

42nd Annual Conference & Exhibition

April 3-6, 2023

Embassy Suites Loveland Hotel & Conference C

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TO APR 6

**REGISTRATION IS NOW OPEN!**

42

**COLORADO**

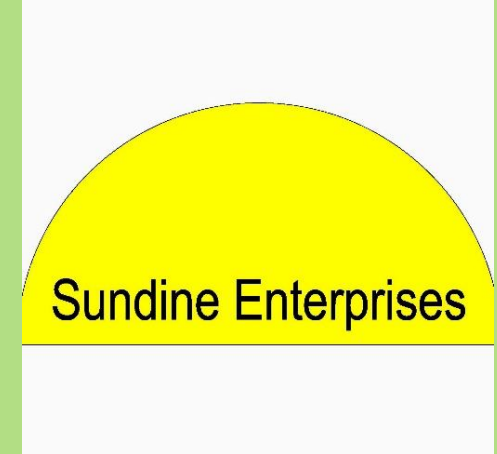
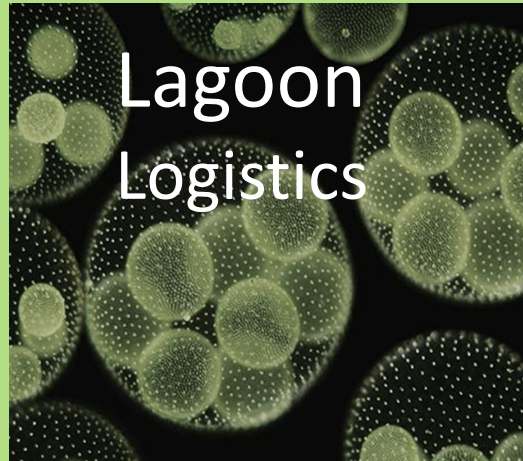
RURAL WATER

CONFERENCE & EXHIBITION

GET THE **LEAD** OUT

<https://www.crwa.net/>

# Powell Water Micro Algae System (PWMAS) Natures Way of Cleaning Water for Abundant Use



Electrocoagulation &  
Support Equipment

[www.powellwater.com](http://www.powellwater.com)

Powell Water System, Inc.

Scott Powell, President

**(303) 241-2489**

Design, Build and  
Operation

Lagoon Logistics, LLC

Jeff Couch

President

**(970) 231-9937**

Sundine Enterprises

Microalgae Microbe  
Assemblages

Sundine Enterprises,  
Inc.

Judd Sundine,  
Horticulturist

**(720) 363-0548**

United States Patent Number 10358361 B2 & 11407660 B2. System and Method for Remediation of Wastewater Including Aerobic, Anaerobic and Electrocoagulation Technology. This patent is wholly licensed by Powell Water Systems, Inc.

# Powell Water Micro Algae System

Biological and Electrical Treatment Advantages  
Broad Spectrum Treatment

- PFOA/PFOS (Removal in Both Water and Solids)
- Solid Removal with Biological Conversion
- Arsenic Removal Below Detectable Limits
- Lead & Copper Removal
- Cadmium & Zinc ions
- Effective Disinfection
- Nutrient Removal
- Lower Initial Investment
- Lower Operating Costs



# Proposed New Discharge Limits

## Colorado

- **PFOA PFOS PFAS – 0.004 ug/l**
- **Lead – 0.015 mg/l Action Level**
- **Copper – 1.3 mg/l Action Level**
- **Arsenic – 0.02 ug/l**
- **Phosphate – 0.025 mg/l**

## Missouri

- **Ammonia – 0.60 mg/l**
- **Phosphorus – 0.50 mg/l**

**Virtually all EPA wastewater discharge permits will have more restrictive effluent standards between now and 2027.**

# We need to change the way we approach water treatment

**Traditionally:** we try to solve one water treatment problem at a time, and we ignore the overall consequences of the traditional water treatment step.

**For example:** Hard water in our homes block our pipes, makes our skin uncomfortable after bathing, and makes washing our clothes more difficult.

**Traditional Solution:** Ion exchange water softening removes calcium, magnesium, and hardness from the water used in the house.

**Unintended problem:** The added Total Dissolved Solids (TDS) being discharged back into the river makes it more difficult for the cities down stream to make drinking water! The problem is compounded in each city.

**Innovative Solution:** **Municipal Electrocoagulation, at the well head before potable water distribution, will remove calcium, magnesium, and hardness, in a solid form, with clean electricity, eliminating the need for in home ion exchange water softening.**

**Overall Benefit:** Soft Water in every home in the city. Less cleaning product TDS added to sewer. Cleaner softer drinking water for the city downstream.

# Well Water Eastern Colorado City

Table 1: Summary of Potable Water Quality

(all wells combined, samples collected between January and March 2020)

<u>Parameter</u>	<u>Unit</u>	<u>Average</u>	<u>Maximum</u>
TDS	mg/L	268	295
pH	s.u.	7.5	8.0
Alkalinity	mg/L as CaCO <sub>3</sub>	141	157
Calcium	mg/L	105	121
Magnesium	mg/L	35	50
Hardness	mg/L as CaCO <sub>3</sub>	407	506
Sulfate	mg/L	11	14
Chloride	mg/L	10	12

## Hardness Classification as Calcium Carbonate in mg/l

Soft water	less than 17	Hard water	121 to 180
Slightly hard	17 to 60	Very hard	above 181
Moderately hard	61 to 120	<b>This city</b>	<b>407 mg/l</b>

# City Wastewater Entering the Sewer

Table 2: Summary of Influent Wastewater Quality  
(samples collected between January and March 2020)

<u>Parameter</u>	<u>Unit</u>	<u>Average</u>	<u>Maximum</u>
TDS	mg/L	553	611
pH	s.u.	8.0	8.6
Alkalinity	mg/L as CaCO <sub>3</sub>	300	348
Calcium	mg/L	135	229
Magnesium	mg/L	38	60
Hardness	mg/L as CaCO <sub>3</sub>	493	819
Sulfate	mg/L	13	27
Chloride	mg/L	95	135

Environmental Protection Agency (EPA) **National Secondary Drinking Water Regulations for Total Dissolved Solids (TDS) is 500 mg/l**

# TDS Increases From Wells to Sewer

TDS increase	285 mg/l	106%
Calcium increase	30 mg/l	29%
Magnesium increase	3 mg/l	9%
Sulfate increase	2 mg/l	18%
Chloride increase	85 mg/l	850%

Colorado Department of Public Health and Environment (CDPHE) would like a Total Dissolved Solids (TDS) reduction of 150 to 200 mg/l



# Home Water Softeners Add TDS

**Ion exchange water softeners** add two Sodium ions and two chloride ions into the home water for each Calcium ion removed from the water.

To regenerate the ion exchange resin, saturated sodium chloride is used. The sodium, chloride, magnesium, calcium, and hardness is returned to the water going to the sewer plant.

In home water softeners added 85 mg/l chloride & 55 mg/l sodium, or **140 mg/l TDS** to the well water entering the home creating sewer water leaving the home.

# Softening Well Water with Electricity

Calcium removal at 90% of 105 mg/l	94 mg/l
Magnesium removal at 90% of 35 mg/l	<u>32 mg/l</u>
Total TDS removed as solids	126 mg/l
Sodium Chloride that was not added	<u>140 mg/l</u>
Effective reduction of TDS at sewer	266 mg/l

CDPHE TDS desired reduction is 150 to 200 mg/l

If you do not add the Sodium Chloride to the water in the home, you do not need to take it out at the sewer.

Every Home benefits from Soft Water.

The Towns Down Stream receive Soft Water.

# Powell Water Micro Algae Systems

## Innovative Lagoon and Electrocoagulation

90% reduction in electrical aeration costs.

90% reduction in accumulated lagoon solids.

90% reduction in carbon dioxide creation.

50% reduction in disinfection costs.

