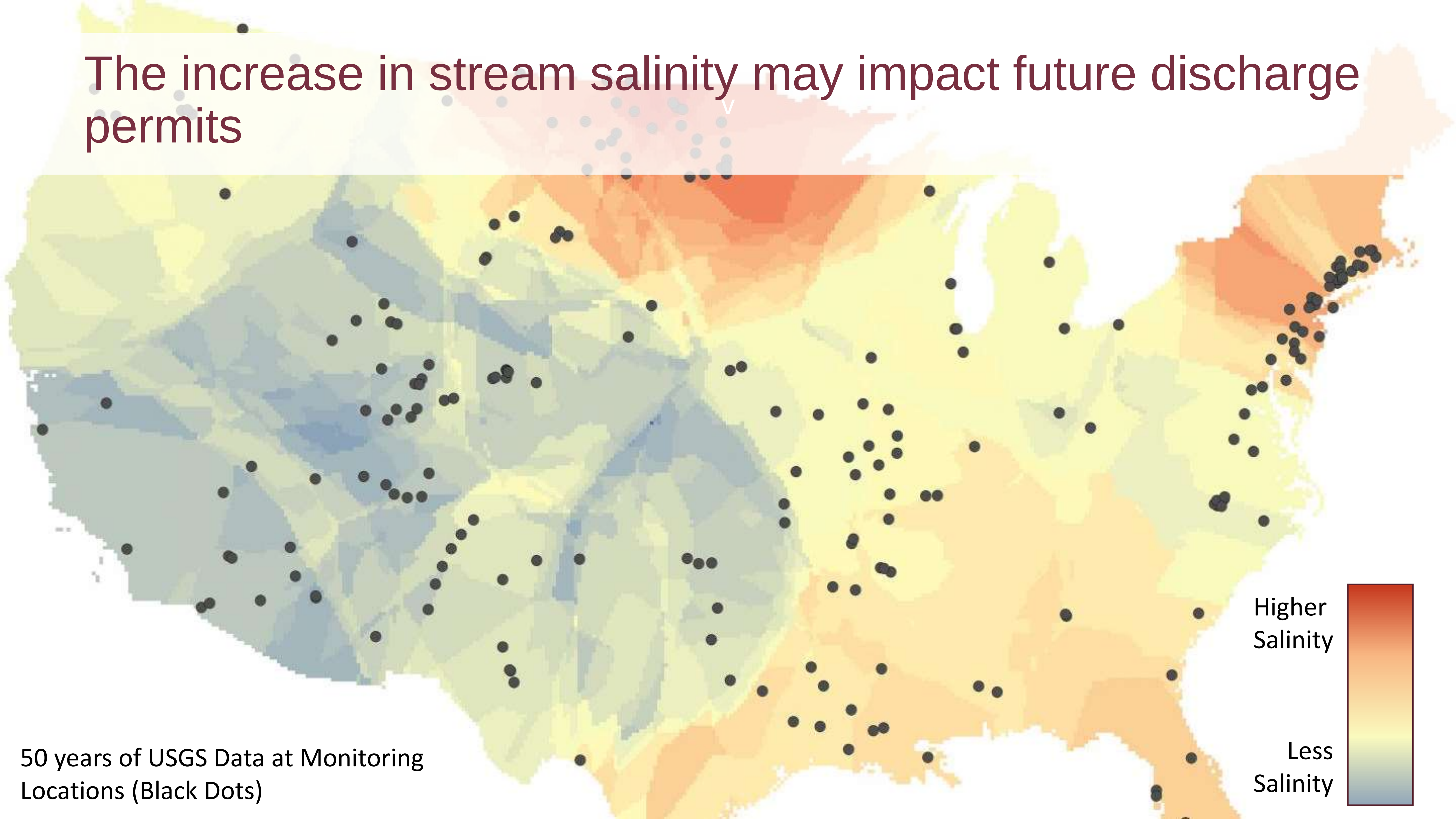


Both Ferric and Alum require the addition of a counter-ion that contributes to effluent Total Dissolved Solids

Alum $Al_2(\underline{SO_4})_3 + 6H_2O \rightarrow 2Al(OH)_3 + 3H_2\underline{SO_4}$

Ferric $2Fe\underline{Cl_3} + 3H2O \rightarrow Fe_2O_3 + \underline{6HCl}$

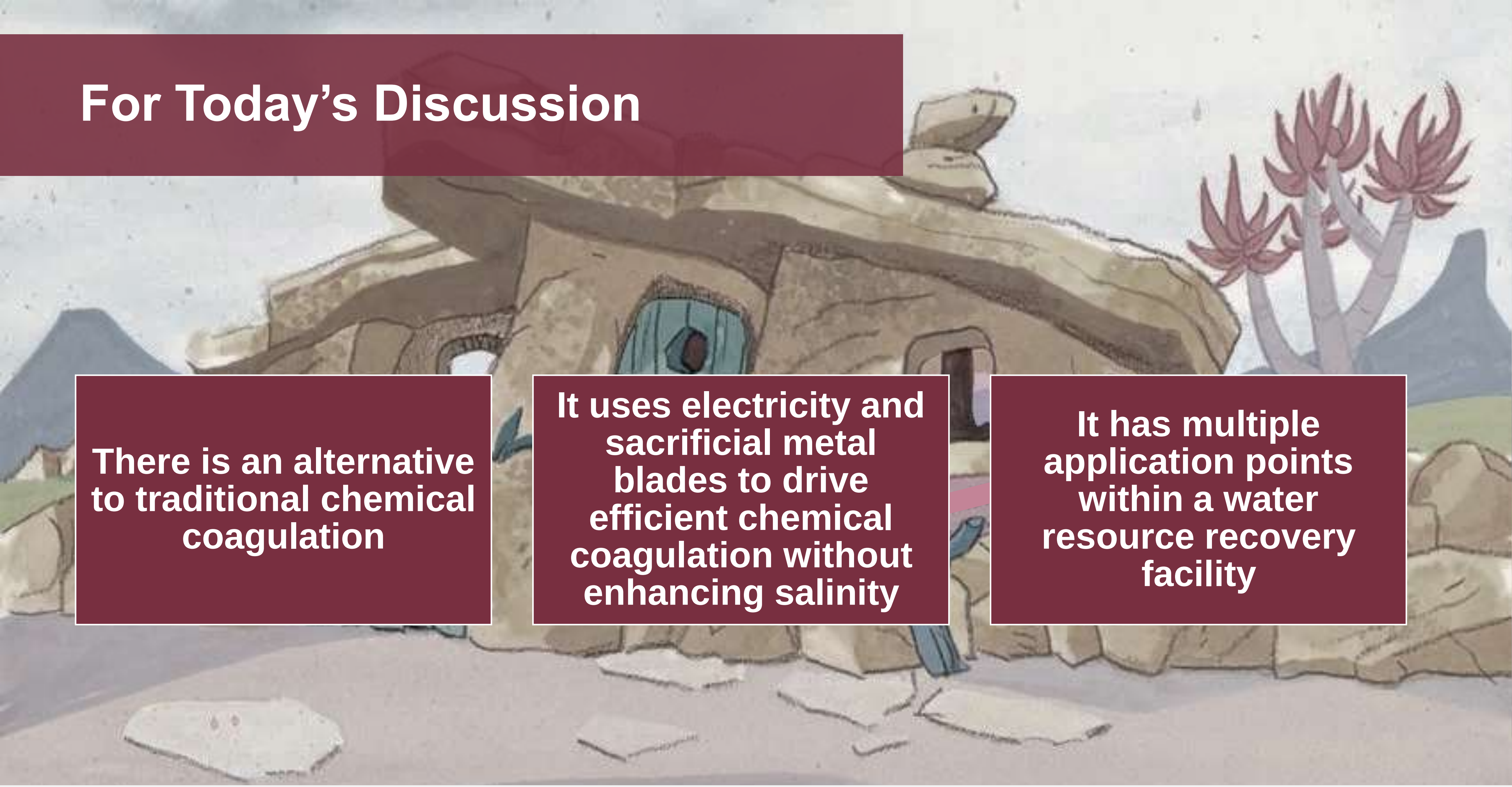
The increase in stream salinity may impact future discharge permits