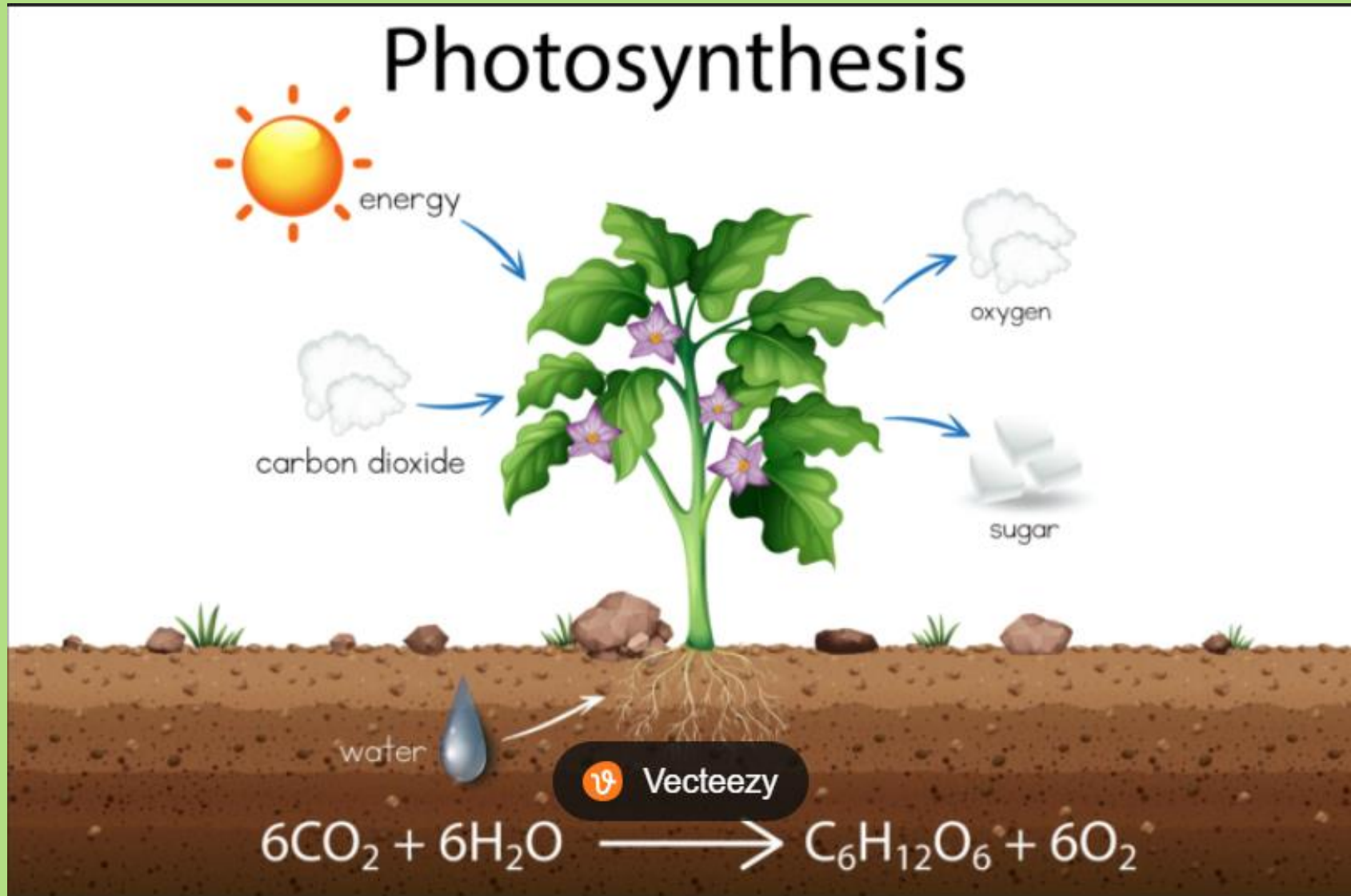


**Primary Treatment**



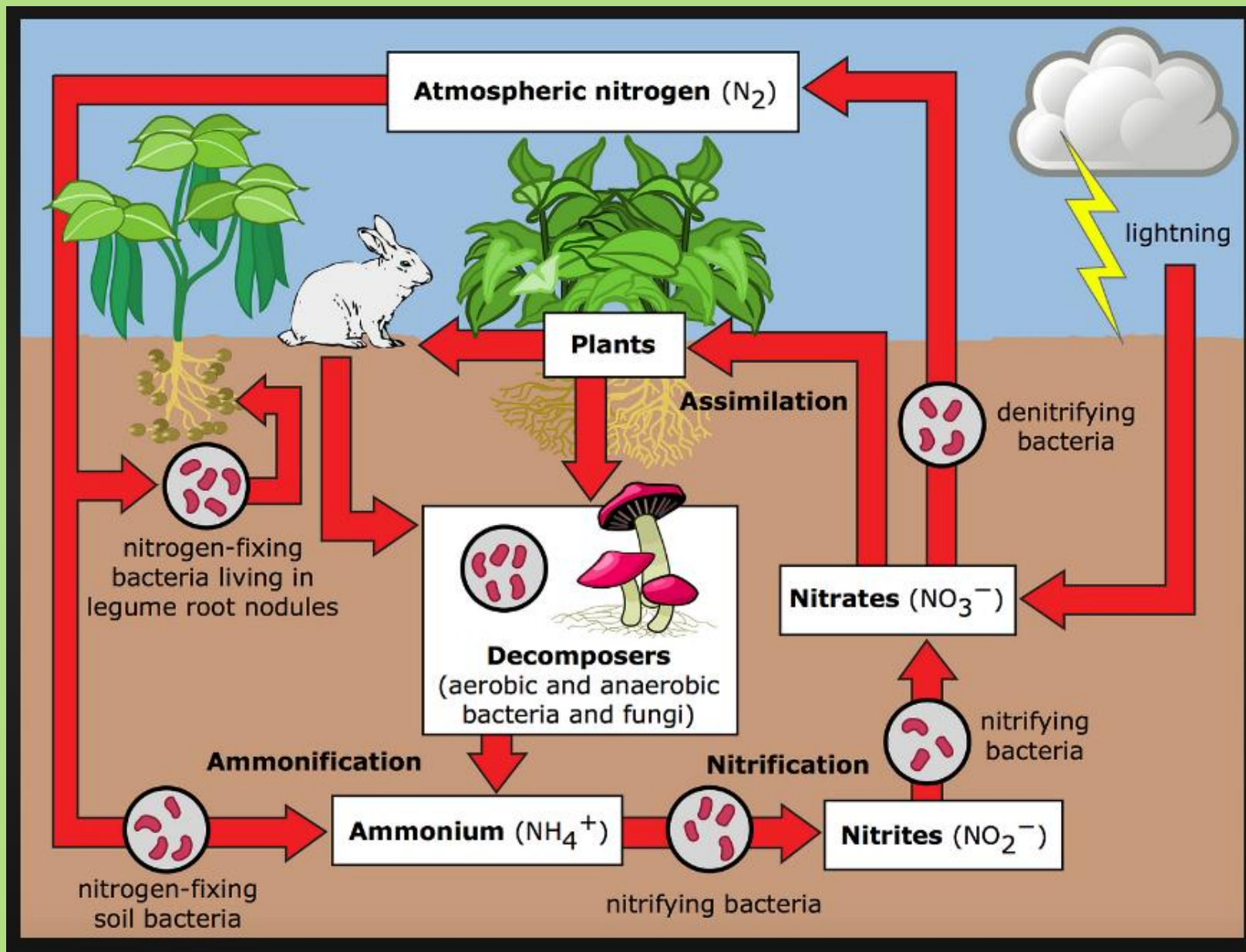
**Tertiary Treatment**

# Micro Algae Converts Carbon Dioxide to Oxygen



Microbes Consume the Sugar and the Oxygen in the Lagoon

# Microbes Convert Ammonia to Nitrogen Gas



# Cultivated Micro Algae and Microbes





Eliminate  
mechanical  
aeration

Eliminate  
Odor

Reduce  
aeration  
electricity  
cost by 90%

# Organics are Consumed in the Lagoons

## Drying Bed for Inorganics



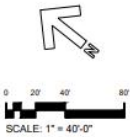
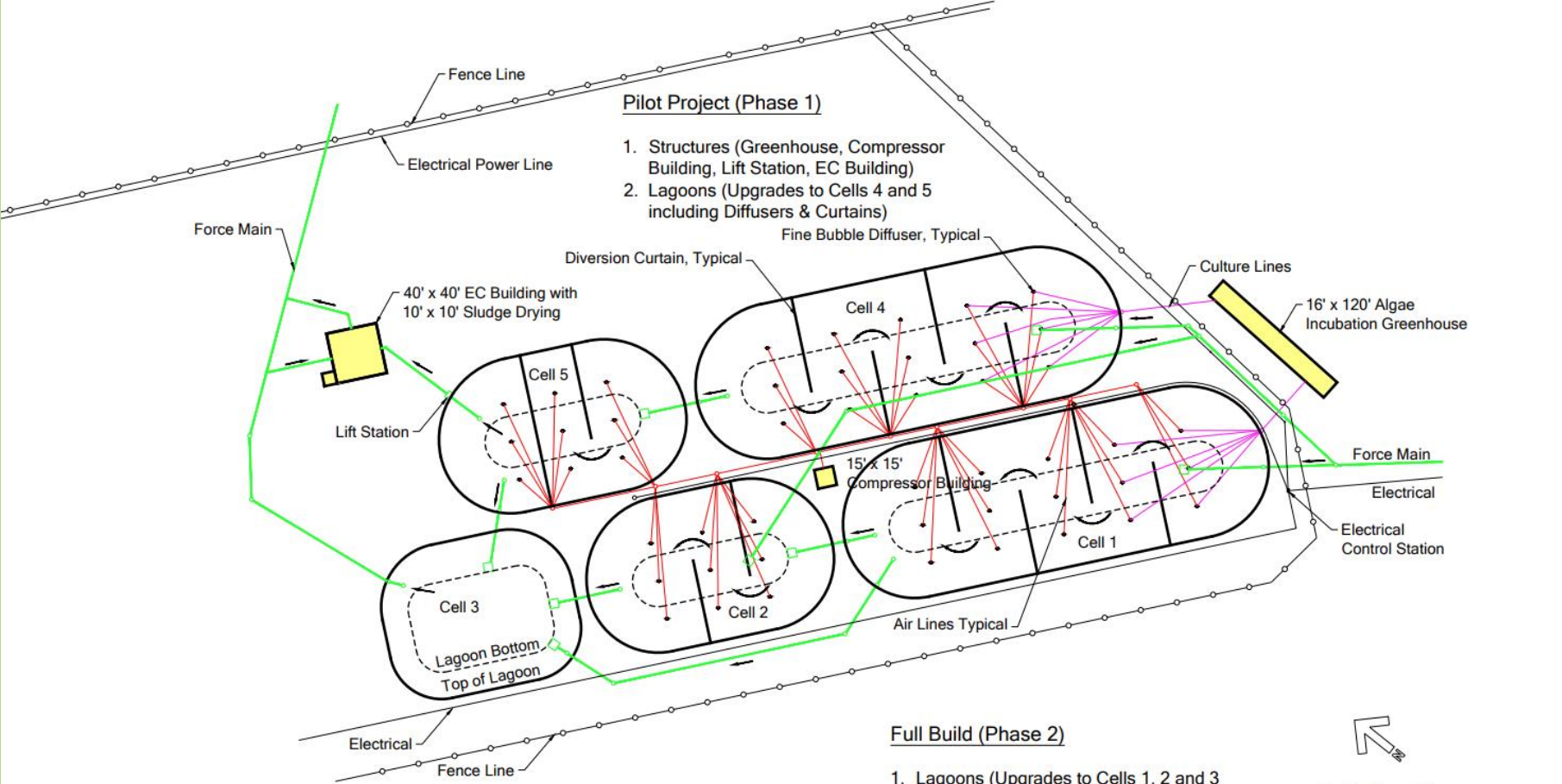


# Enhance Existing Lagoon System



# PWMAS Modification Details

## Greenhouse and Electrocoagulation Buildings



# Economic Reasons for PWMAS

Colorado Sanitation District:

1,100 people

700 taps

\$40,000 annual median household income

	<b>SBR UV</b>	<b>PWMAS</b>
Capital	\$14,100,000	\$4,400,000
Personnel	8 hours/day	2 hours/day
2027 EPA Regs	No	Yes
CO <sub>2</sub> Reduction	No	Yes

# Cadmium Copper Lead Zinc

## The Doe Run Company Brushy Creek Mine Storm Water Run Off

	Cadmium	Copper	Lead	Zinc
Raw water ppb	36	23	1,285	6,675
Powell EC ppb	0.29	0.38	0.76	18
% Reduction	99.19%	98.35%	99.94%	99.73%
<b>Action Level</b>	5	1,300	150	5,000

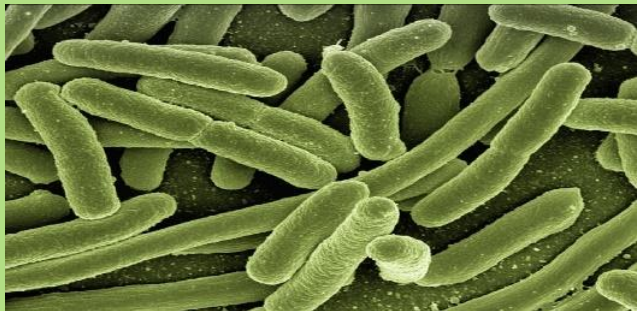
# Cadmium Copper Lead Zinc

Berkeley Pit, Butte Montana, Horseshoe Bend Mine  
Acid Mine Drainage

	Cadmium	Copper	Lead	Zinc
Raw water ppb	1,014.65	30,983.5	3.08	260,050
Powell EC ppb	4.61	6.860	< 0.6	29
% Reduction	99.55%	99.98%	>80.5%	99.99%
<b>Action Level</b>	<b>5</b>	<b>1,300</b>	<b>150</b>	<b>5,000</b>

# Bacterial Components

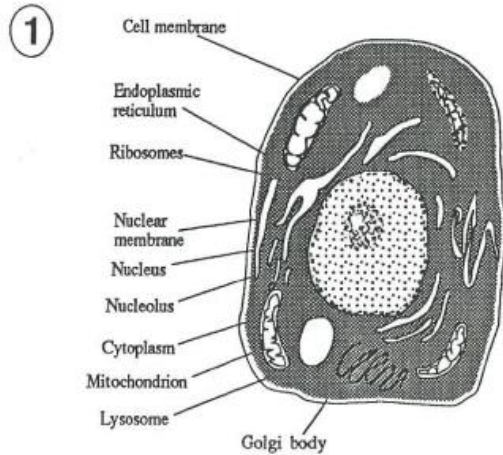
	<b>Fecal Coliforms (CFU/ml)</b>	<b>Enterococci (CFU/ml)</b>
<b>Before EC</b>	<b>1,000,000</b>	<b>1,000,000</b>
<b>After EC</b>	<b>ND</b>	<b>ND</b>



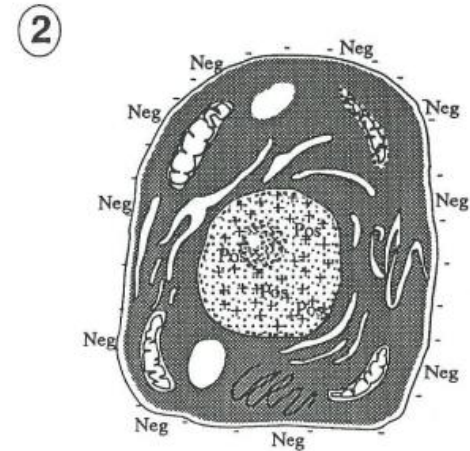
Data Source: Rosario and Adkinson

# Bacteria Cell Walls are Broken

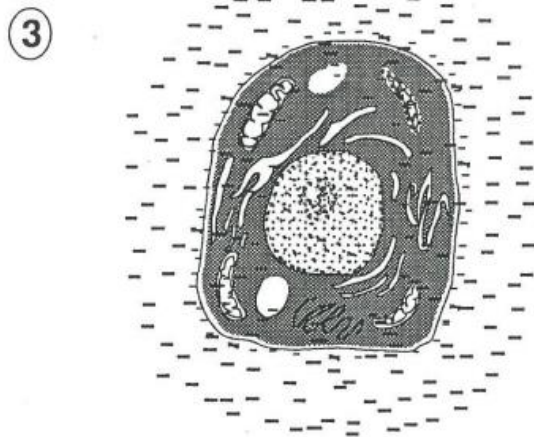
ELECTROPHORETIC / ELECTROCIDAL- EFFECT ON NUCLEATED MICROORGANISMS  
" CHEMICAL FREE "



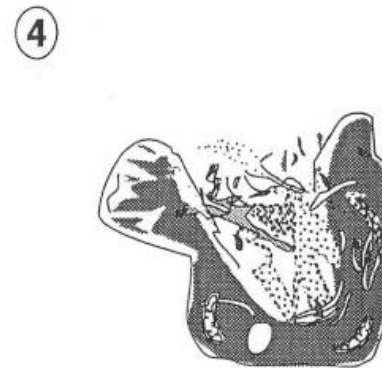
**NORMAL NUCLEATED MICROORGANISM**



**TYPICAL ELECTRICAL NET SURFACE CHARGE ON OUTER MEMBRANE**



**INDUCED PLASMA SURCHARGE ON OUTER MEMBRANE**

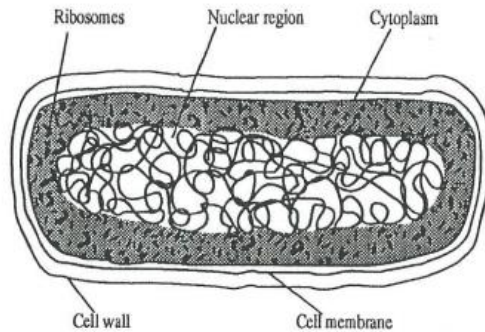


**CAVITATION AND DNA DESTRUCTION  
( DEATH OF THE MICROORGANISM )**

# Cell Contents are Denatured

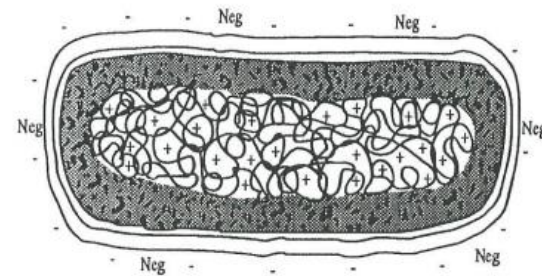
ELECTROPHORETIC / ELECTROCIDAL- EFFECT ON NON-NUCLEATED MICROORGANISMS  
"CHEMICAL FREE"

①



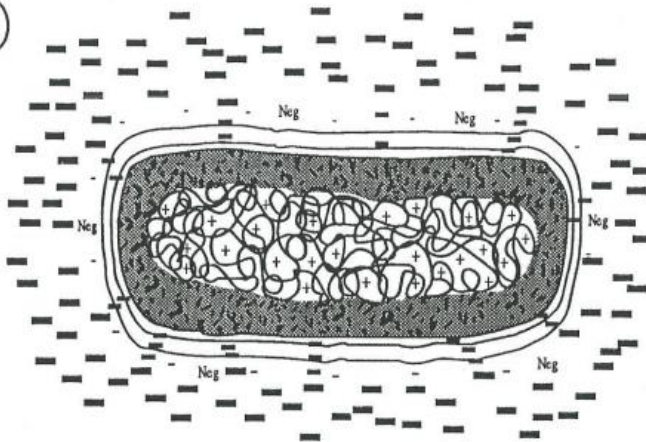
NORMAL NON-NUCLEATED MICROORGANISM

②



TYPICAL ELECTRICAL NET SURFACE CHARGE ON OUTER MEMBRANE

③



INDUCED PLASMA SURCHARGE ON OUTER MEMBRANE

④



CAVITATION AND DNA DESTRUCTION  
(DEATH OF THE MICROORGANISM)





**50 gpm**



# Cyanobacteria and Toxins Destruction

# Celina, Ohio Grand Lake

## Drinking Water

Mono Species of Planktatherix (Neurotoxic Species) Cyanobacteria

Raw Lake Water **97.1 ug/l** was reduced to **0.001 ug/l** with Powell EC



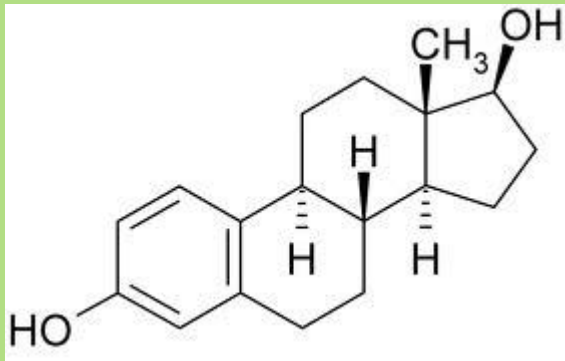
# Virus Destruction

	<b>Phage, <i>E. coli</i></b> (Pfu/ml)	<b>Phage, <i>B. subtilis</i></b> (Pfu/ml)	<b>PMMoV</b> (copies/ml)	<b>HPyV</b> (copies/ml)
Before EC	<b>12,800</b>	<b>2,220</b>	<b>60,100</b>	<b>100,000</b>
After EC	ND	ND	ND	ND

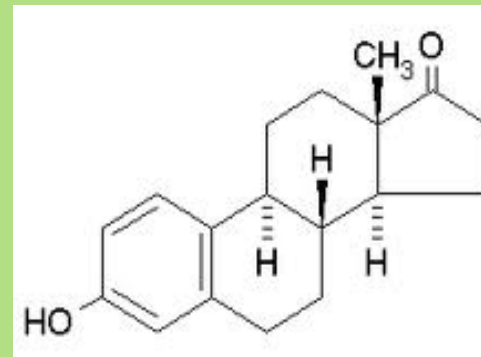


Data Source: Rosario and Adkinson

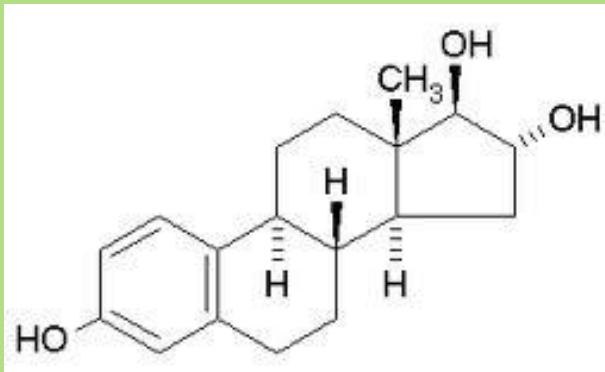
# Estrogenic Endocrine Disruptors



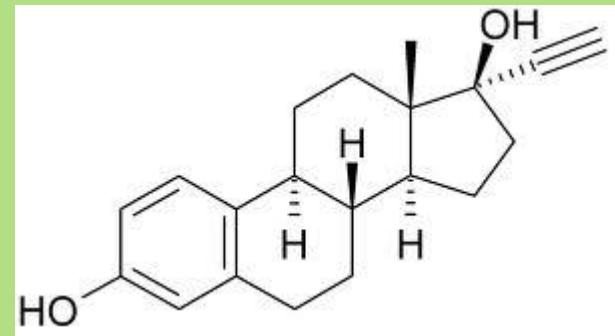
Estradiol



Estrone



Estriol



Ethinyl Estradiol

Deformed white sucker fish with both male and female sex tissue have been discovered near Colorado wastewater treatment plants on the South Platte River and Boulder Creek. Female fish far outnumber the male fish near the plants.

<https://www.chron.com/news/nation-world/article/Discovery-of-deformed-fish-scares-scientists-1679259.php>

# PFOA


# PFOS

	PFOA Liquid ng/l (ppt)	% Removal Liquid	PFOA Solids ng/l (ppt)	PFOS Liquid ng/l (ppt)	% Removed Liquid	PFOS Solids ng/l (ppt)
<b>Landfill Leachate as Received</b>	1,540			421		
<b>Electrocoagulation + H<sub>2</sub>O<sub>2</sub></b>	3.97	99.74	70	2.36	99.94	20

**Powell Water Systems not only separates the PFAS from the water, but also destroys the PFAS in the coagulate solids. US Patent No. 8,048,279**



# Fluoride Carbon Bond Destruction in the Solids- One of the Strongest Single Bonds in Chemistry

	PFOA Liquid ng/l (ppt)	% Removal Liquid	PFOA Solids ng/l (ppt)	PFOS Liquid ng/l (ppt)	% Removal Liquid	PFOS Solids ng/l (ppt)
Landfill Leachate as received	1,540			421		
Electrocoagulation Aluminum blades	193	87.47%	31,900	11.1	97.36%	8,230
Electrocoagulation Iron and aluminum	284	81.56%	12,600	11.6	97.24	3,390
Electrocoagulation and Processing Aid Hydrogen peroxide	3.97	99.74%	70	2.36	99.94%	20

**EPA Proposed Regulation Limit for PFOA & PFOS is 4 ng/l (ppt)**



# Fluoride Carbon Bond Destruction Bureau of Reclamation

Bureau of Reclamation owns and operates [\(BGNDRF\)](#) in Alamogordo, NM

Four groundwater wells used for supply of brackish water to desal research trains and three evaporation ponds to store spent brine

Salinity of these wells range from 1,000 to 6,000 mg/L total dissolved solids (TDS)

2 of the 4 wells are contaminated with PFAS and were bench tested by Garver on 7/27/22... Well 2 and Evaporation Pond (EP)

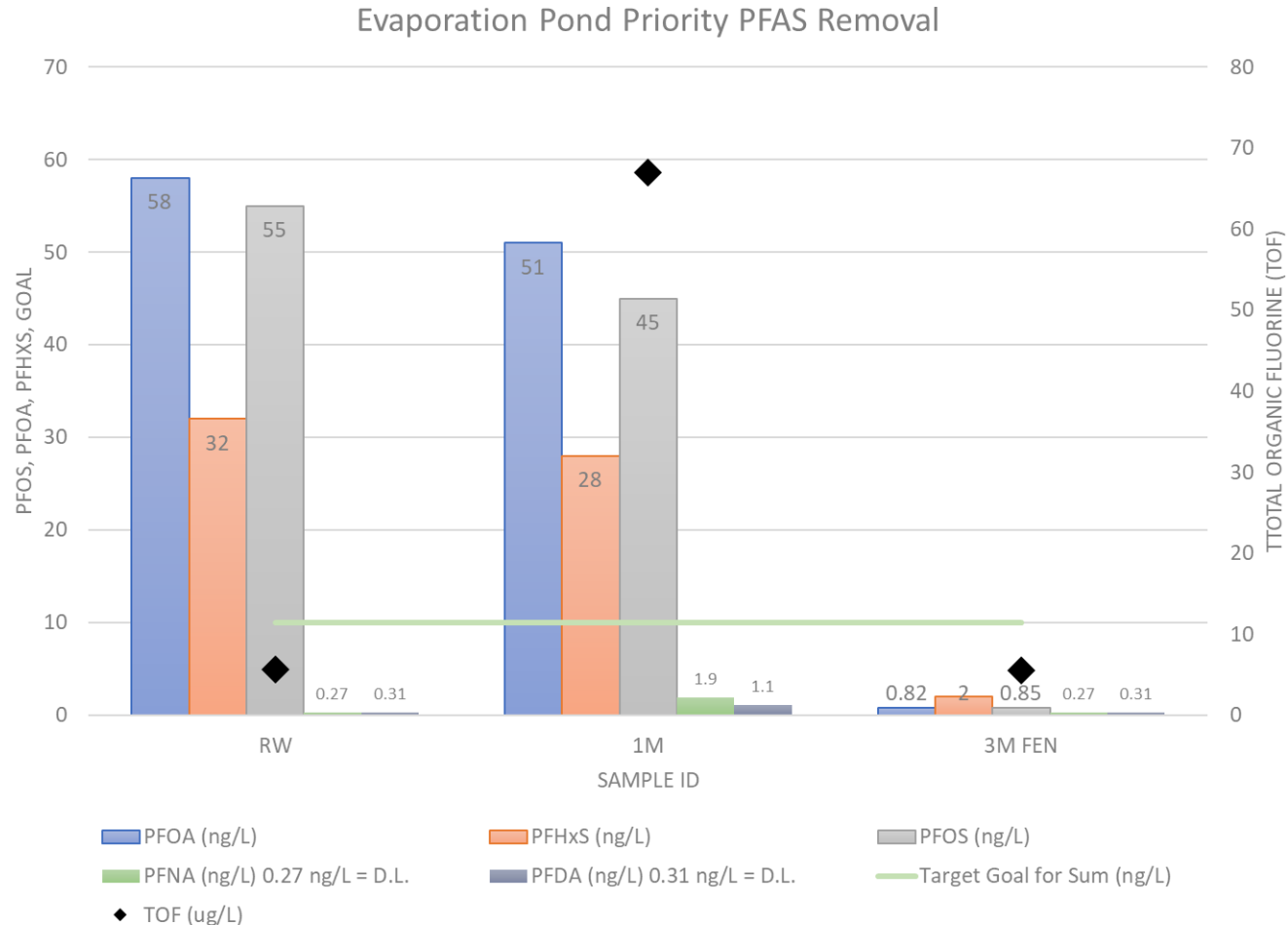
## Problem

Due to NM regulations the facility's discharge permit no longer allows any water with PFAS to enter the sewer adding stress to the evaporation ponds capacity



## EP – Lab Data

- Longer, E-Fenton run time resulted in better removal for PFOA, PFOS, PFHxS, PFDA and PFNA
- 1M FEN led to 255% to 600% increase in PFDA and PFNA
- 3M FEN brought PFNA and PFDA back to ND
- TOF increase in 1M Centrate samples may be indicator of C-F destruction



Eric Dole @ Garver 602 881 0186



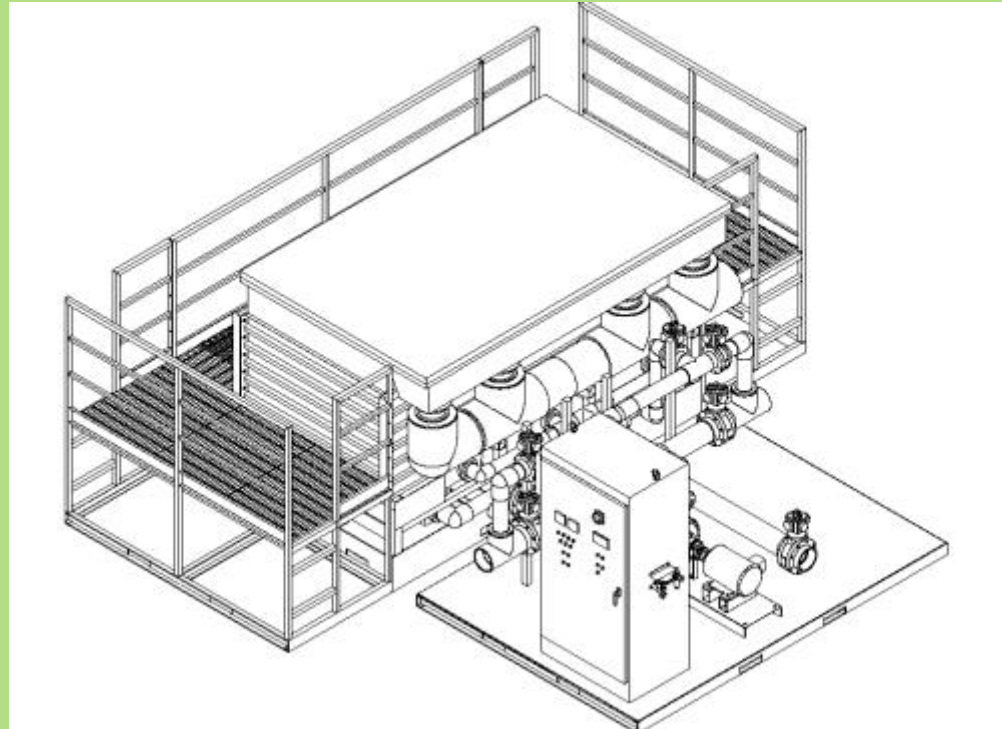


# Chemical Lime Softening Compared to Powell Electrocoagulation for Steam Assisted Heavy Crude Oil Extraction.

**As a practical matter the most difficult aspect of Lime Softening is the truck traffic flow to haul in the lime and haul away the coagulated solids.**

If you do not add contaminants to the water, you do not need to remove them from the water.