50 years of USGS Data at Monitoring Locations (Black Dots)

Much like Fred Flintstone evolved from selling cigarettes to grape juice, **WRRF coagulation is likely to adopt ‘healthier’, salt-less alternatives in the future**

For Today's Discussion



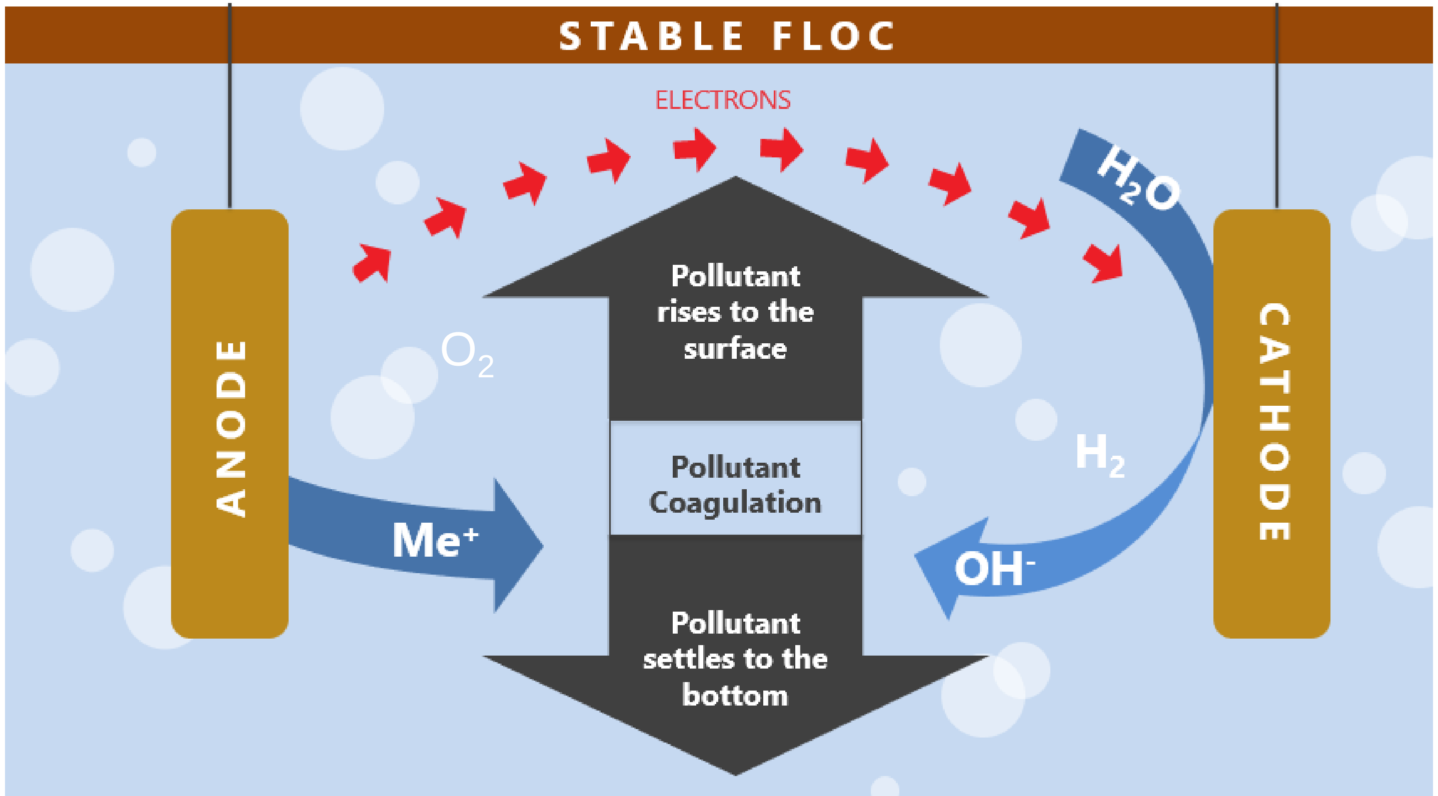
There is an alternative to traditional chemical coagulation

It uses electricity and sacrificial metal blades to drive efficient chemical coagulation without enhancing salinity

It has multiple application points within a water resource recovery facility

Electro-chemistry can provide coagulation without salt addition

Electro-coagulation processes utilize electrodes (cathode/anode) submerged in a solution with conductivity (i.e., TDS)