**Powell 500  
gpm EC  
Assembled  
skid is 18 ft by  
17 ft, 7 ft tall**

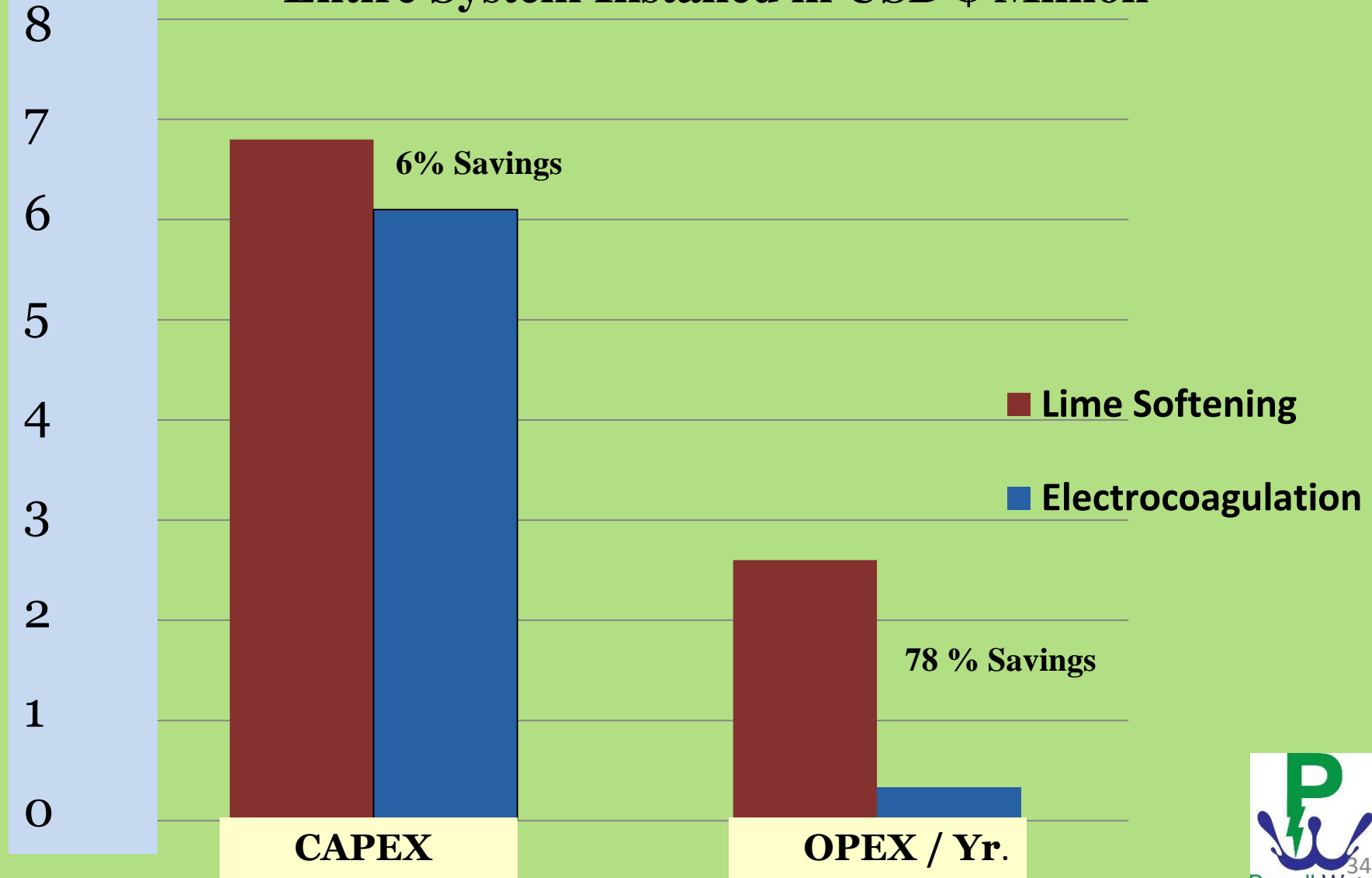


# 500 GPM Lime Softening vs. Electrocoagulation

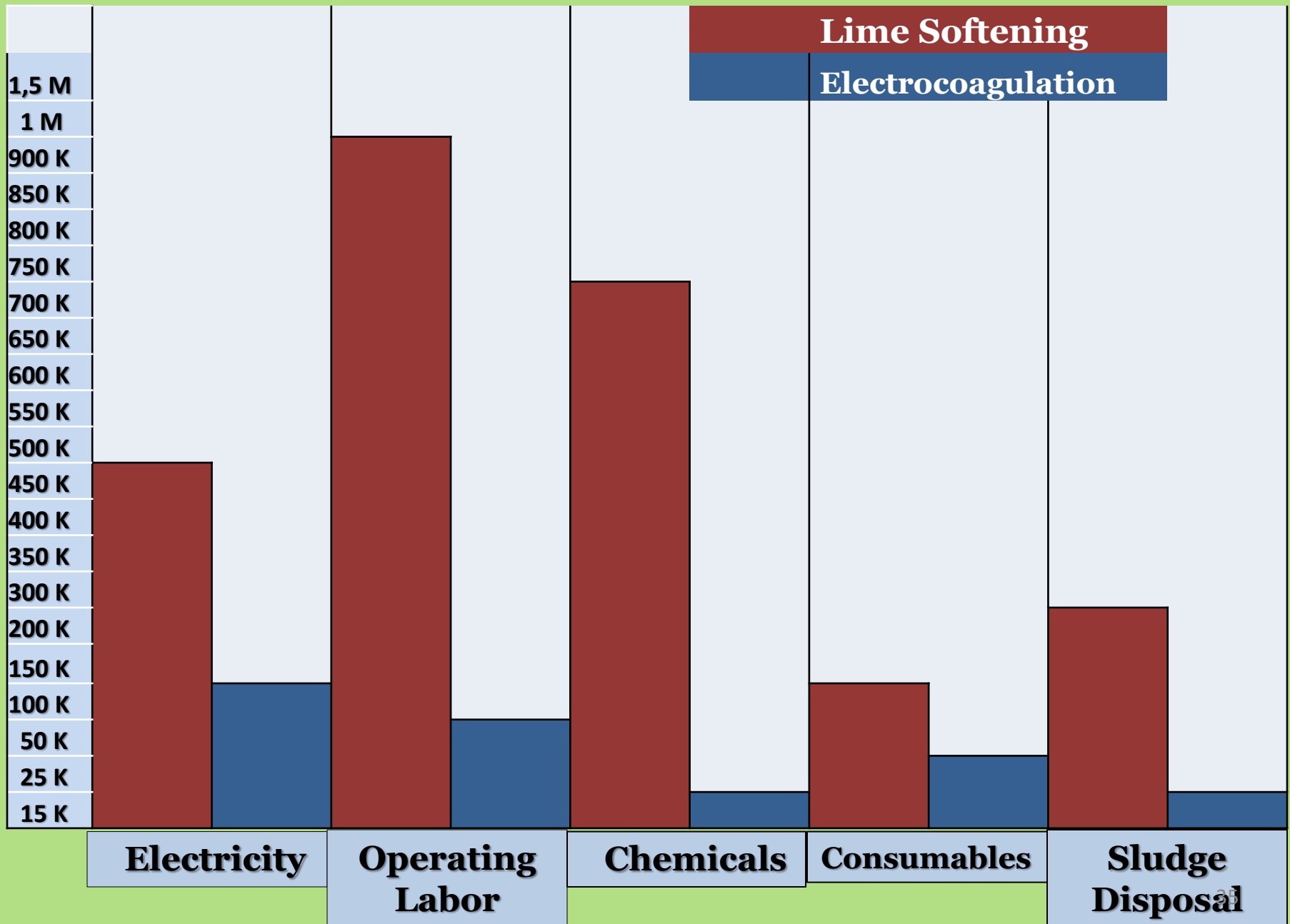
## CAPITAL EXPENSE – OPERATING EXPENSE

Entire System Installed in USD \$ Million

MILLION



# Operating Expense /Yr. (OPEX)



# Red Rocks Community College



- Water Quality Management (WQM) classes start at 6pm, and meet once per week
- Varied schedules- online, remote, in-person, accelerated, etcetera
- Prior Learning Assessment- turn experience into college credit
- All courses have Training Units
- Certificates
- Associates of Applied Science (2 years)
- Bachelors of Applied Science (4 years)
- Chelsea Campbell; Faculty [Chelsea.Campbell@rrcc.edu](mailto:Chelsea.Campbell@rrcc.edu)



# Bureau of Reclamation



*For more information on this project, please contact Eric Dole.*

EJDole@GarverUSA.com  
303.721.6932

## PROJECT PARTNERS

Desalination and Water Purification Research Program  
Pitch to Pilot for Fiscal Year 2019 NO. BOR-DO-19-F017





# Consistent High Quality Permeate Without Irreversible Fouling

TARGET CONSTITUENT	10th Percentile			Average			90th Percentile		
	Raw Water	Filtered EC Supernatant	Permeate	Raw Water	Filtered EC Supernatant	Permeate	Raw Water	Filtered EC Supernatant	Permeate
TH as CaCO3 (mg/L)	699.7	174.3	0.1	743.38	428.68	1.38	810.4	723.4	4.86
pH	8.1	7.9	7.1	8.3	8.8	8.8	8.7	9.3	9.9
TDS (mg/L)	1683	1515	5	2848.7	1686.2	11.4	1992	1966	21.2
Silica (mg/L)	15.61	0.30	0.3	17.7	1.39	0.3	19.4	3.24	0.3
TSS (mg/L)	5.0	5	5	5.3	12.5	5	5.3	17.8	5
Total Phosphate (mg/L)	0.11	0.05	0.05	0.16	0.06	0.05	0.19	0.05	0.05
TOC (mg/L)	5.79	4.84	0.5	6.38	5.18	0.51	7.34	5.46	0.5
*ORP (mV)	180	-141.8	-182.9	194.00	-112.40	-124.60	211	-70	-61.2
*Temperature (°C)	15.86	13.19	12.86	18.09	16.99	16.96	19.94	21.23	21.33
Total Coli (mpn/100 mL)	1.0	1.0	1.0	1.18	1.67	1.0	1.0	1.0	1.0
OPERATING PARAMETER	10th Percentile			Average			90th Percentile		
Energy Intensity (kWh/kgal)	39.6			44.9			51.4		
Pressure (psi)	312			346			386		
Permeate Flow (gpm)	0.72			0.80			0.86		
Perm Flux (gfd)	11.9			13.2			14.3		
Concentrate Flow (gpm)	0.80			0.88			0.97		
% Recovery 3-stg RO	43%			48%			52%		
**% Recovery Overall	49%			54%			59%		

\*As trended through in-line analyzers

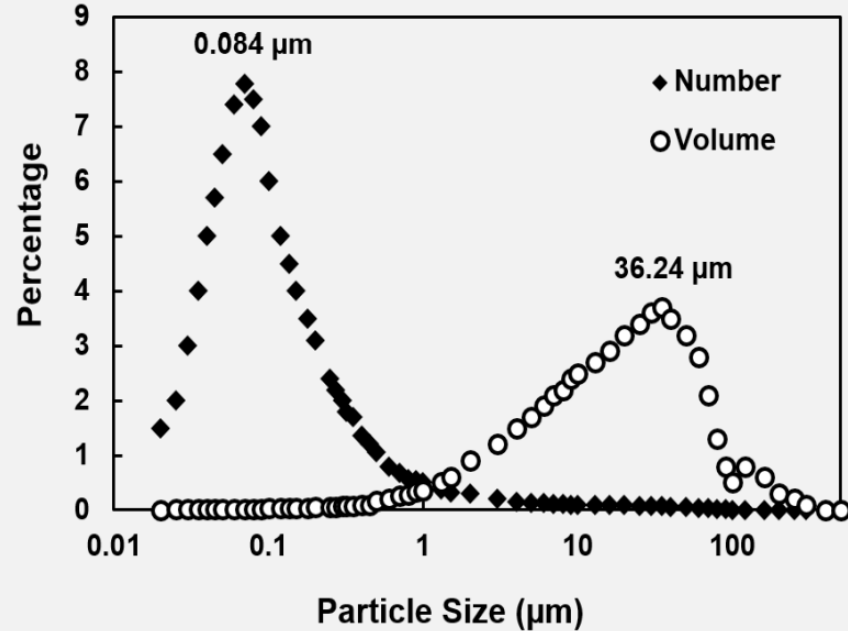
\*\*@ 400 ppm TDS w/ Blend

98% EC RO water recovery with implementation of recommended modifications from original test parameters