The EC process applies electricity to sacrificial electrodes in order to…

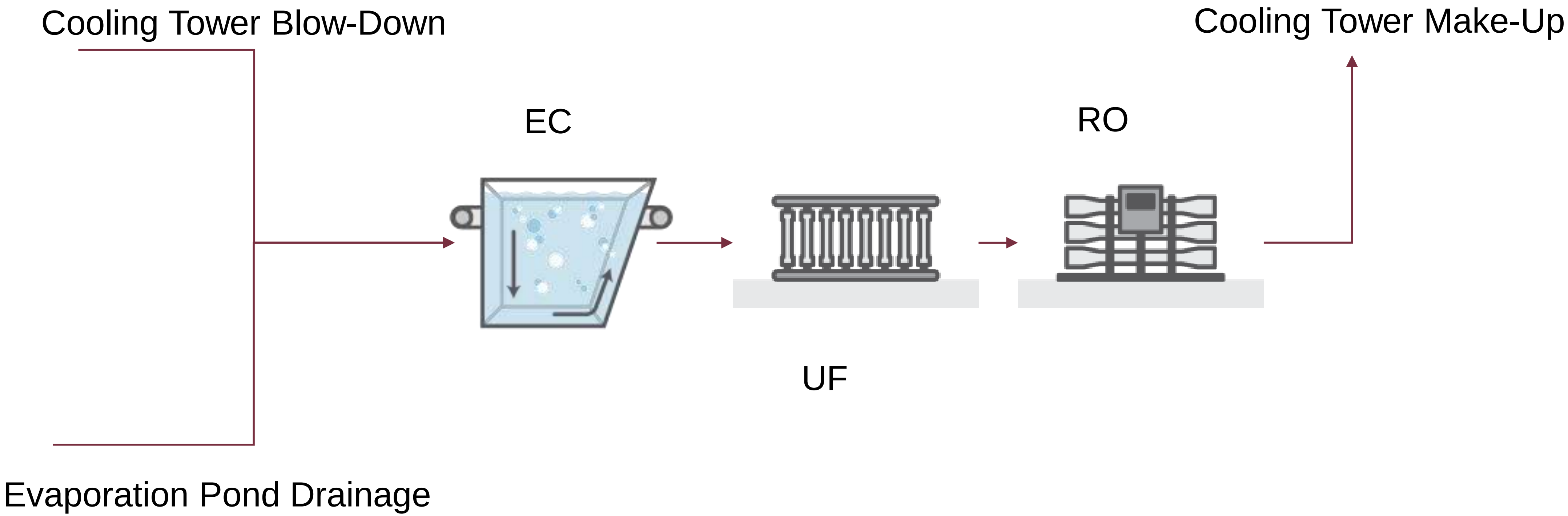
Generate coagulants

Destabilize contaminants

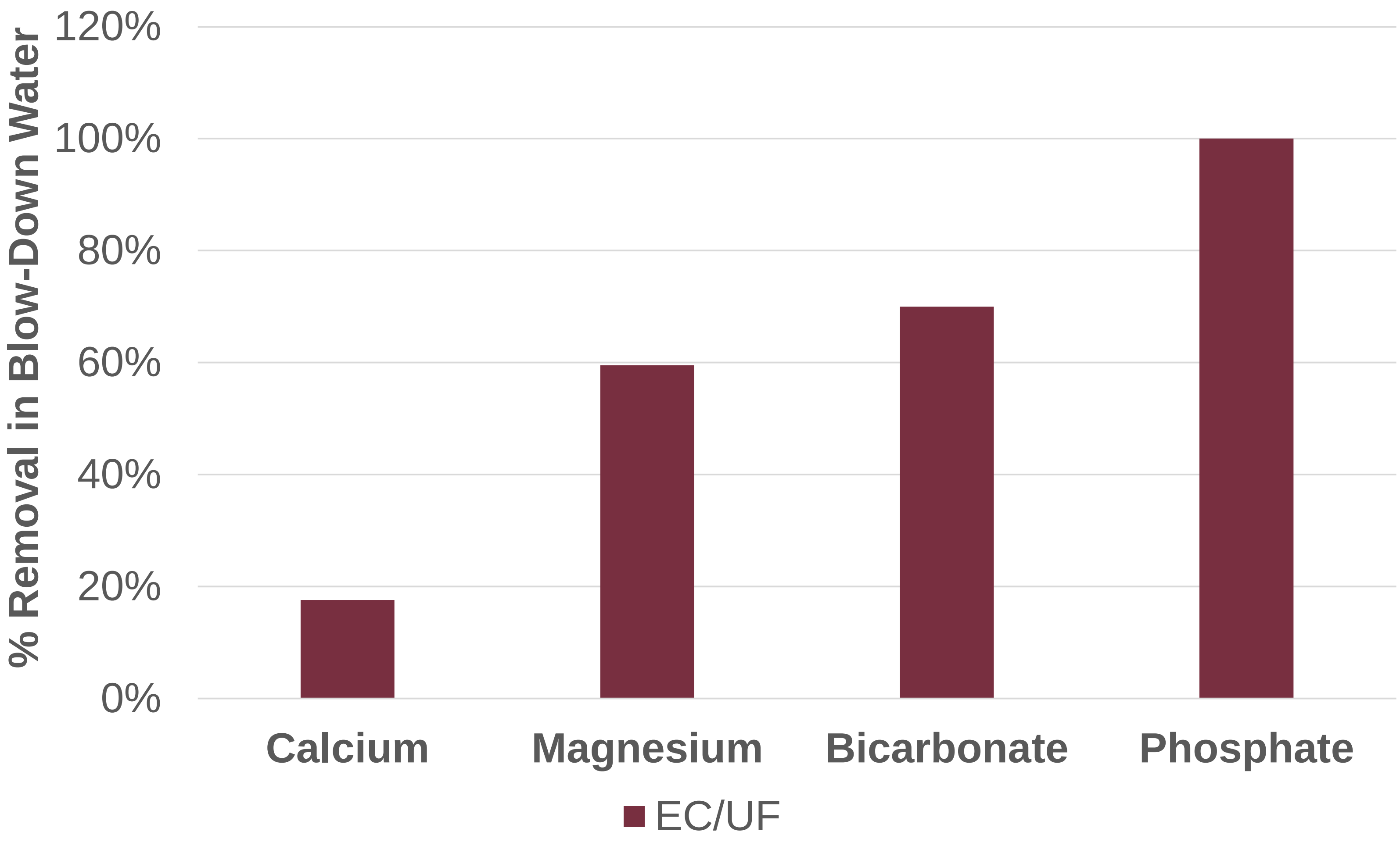
Enhance the suspension of particulates

Disrupt emulsions

El Paso Electric **currently employs Electro-coagulation** (EC) for pretreatment of desalting membrane feed flow



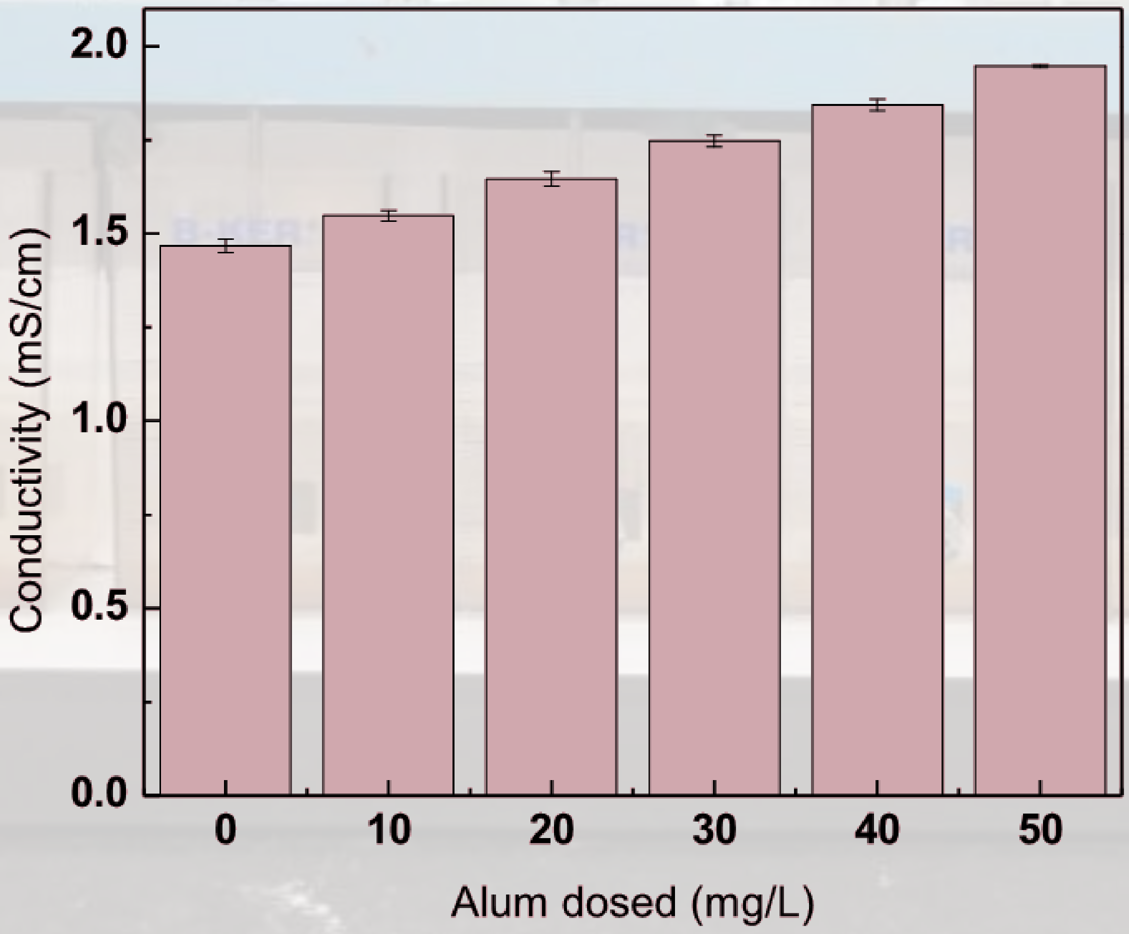
EC for RO pretreatment provides **significant removal of scale forming constituents**



Source: Bustamante and Mauricio, 2010

It uses electricity and sacrificial metal blades to drive efficient chemical coagulation without adding salt

In most cases, **TDS (as conductivity) increases** with alum dosage

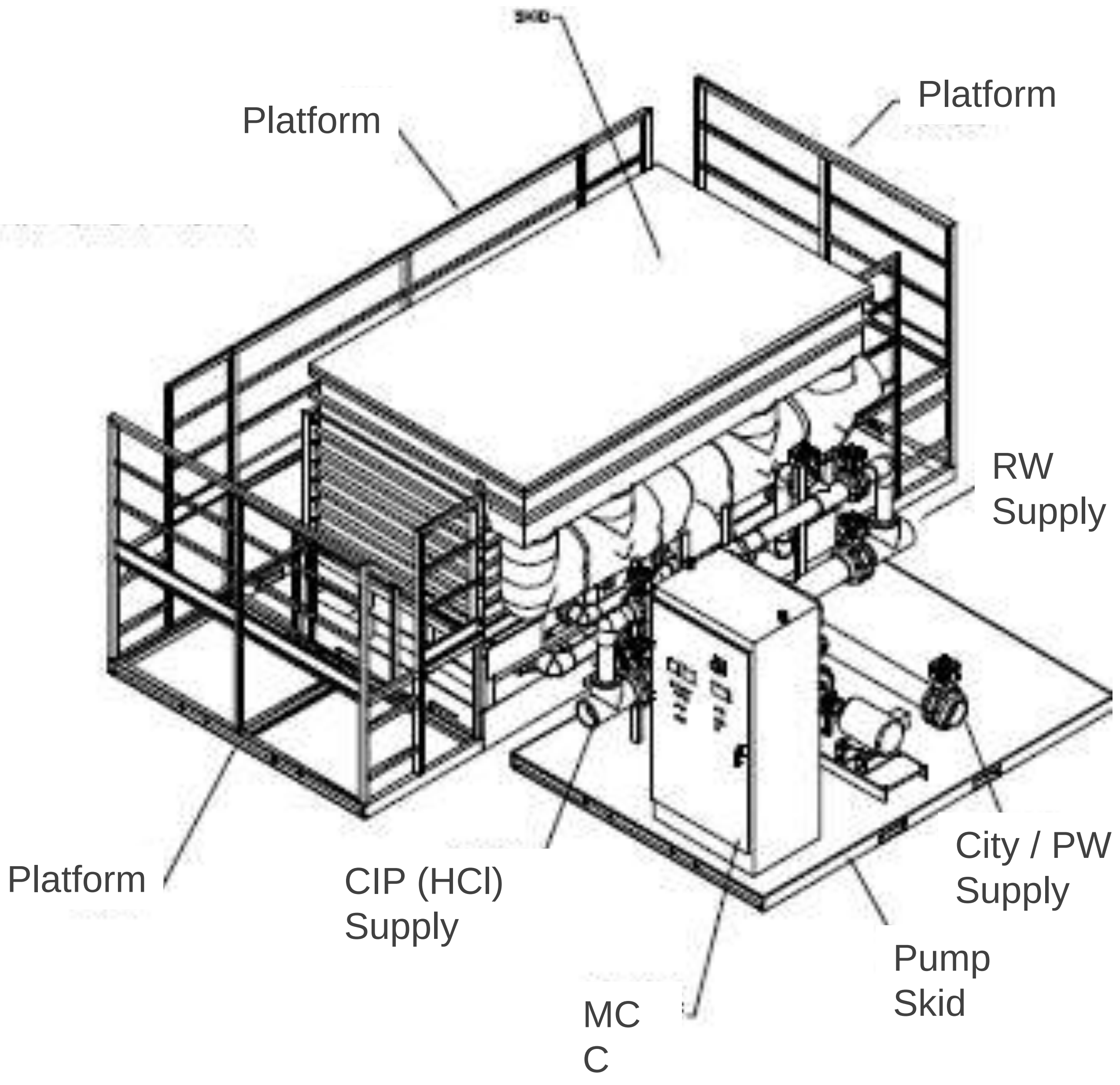


A standard (ASTM A-1011) iron blade for EC will have minimal counter-ions for dissolution

Blade Constituent	%
Iron	99.185
Carbon	0.02 – 0.15
Manganese, max.	0.60
Phosphorus, max.	0.03
Sulphur, max.	0.035

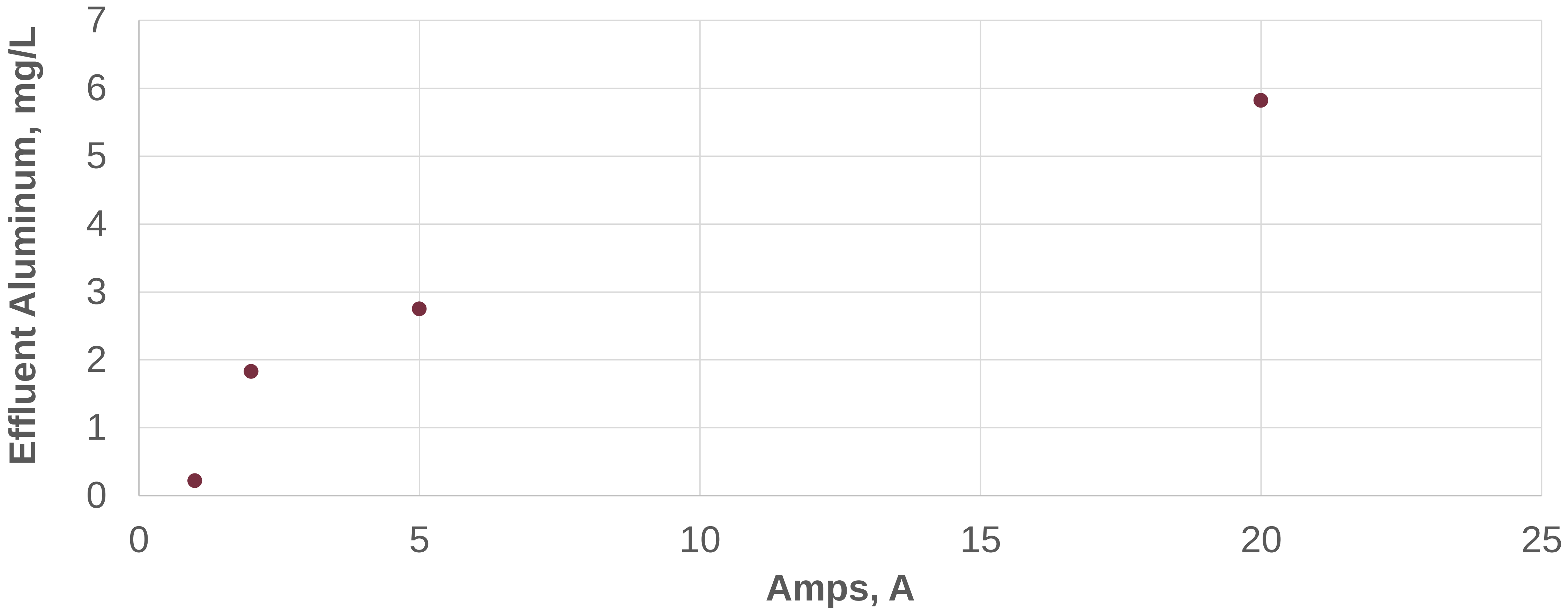
Iron Blades for EC can be \$0.2 - \$0.5 per lb. (typical)