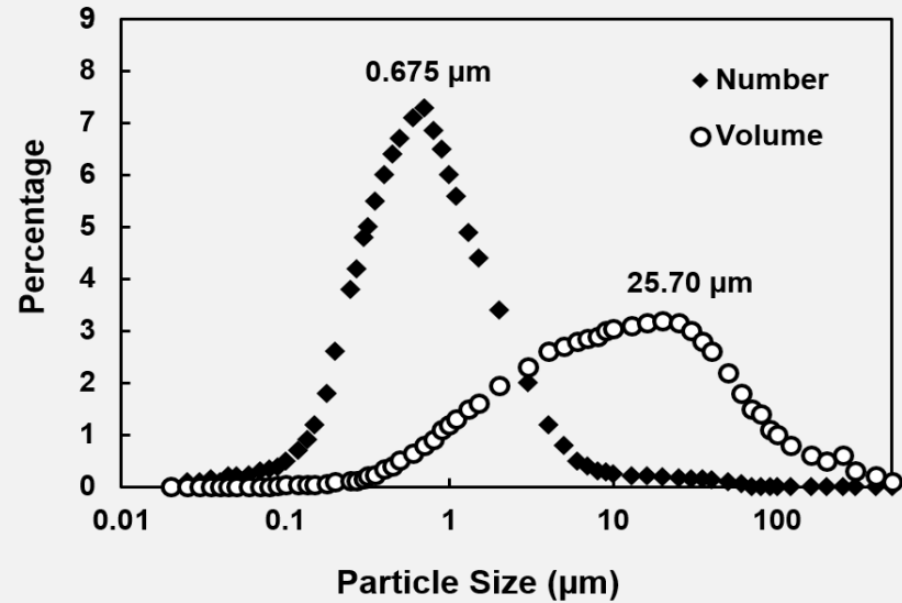


# Particle Size Distribution

(A) Raw PPW



(B) EC Pretreated PPW



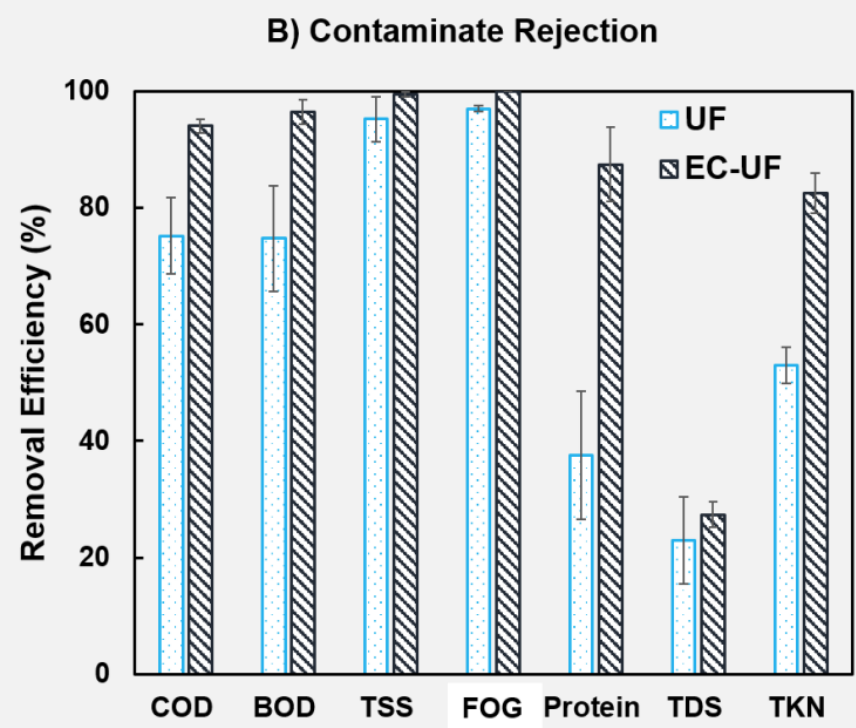
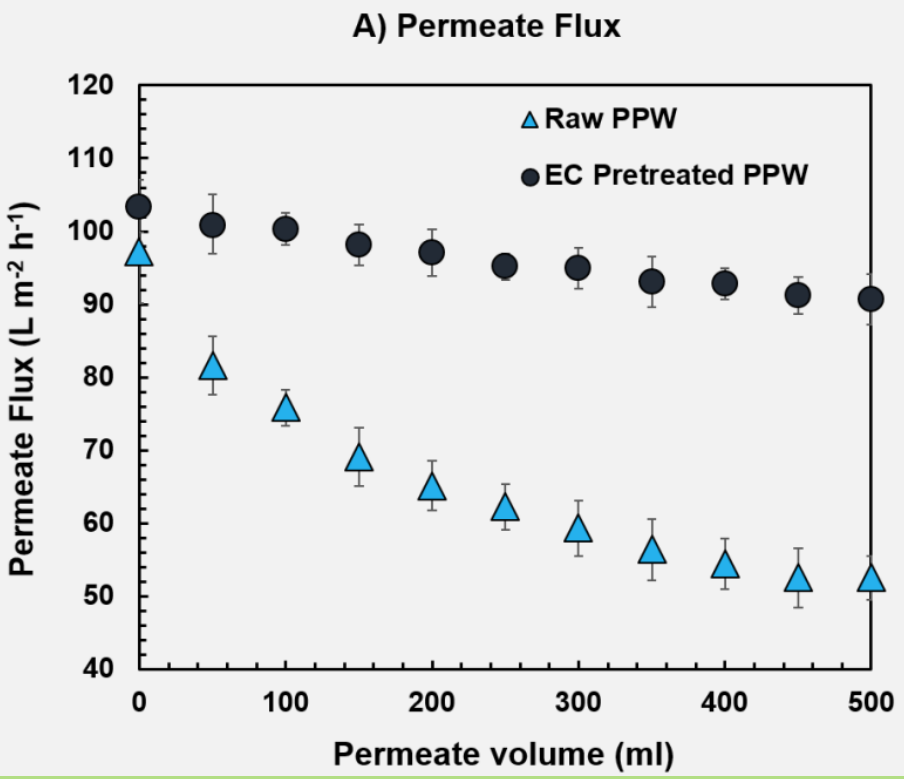
UF Membrane



UF Membrane



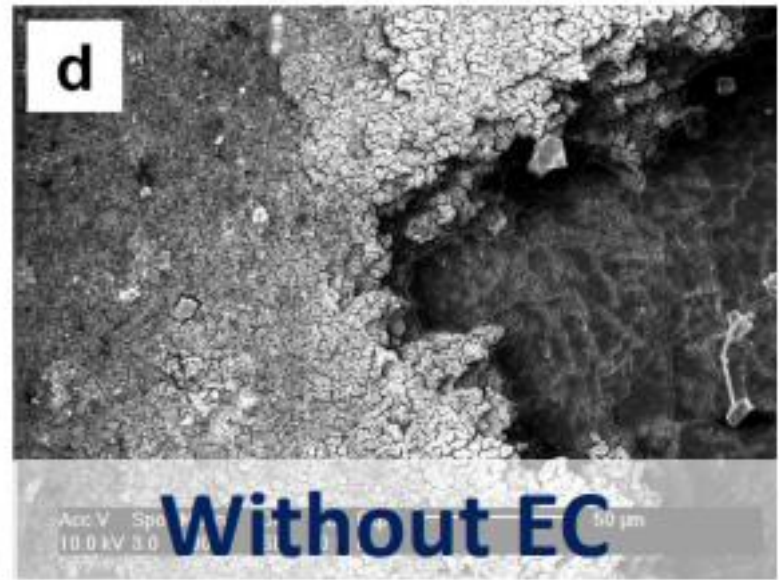
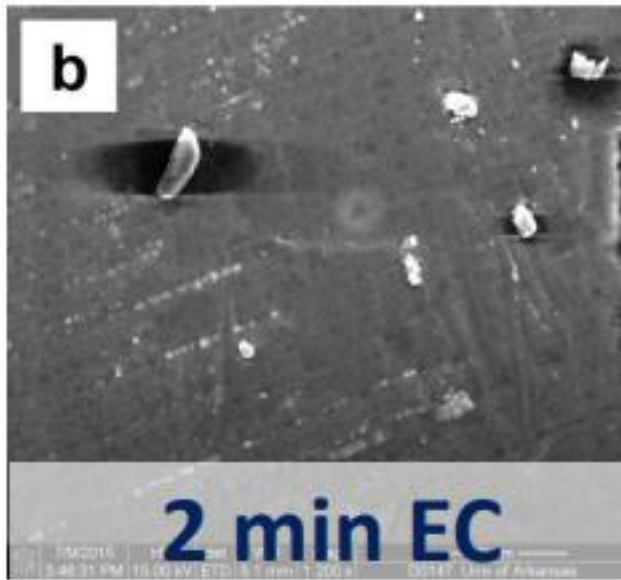
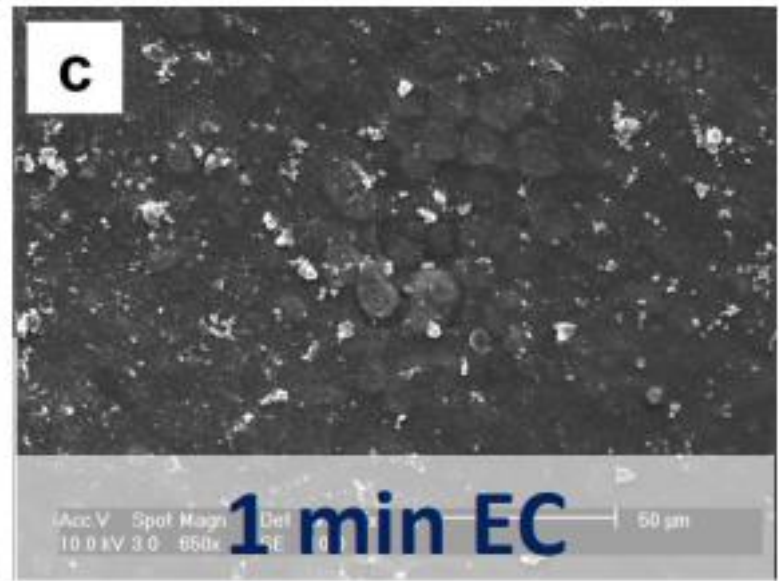
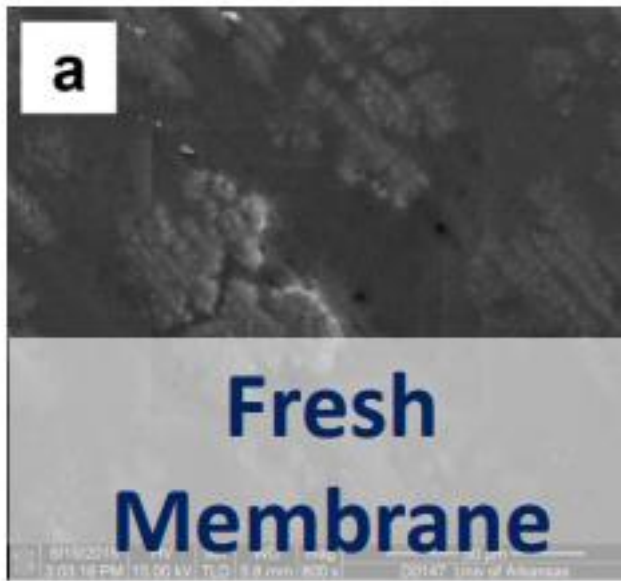
# Ultra - Filtration Performance Significantly Improved With EC Pretreatment



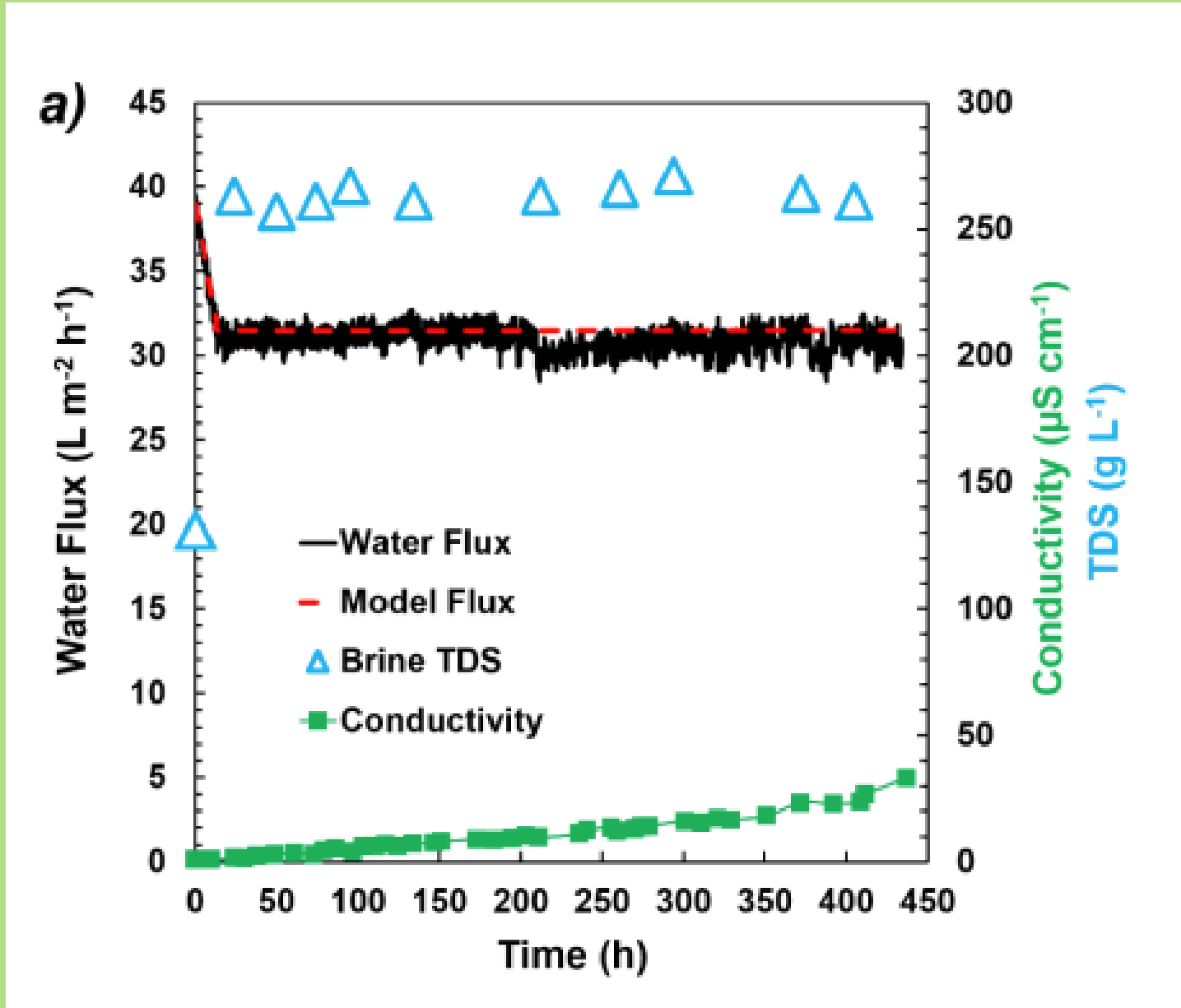
35% increase in permeate flow rate with Powell EC pretreatment