EC systems include…

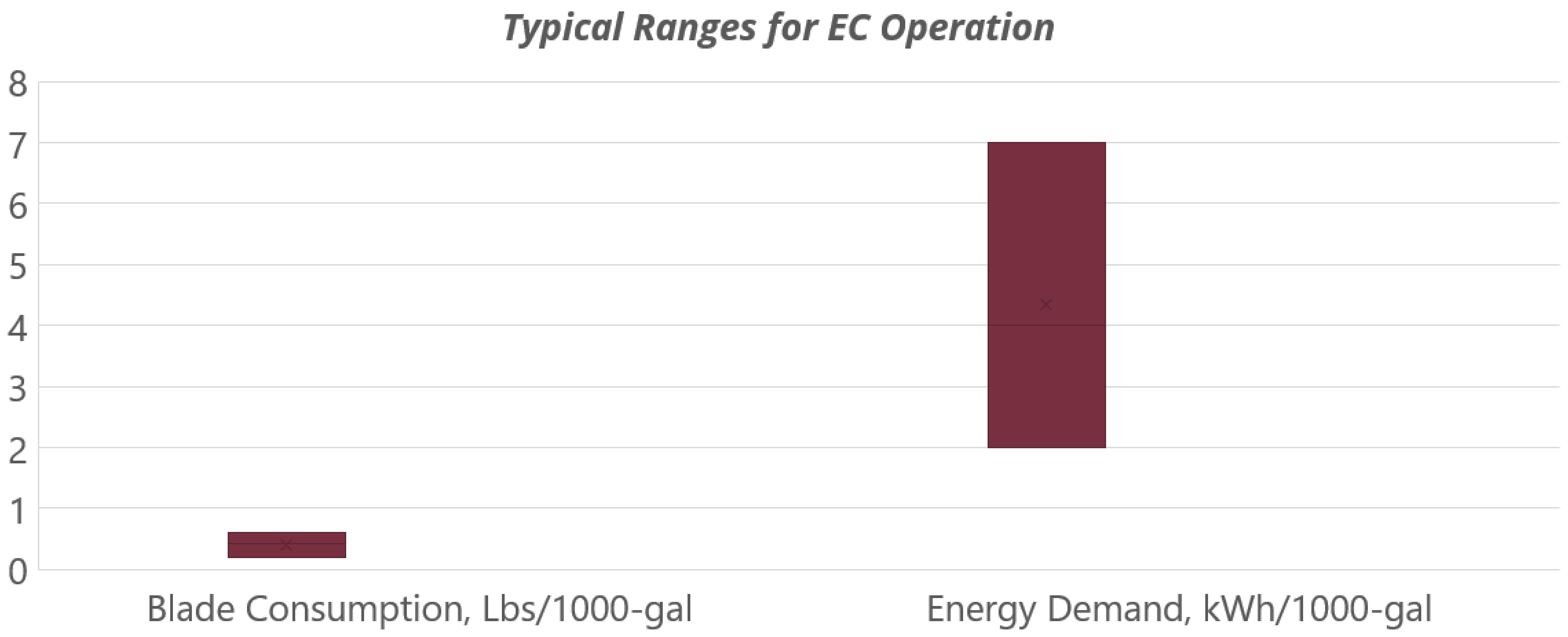


Applied amperage drives the dissolution of M(s)

Example: Pilot test with aluminum EC for Fluoride removal (Courtesy of Castle Rock, CO)