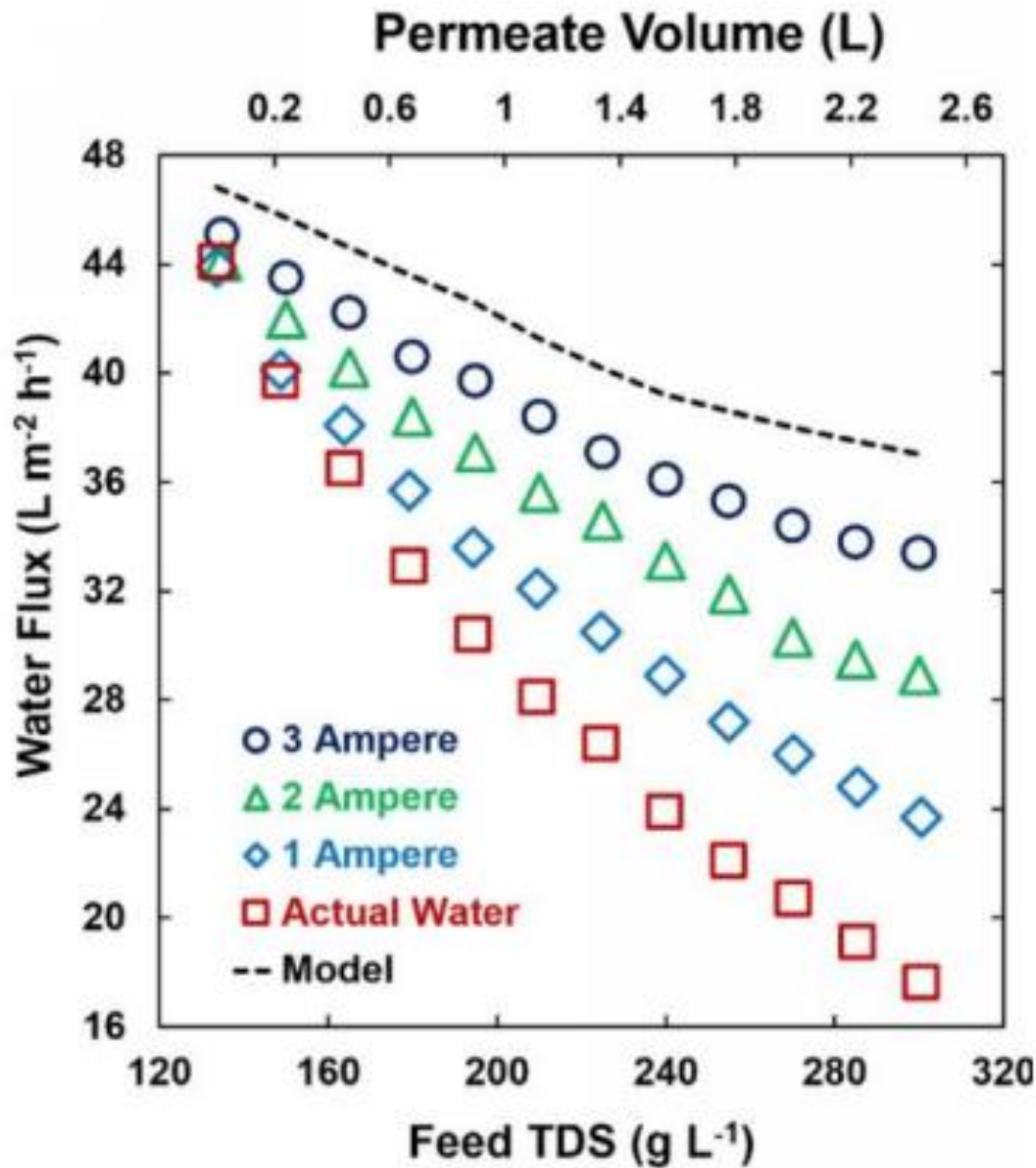
Scanning  
Electron  
Microscopy  
Imaging  
Shows  
Reduced  
Fouling via  
EC  
Pretreatment



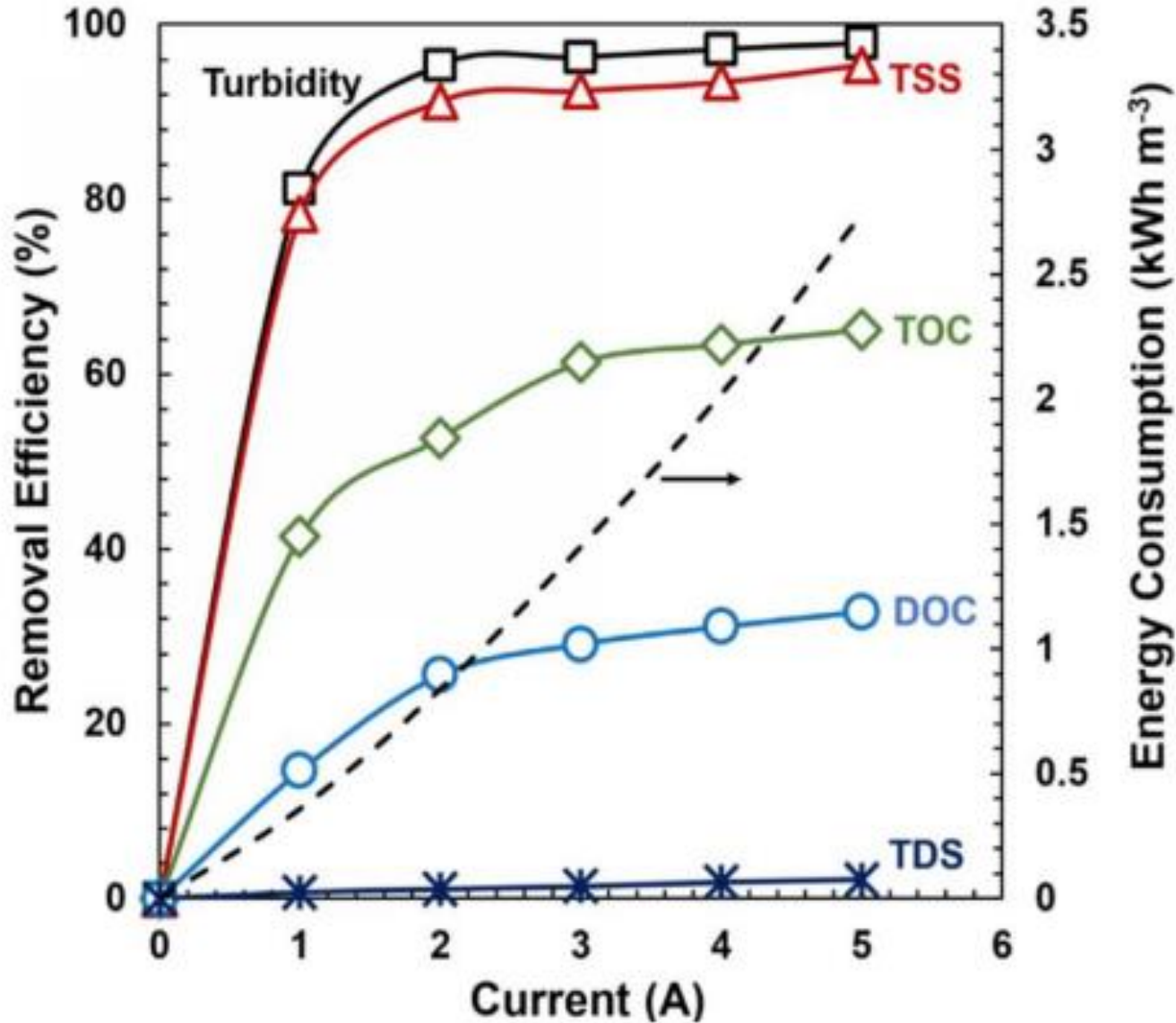
# 400 + Hours With No Reduction in Water Flux



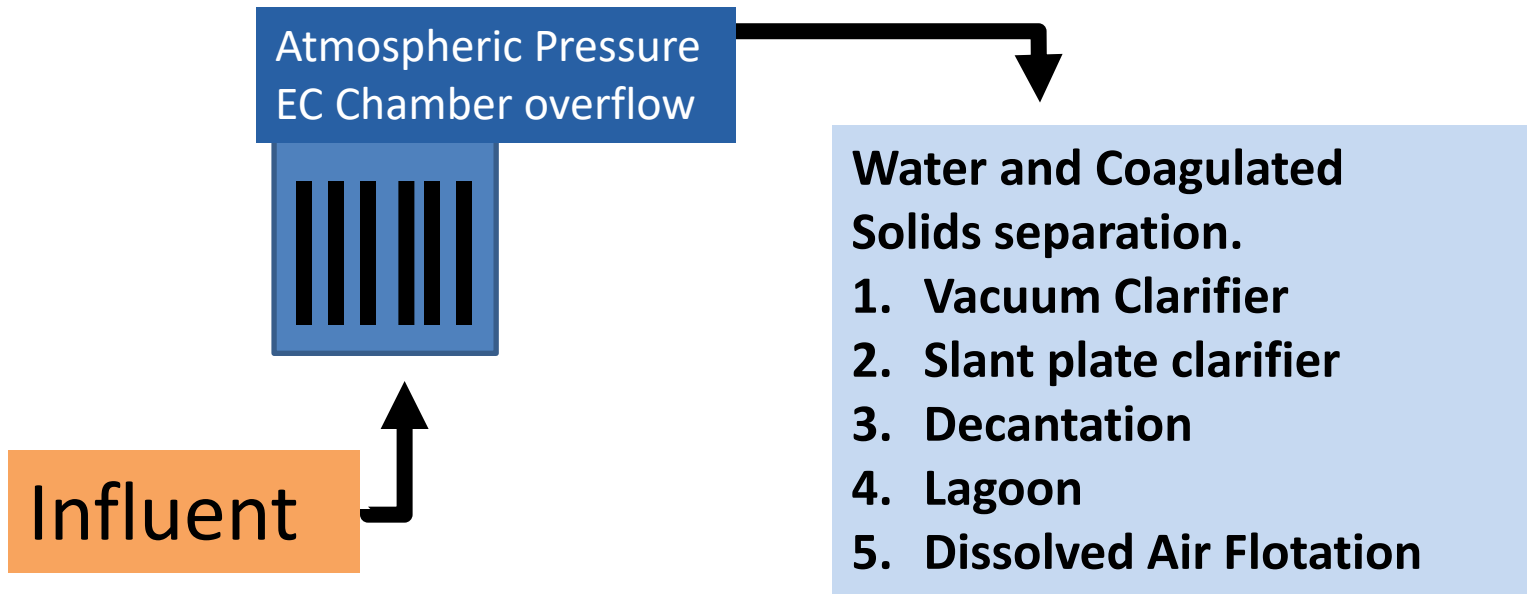
# Amperage vs Flux Decline



# Removal Efficiency vs Amperage



# Electrocoagulation Typical Flow Diagram



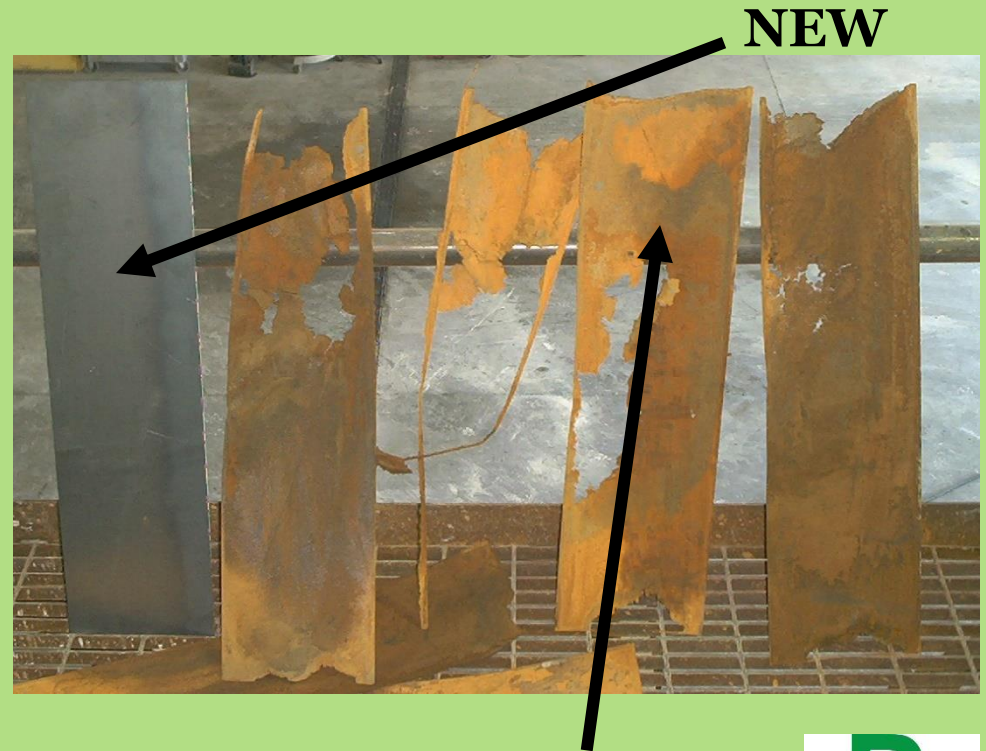
**Atmospheric Pressure Electrocoagulation Chamber**  
**Off the shelf dissolvable electrocoagulation blades**

# Powell Water Electrocoagulation

- uses electricity and sacrificial metal blades/plates to coagulate solids



**50 gpm Tertiary Treatment  
Oklahoma WWTP**



**USED**

# Electro-Coagulation vs. Chemical Coagulation

	Potassium Alum $KAl(SO_4)_2 \cdot 12(H_2O)$	Ferric Chloride $FeCl_3 \cdot 6(H_2O)$	Electro-coagulation $Fe^{2+}$ or $Al^{3+}$
Alum and ferric chloride cause salinity increase b/c of salt counter-ions	Potassium K = 39.10 Aluminum Al = 26.98 Sulfur S = 32.06 Oxygen O = 16.00 Hydrogen H = 1.01 $KAl(SO_4)_2 \cdot 12(H_2O) = 474.44$	Iron Fe = 55.85 Chlorine Cl = 35.45 Hydrogen H = 1.01 Oxygen O = 16.00 $FeCl_3 \cdot 6(H_2O) = 270.32$	Metal Sheet
Total Dissolved Solids reduction in place of TDS increase	17.6 to 1 5.7% Al	4.8 to 1 20.66% Fe	1 to 1 100%

“When compared with alum treatment, electrocoagulation provided approximately **83% less sludge** volume and a **76% improvement in filtration rate.**” (EPA / 540 / S-937504 September 1993 Emerging Technology)





- Plates are placed vertically within the patented reaction chamber
- Direct current is applied to the first and last blade
- Untreated water is introduced into the bottom of the chamber
- Water is dispersed evenly as it moves upward through the blades
- Water conducts electricity throughout the chamber



Samsung 600 gpm unit South Korea

- Metal blades change from a solids to an ion when electrons pass through.
- Electron flooded water neutralizes charged particles, Van der Waals force, making them separable (precipitate) from the water
- Treated water overflows to secondary separation such as ponds, clarifiers, filters, or etcetera.



Central Wastewater Treatment Facility (CWT)  
50 gpm, Denver, Colorado

- Heavy metals precipitate into acid-resistant oxide sludge that passes the Toxic Classification Leaching Procedure (TCLP), making the sludge non-hazardous

The Powell Electrocoagulation Process is Scalable to accommodate larger flow rates. 600 gpm is the manufacturing economy of scale and then parallel units can be used to treat any size flow rate.



500 gpm  
1,866,240 square inch  
Wet blade surface area



50 gpm  
186,624 square inch  
Wet blade surface

# Two 500 gpm EC Systems in Parallel

With ultra filtration and reverse osmosis for 95% water recovery



# Electrocoagulated, Ultra Filtration Reject Water is Pulled into a Vacuum Tower



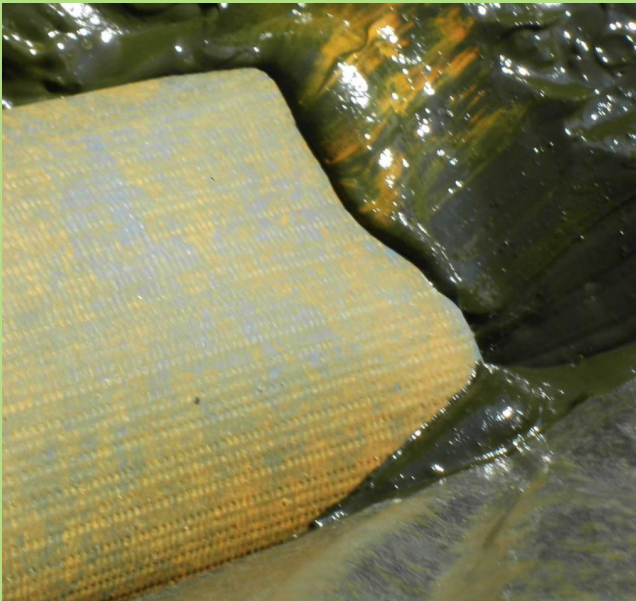
**Coagulated solids are pumped into a dumpster at 23% solids by weight.**

**The solids continue to dewater over time.**

# Solids Handling

“When compared with alum treatment, electrocoagulation provided approximately **83% less sludge volume** and a **76% improvement in filtration rate.**”

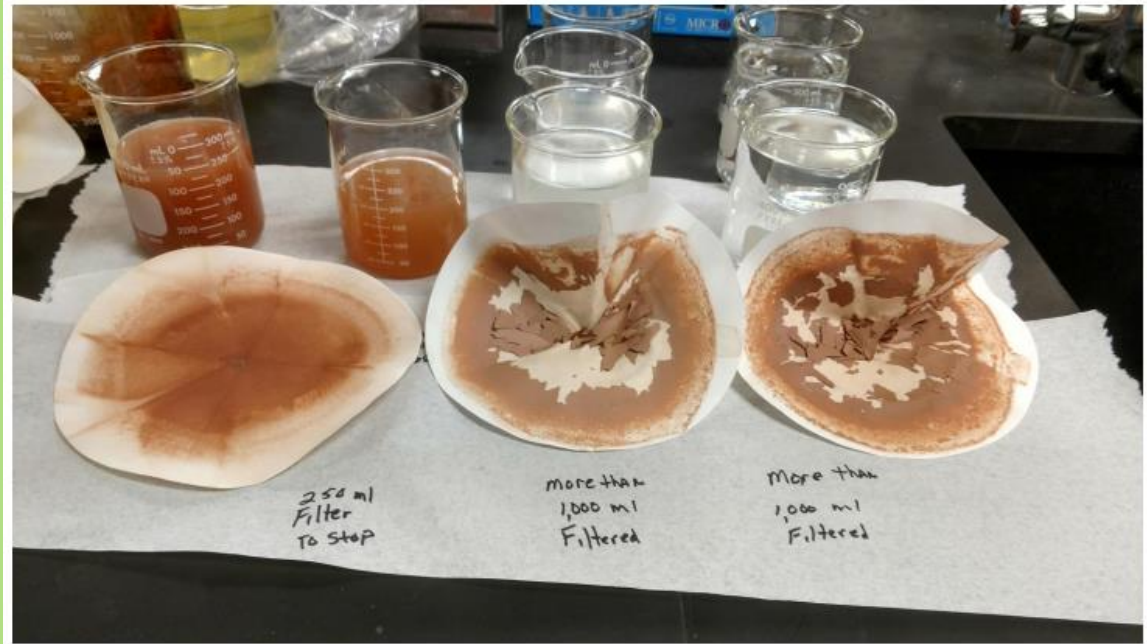
*EPA / 540 / S-937504 September 1993 Emerging Technology  
Summary, Superfund Innovative Technology Evaluation*



# EC Solids Dry in the Oxide Form



Coal Mine Surface Run Off Water  
Powell Electrocoagulated Solids



## Sludge from EC:

- Solids dewater completely
- Metals are non-hazardous as oxides
- Does not leach at ambient landfill pH
- Passes EPA TCLP and California Title 22 STLC and TTLC leach tests





# Canadian Oil Tar Sands Mature Fine Tails

<b>Filtered Solids after 10 days</b>				
Moisture in filtered solids	0.20%	Wt% moisture		
Compressive Strength	47.6	Kilopascal (kPa)		
Compressive Strength	6.9	lbs/sq in (psi)		
Specific Gravity	2.222			
<b>Mature Fine Tails</b>	<b>Sample 100819 - 1 As Received</b>			
pH	7.2	pH Units		
Fluid Ratio - oil	0.50%	Vol%		
Fluid Ratio - Water	74.50%	Vol%		
Fluid Ration - Sediment	25%	Vol%		

Solids concentration of 25% after 40 years went to 99.8% in 10 days, By adding the electro mode of force to drive the normal reaction in nature.