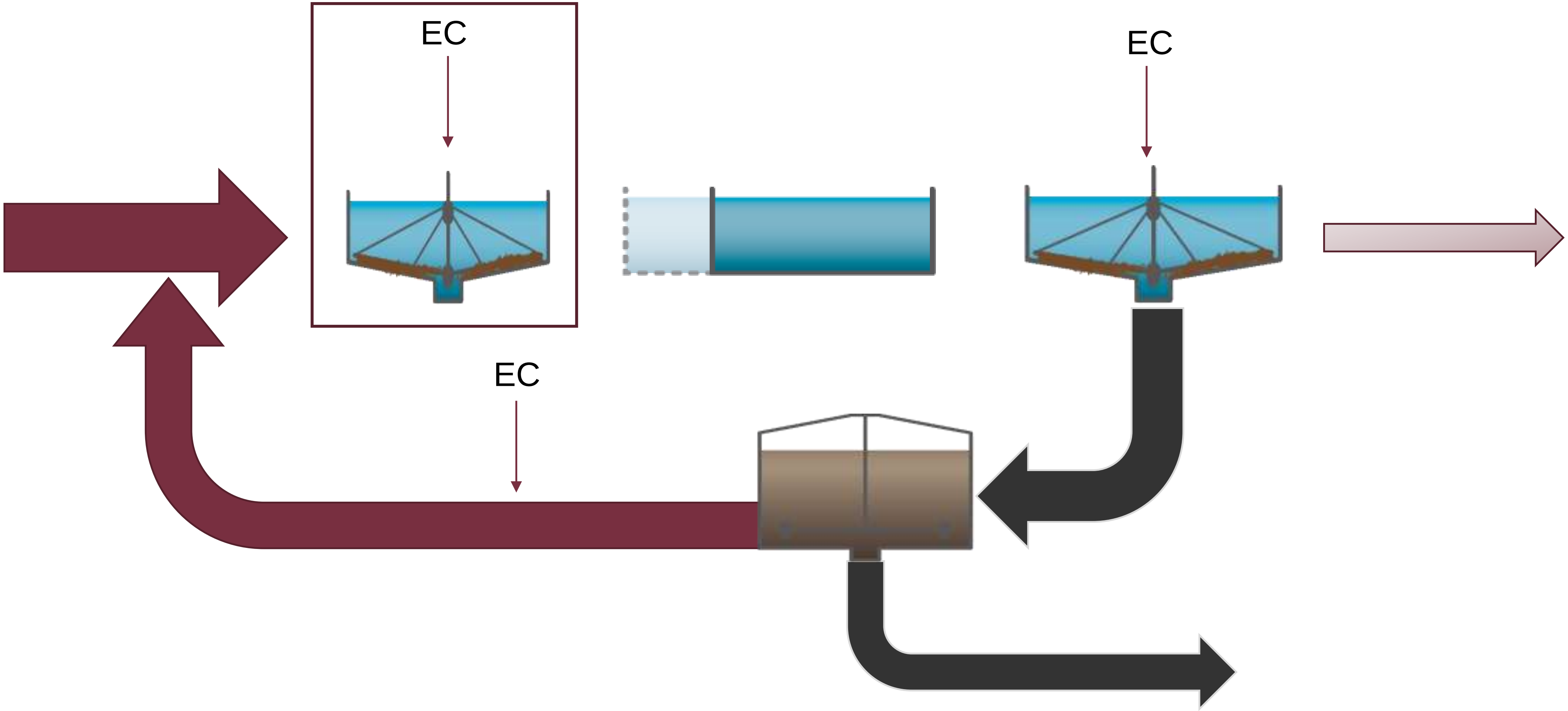


Therefore, OPEX is driven by both blade costs and power consumption

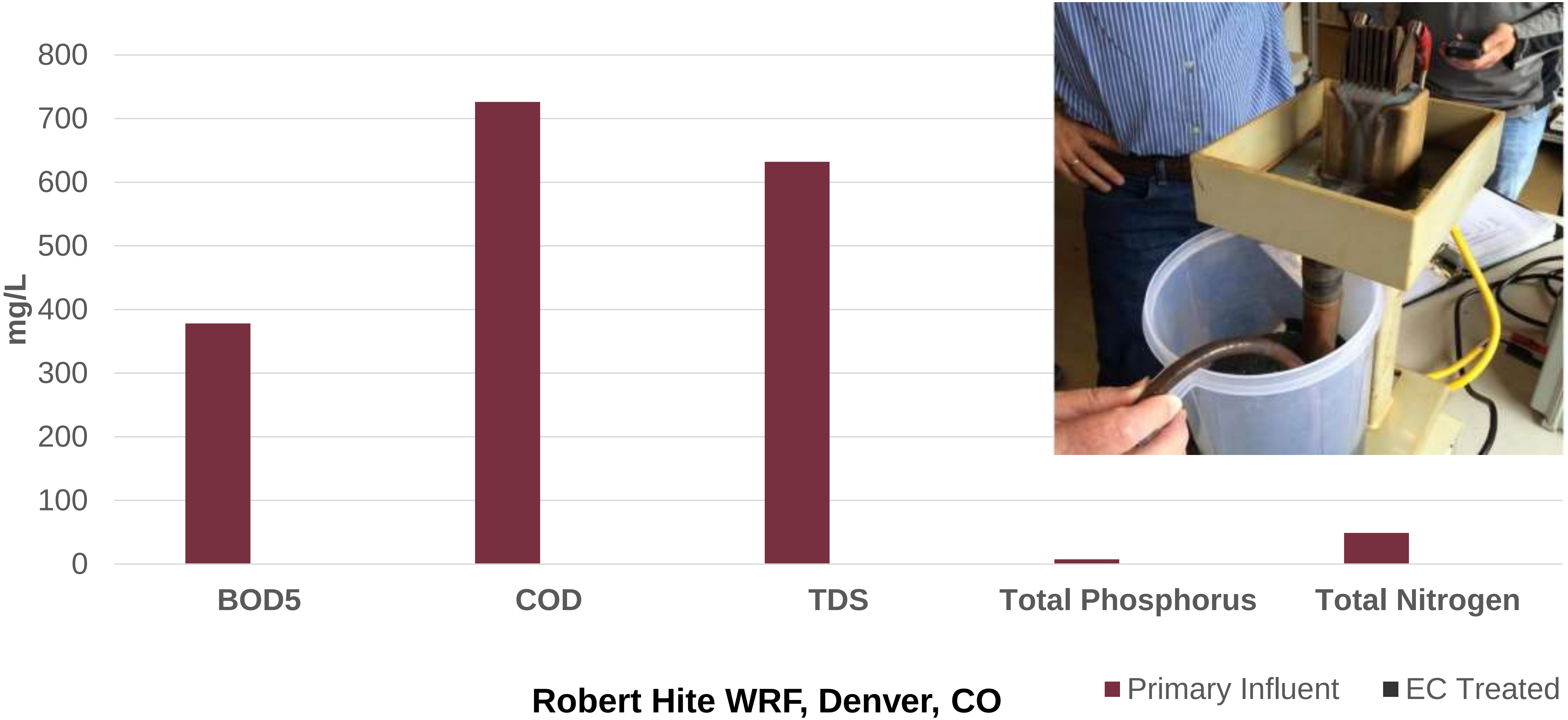


EC has multiple application points within a WRRF

EC can replace chemical coagulation at three primary application points within the solids and liquids trains



Primary Influent characteristics before EC treatment



Robert Hite WRF, Denver, CO

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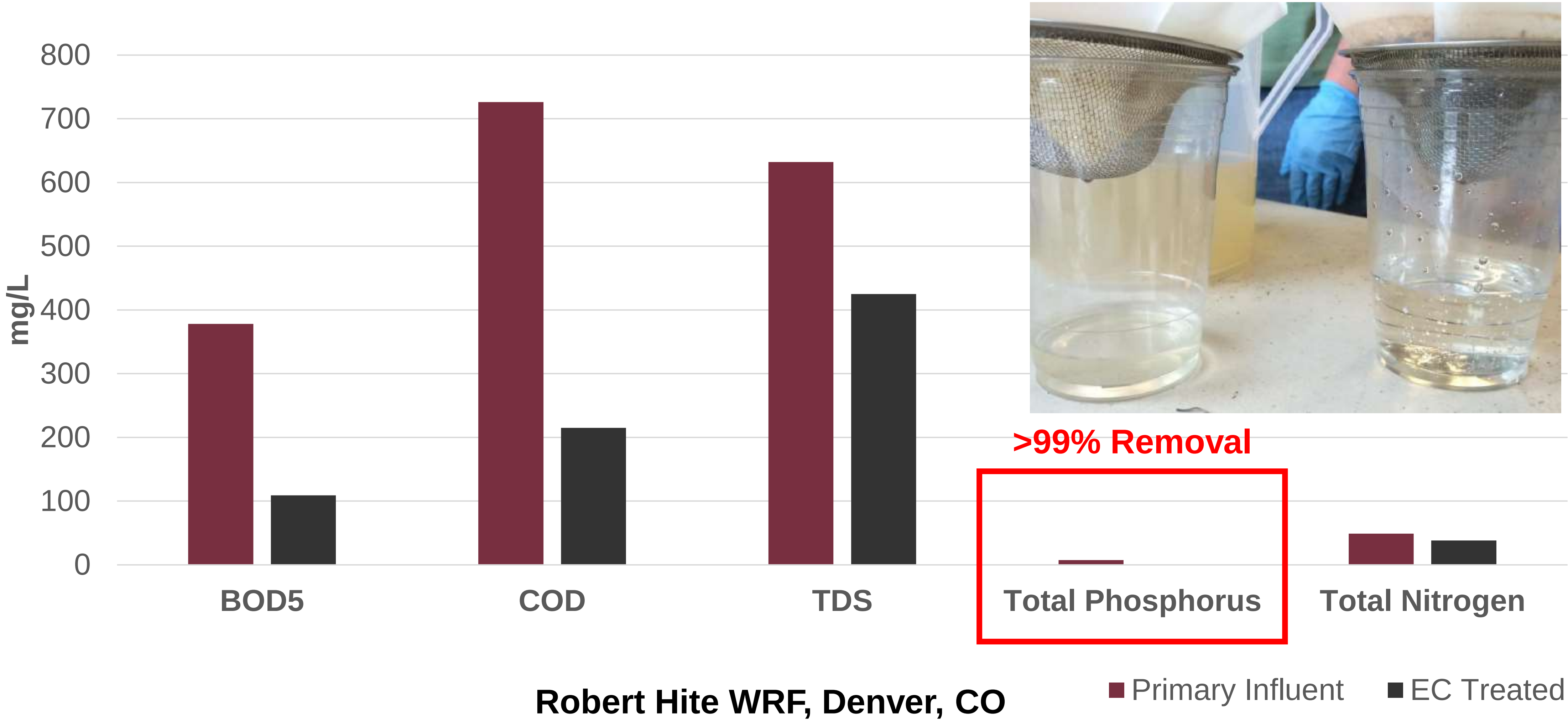