# Post Powell EC-Filter Press

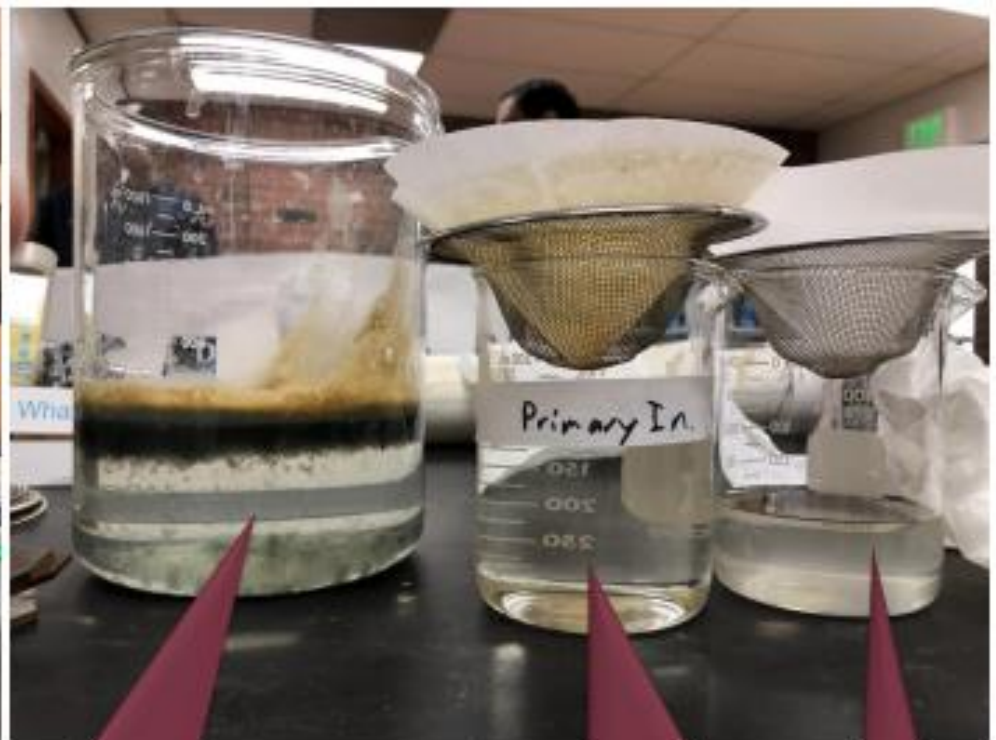


**Denver Central Wastewater Treatment  
(CWT)**

# Primary Clarifier Influent, Robert Hite Water Reuse Facility Denver Colorado



Floc flotation after 60 sec HRT in CSTR configuration

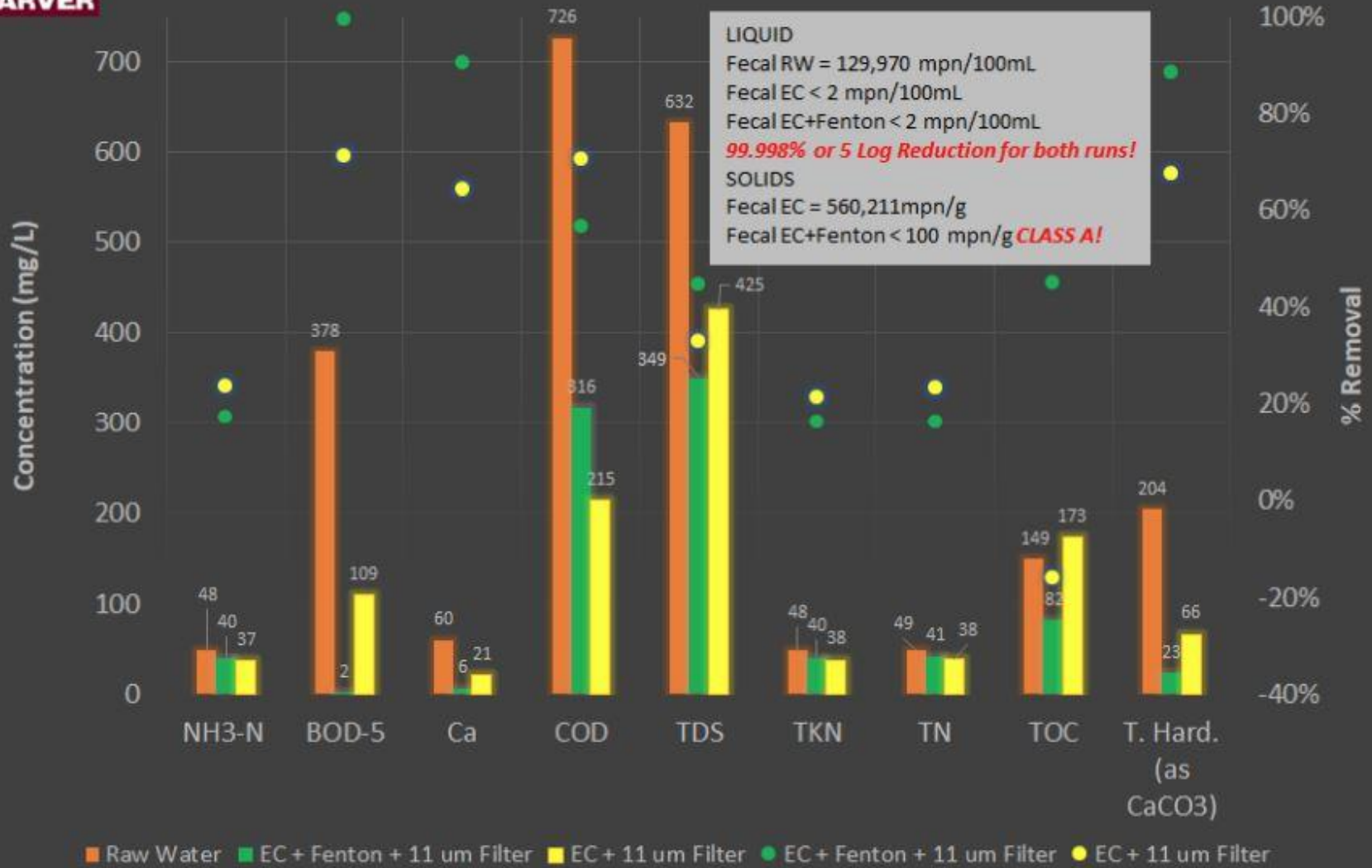


Electro-coagulated 11 micron gravity filtrate

11 micron gravity filtrate control

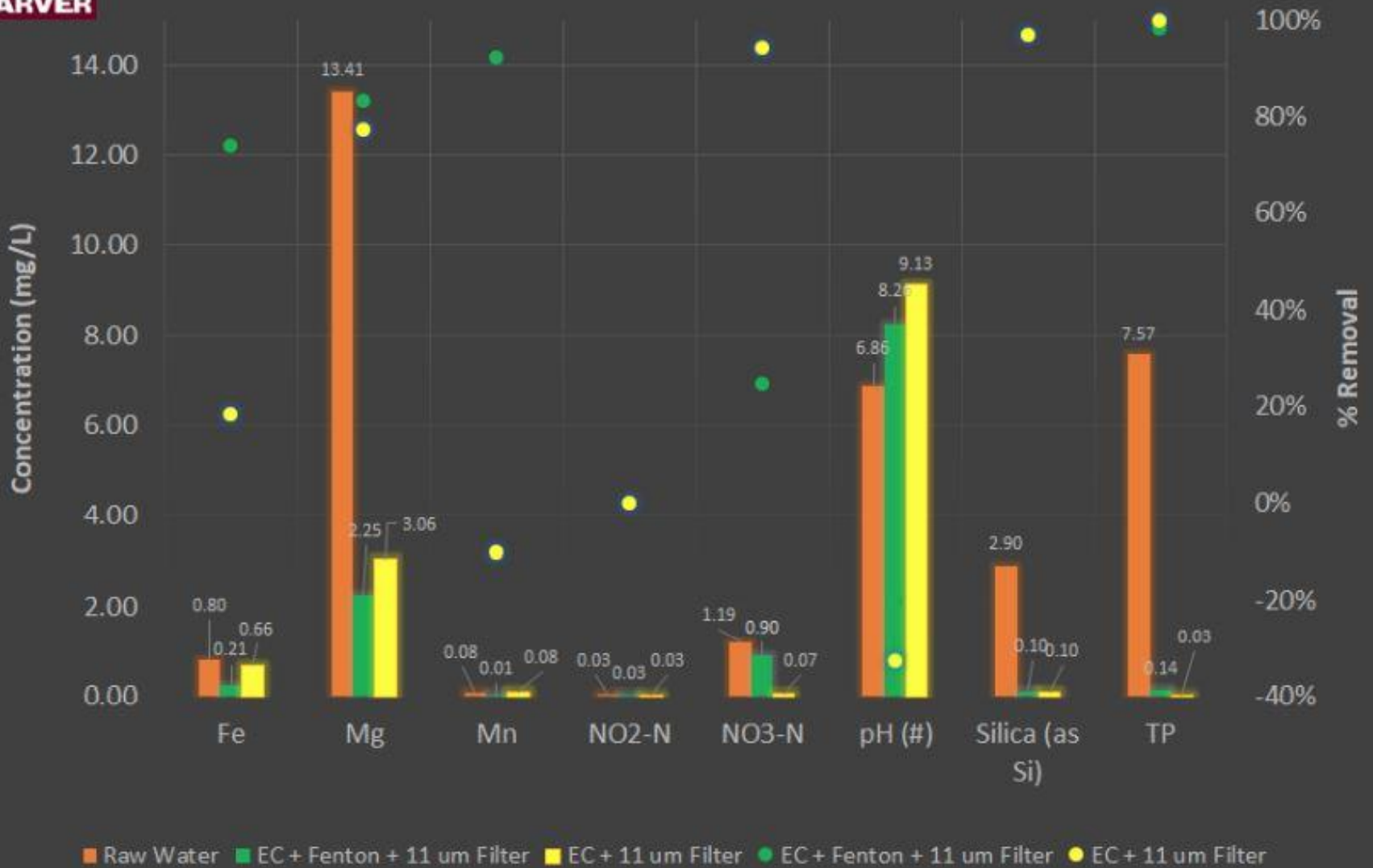


## Robert Hite WTF Electro-coagulation Tests on Primary Clarifier Influent - RW values > 40



Henry Fenton's reagent is the addition of hydrogen peroxide (H2O2) with ferrous iron 60

## Robert Hite WTF Electro-coagulation Tests on Primary Clarifier Influent - RW values <= 40



# Vanderbilt Study

## Municipal Wastewater Nashville, Tennessee

	<u>Raw</u>	<u>Treated</u>	<u>% Removal</u>
COD	490	26	94.70
Total Solids	602	401	43.40
Suspended Solids	73	7	90.4
Settleable Solids	21	5	76.20
Total Hardness	127	11	91.30
Alkalinity	267	11	95.80
pH	6.88	7.02	
IOD	0.98	<0.1	89.80
BOD	220	9	95.90
Coliform	318,000/ml	0	99 +
Phosphates	38	0	99 +

# Coagulated Solids from Industrial Process, 75% of the Wastewater Converted to Fertilizer.



# 29,000 mg/l BOD Waste to Fertilizer

Sample ID	44624-25		
Sample Detail	Cooker Water		
mg/l	As Received	Dry Weight	Percentage
Total Kjeldahl Nitrogen (TKN)	1,580	9,190	0.92%
Phosphorus	18,970	110,300	11.03%
Potassium	3,686	21,430	2.14%
Calcium	1,272	7,395	0.74%
Magnesium	1,100	6,395	0.64%
Sodium	17,590	102,300	10.23%
Sulfur	15,000	87,200	8.72%
Iron	37,770	219,600	21.96%
<b>Phosphate P205</b>	43,400	252,000	<b>25.20%</b>
Potash K20	4,440	25,800	2.58%



# Army Corp of Engineers 30 gpm Huntsville, Alabama



Adjustable to 3, 6, and 12 volt between the blades to accommodate for the conductivity of the water.

# Office of Navel Research 6 gpm Skid Mounted Unit Oxnard, California



08/07/2008

# Typical Removal Rates

# Metals And Minerals

<b>Contaminant</b>	<b>Before (mg/l)</b>	<b>After (mg/l)</b>	<b>% Removal</b>
<b>Aluminum</b>	224	ND (0.7)	99+
<b>Arsenic</b>	0.076	ND (<0.002)	97
<b>Barium</b>	0.014	ND (<0.001)	93
<b>Boron</b>	4.86	1.41	70
<b>Cadmium</b>	0.125	ND (<0.004)	96
<b>Calcium</b>	1,321	21.4	98
<b>Chromium</b>	139.	ND (<0.1)	99+
<b>Cobalt</b>	0.1238	0.0214	82
<b>Copper</b>	0.7984	ND (<0.0020)	99+
<b>Cyanide (free)</b>	723	ND (<0.02)	99+
<b>Fluoride</b>	1.1	0.415	62
<b>Gold</b>	5.72	1.38	75
<b>Iron</b>	68.34	0.19	99+
<b>Lead</b>	0.59	0.0032	99+
<b>Magnesium</b>	13.15	0.04	99+
<b>Manganese</b>	1.061	0.018	98
<b>Mercury</b>	0.72	ND (<0.003)	98
<b>Molybdenum</b>	0.35	0.029	91
<b>Nickel</b>	183	0.07	99+
<b>Platinum</b>	4.4	0.68	84
<b>Selenium</b>	68	38	44
<b>Silicon</b>	21.07	ND (0.10)	99+
<b>Silver</b>	0.0081	0.0006	92
<b>Tin</b>	0.213	ND (<0.020)	90
<b>Vanadium</b>	0.262	ND (<0.002)	99+
<b>Zinc</b>	221	0.140	99+ <sup>67</sup>

# Nutrients

Contaminant	Before (mg/l)	After (mg/l)	% Removal
Ammonia	49	19.4	60
Nitrate	11.7	2.6	77
Nitrite	21	12	42
Nitrogen TKN	1,118.88	59.08	94
Phosphate	28	< 0.2	99+
Potassium	200	110	45
Sulfate	104	68	34

Removal rates improve significantly when combined with processing aids like micro algae, microbes, and or hydrogen peroxide.

# Biologicals

Contaminant	Before	After	% Removal
<b>Bacteria</b>	110,000,000 cfu	2,700 cfu	99+
<b>Coliform</b>	318,000,000 cfu	ND (<1) cfu	99+
<b>E. coli</b>	>2,419.2 mpn	ND (<0.01) mpn	99+
<b>Enterococcus</b>	83 mpn	ND (<10) mpn	82
<b>Total Coliform</b>	>2,419.2 mpn	ND (<0.1) mpn	99+
<b>Cyanotoxin</b>	97.1 ug/l	0.001 ug/l	99

# Pesticides

<b>Contaminant</b>	Before (mg/l)	After (mg/l)	% Removal
<b>Aldrin</b>	0.063	ND (0.001)	98
<b>Chlorpyriphos</b>	5.87	ND (0.03)	99+
<b>Cypermethrin</b>	1.3	0.07	94
<b>DDT</b>	0.261	0.002	99+
<b>Diazinon</b>	34	0.21	99+
<b>Lindane</b>	0.143	ND (0.001)	99+
<b>Propetamphos</b>	80.87	0.36	99+

# Hydrocarbons

Contaminant	Before (mg/l)	After (mg/l)	% Removal
<b>Benzene</b>	90.1	0.3590	99+
<b>Ethyl Benzene</b>	428	0.372	99+
<b>MP-Xylene</b>	41.6	0.057	99+
<b>MTBE</b>	21.58	0.0462	99+
<b>O-Xylene</b>	191	0.416	99+
<b>PCB</b>	0.0007	ND ( $<0.0001$ )	85
<b>Petroleum Hydrocarbons</b>	72.5	ND ( $<0.2$ )	99+
<b>Toluene</b>	28,480	0.227	99+

# Dyes

Contaminant	Before (NTU)	After (NTU)	% Removal
Ref. 006-691	125.1	12.1	90
Ref. 006-692	129.4	2.2	98
Ref. 006-854	68.30	0.68	99+
Ref. 006-851	2,340	4.5	99+

# Radioisotopes

Contaminant	Before	After	% Removal
Americium-241	71.99 pCi/l	0.57 pCi/l	99+
Plutonium-239	29.85 pCi/l	0.29 pCi/l	99+
Radium	1093 pCi/l	0.10 pCi/l	99+
Uranium	0.13 mg/l	0.0002 mg/l	99+



# Organic & Inorganics Compounds

Contaminant	Before	After	% Removal
<b>BOD<sub>5</sub></b>	1,050 mg/l	14 mg/l	98
<b>NTU</b>	35.38 mg/l	0.32 mg/l	99+
<b>TSS</b>	1,560 mg/l	8 mg/l	99+
<b>PFOS</b>	421 ng/l	<2.36 ng/l	99
<b>PFOA</b>	1,540 ng/l	<3.97 ng/l	99

# BTEX in 260,000 mg/l TDS Water

## United Arab Emirates 130 gpm System

<u>mg/l</u>	<u>Untreated</u>	<u>Treated</u>	<u>% Removed</u>
• Benzene	90.1	0.359	99.6%
• Toluene	28.48	0.227	99.9%
• Ethyl benzene	428	0.372	99.9%
• M, P - Xylene	41.6	0.057	99.8%
• O-Xylene	191	0.416	99.7%

# United Arab Emirates

130 gpm system  
At an Oil Refinery

pH adjustment  
Electrocoagulation

Vacuum  
Clarification

80 degrees cooling



# Red Desert, Wyoming

## Frack Flow Back and Produced Water Mixture



# Hydraulically-Dredged Wastewater Hudson River Project

Results are reported in ug/L except as noted

<u>Analyte</u>	<u>Raw</u>	<u>Post EC &amp; Clarification</u>	<u>% Reduction</u>
<b>Arsenic</b>	<b>30</b>	<b>3.2</b>	<b>89.3</b>
<b>Cadmium</b>	<b>10</b>	<b>0.32</b>	<b>96.8</b>
<b>Chromium</b>	<b>330</b>	<b>13.0</b>	<b>96.1</b>
<b>Copper</b>	<b>230</b>	<b>3.2</b>	<b>98.6</b>
<b>Iron</b>	<b>22,000</b>	<b>29.0</b>	<b>99+</b>
<b>Lead</b>	<b>590</b>	<b>3.2</b>	<b>99+</b>
<b>Mercury</b>	<b>0.72</b>	<b>0.0031</b>	<b>99+</b>
<b>Zinc</b>	<b>2,200</b>	<b>6.4</b>	<b>99+</b>
<b>TOC (mg/l)</b>	<b>5.8</b>	<b>2.1</b>	<b>65.5</b>
<b>TSS (mg/l)</b>	<b>210</b>	<b>4.0</b>	<b>98.1</b>
<b>Total P (mg/l)</b>	<b>2.3</b>	<b>0.03</b>	<b>98.7</b>



# TOSHIBA

The plant water is electrocoagulated, clarified, and returned to the incoming city water tank.

The people in Thailand drink bottled water.

They probably do not believe me when I tell them that I wash my car and water my lawn with drinking water.



## 250 gpm Unit, Thailand

# Disinfection with Electricity

Eliminates Disinfection By-products Associated with Chlorination -  
Dechlorination and Ultraviolet Light Shadow Challenges



# Thank You! Questions

# [www.powellwater.com](http://www.powellwater.com)



Electrocoagulation  
Equipment

Powell Water System, Inc.

Scott Powell, President

**(303) 241-2489**

United States Patent Number 10358361 B2 & 11407660 B2. System and Method for Remediation of Wastewater Including Aerobic, Anaerobic and Electrocoagulation Technology. This patent is wholly licensed by Powell Water Systems, Inc.

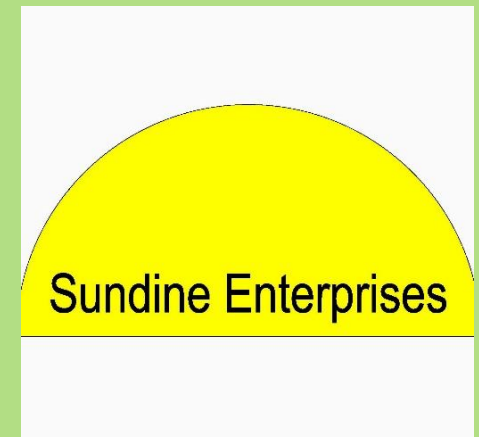


Design, Build and  
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