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Bench-top EC treatment of Primary Influent

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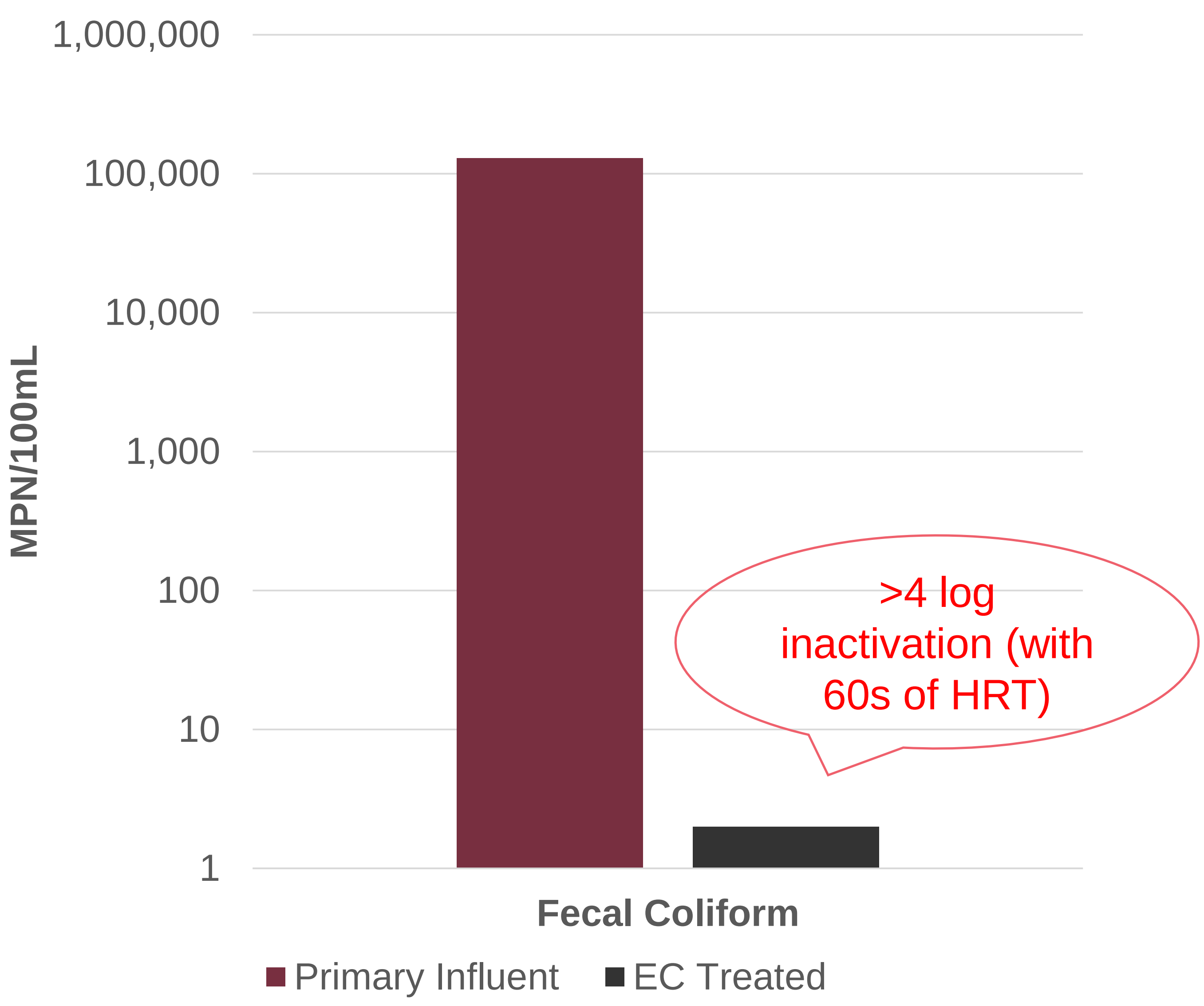

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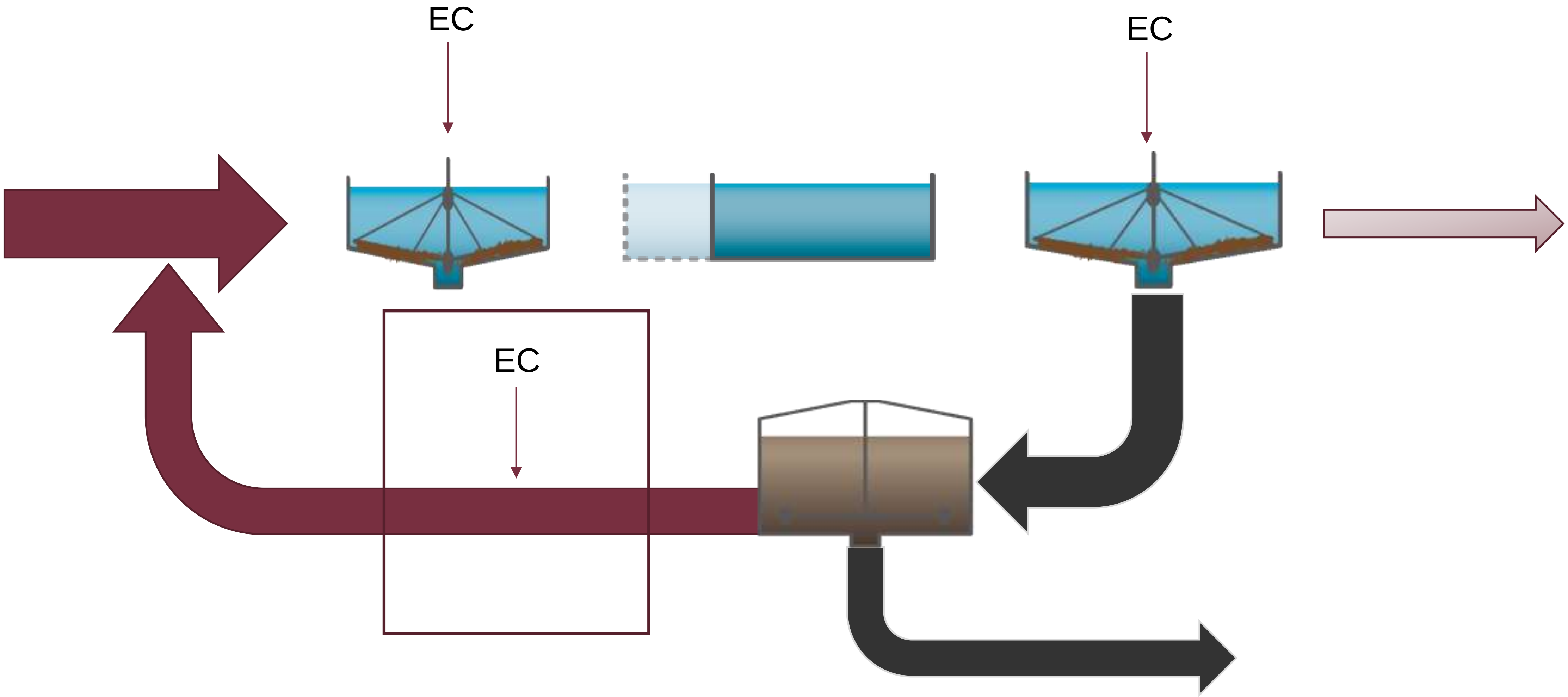
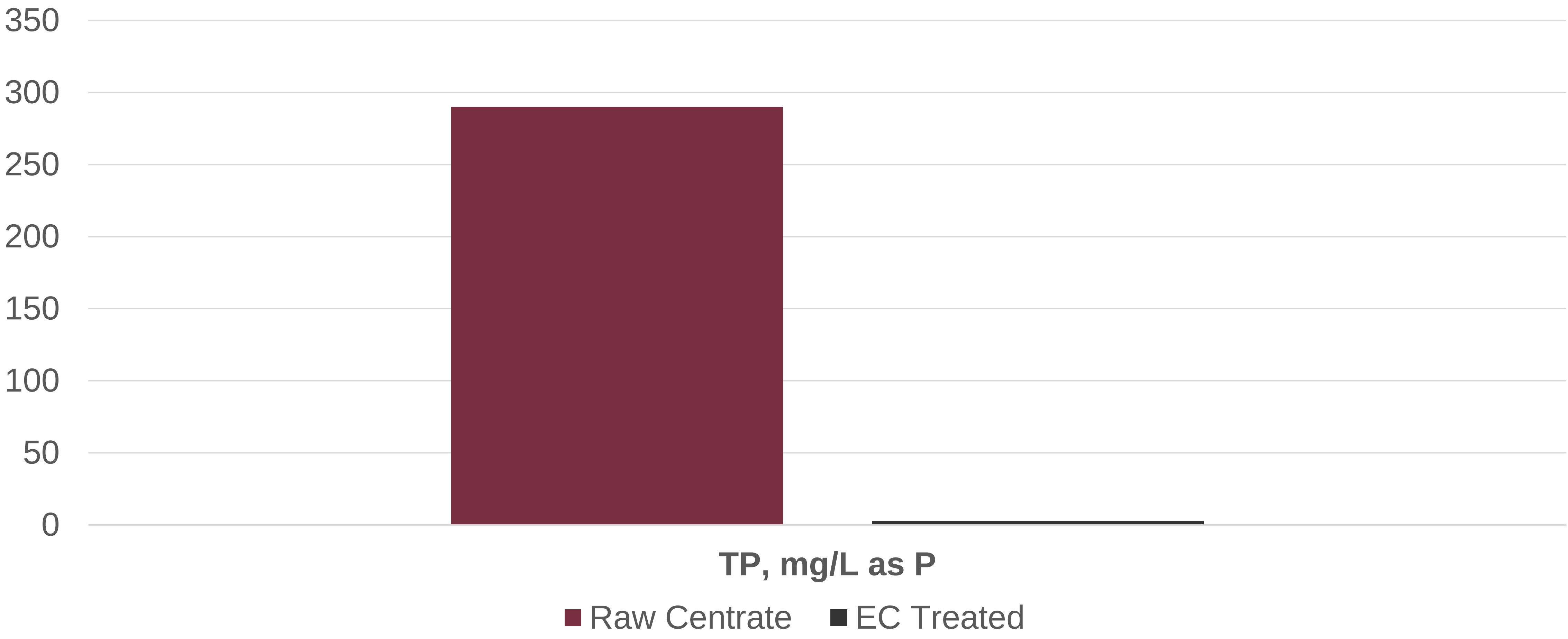


Bench-top testing of centrate return flows (post polymer and peroxide addition) at the Hite WRF (Denver, CO)



Parting Thoughts . . .

There are several EC manufacturers with equipment that can be designed for municipal water resource recovery

1,000 gpm Powell Water EC (left) followed by UF (right)

100 gpm Ecolotron EC Reactor

Baker Corp (formerly Kaselco) EC system

87.5 gpm Origin Clear, Inc EC

Bosque EC (mobile unit)

760 gpm Mobile Cleanwave EC

Laboratory testing can elucidate the appropriate equipment and metal blades for each application

Table 2 - Suggested Test Plan Parameters

LOCATION:	EC Manufacturer #1			EC Manufacturer #2		
Field Analysis - Operating Parameter:	Raw	Treated	Percent Removed	Raw	Treated	Percent Removed
Sample Volume (L)						
pH (#)						
ORP (#)						
Turbidity (FAU)						
Temperature (deg F)						
Nitrate (mg/L)						
Ammonia (mg/L)						
Total Hardness (mg/L as CaCO3)						
TDS (mg/L)						
Wet blade surface area (in^2)						
HRT (min)						
Current (amps)						
Volt (V)						
Blade material (iron/aluminum)						
Blade weight$_i$ / weight$_f$ (mg)						
Catalyst concentration added (type/mg/L)						
Filterability (500 mL @ X min w/ 11 um paper)						
Lab Analysis - Removal Efficiency of:	Raw	Treated	Percent Removed	Raw	Treated	Percent Removed
pH (#)						
BOD (mg/L)						
COD (mg/L)						
Alkalinity (mg/L)						
TKN (mg/L)						
Ammonia (mg/L)						
Nitrate (mg/L)						
Phosphorus (mg/L)						
Fecal (MPN)						
TSS (mg/L)						
Ca Hardness (mg/L)						
Mg Hardness (mg/L)						
TDS (mg/L)						
RCRA 8 Metals						
Fecal (MPN/g dry solids)						
TCLP solids						
Classification of residuals generated from process with respect to:						
amount generated (lb/day)						
percent solids (% by wt.)						
biosolids classification (A or B)						
TCLP hazardous waste (y/n)						
disposal costs ($/yr)						
Configuration of unit process with respect to:						
integration with existing process train						
required footprint (ft^2/gpm)						
energy intensity (kWh/kgal)						
proprietary blades (y/n)						
full scale installations > 50 gpm (#)						
references available (#)						
full scale capital costs ($/gpm)						
full scale operational costs ($/kgal)						

New operational strategies have reduced the challenges that plagued early EC water treatment systems

Oxidation of Blades

Acid (HCl, typ.) CIP

Automatic Reversal of Polarity

Blade Replacement

Atmospheric EC systems for improved blade accessibility

Quick blade release systems

However . . .

Short municipal installation list (no long-term track record)

Energy efficiency is a function of volts per (blade) gap, conductivity of water and EC chamber configuration

Largest EC system can treat 1,000 gpm (1.4 MGD)

Questions?

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